JURNAL EDUSCIENCE (JES)
p-ISSN : 2303 - 355X | e-ISSN : 2685 - 2217
PUBLISHED BY : LPPM of UNIVERSITAS LABUHANBATU

Jurnal Eduscience (JES)
Volume 11, No. 3
December, Tahun 2024
Submit : 01 November 2024
Accepted: 26 December 2024

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

ANDERSON LEONARDO PALINUSSA[1], HANISA TAMALENE[1], EDITH MERLIN LAWALATA[2]

[1]Mathematics Education Department, Pattimura University, Ambon, Indonesia
[2]SMA Swasta Kristen YPKPM Ambon, Indonesia
E-Mail: palinussaandesonl@gmail.com, tamalene80nissa@gmail.com, edith.lawalata22@gmail.com

Abstract

Poor knowledge of mathematical concepts leads to poor math learning outcomes among students. Sound reasoning will equip students to explain and argue mathematically. Therefore, this study uses trigonometric comparison material in right triangles to compare students' learning outcomes and learning styles. 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 from the tenth grade, majoring in mathematics and natural sciences. The data used in this research is quantitative. Quantitative data is data in numbers obtained from a questionnaire consisting of 21 questions and mathematics learning outcomes received after working on a description question with as many as three numbers. The data analysis technique in this study is using the Mann Whitney-U test. The survey results obtained 23 or 29.9% of students with visual learning styles, 41 or 53.2% with auditory learning styles, and 13 or 16.9% 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 analysis using SPSS 26.0, the significance value of each paired group of learning styles is more than the significance level $\alpha = 0.05$. 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 (Winthrop 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 properly understand 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). 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 obtained after the learning process. Learning outcomes are changes in students concerning cognitive, affective, and psychomotor aspects (Rao, 2020). It has been believed by various parties that mathematics has a significant contribution to the development and progress of a nation. Therefore, improving the quality of mathematics education is necessary to improve student learning outcomes. However, in school conditions 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 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 to increase the pass rate in mathematics learning (Mazana et al., 2018).

It is important to recognize that students within each classroom possess varying levels of ability. As a result, they will achieve different educational outcomes (Gamage et al., 2021). Unfortunately, in traditional teaching environments, all learners are required to absorb material in a uniform manner and at a consistent speed (Rijken & Fraser, 2023). Students who struggle academically may find it challenging to passively acquire knowledge if they lack sufficient time (Yeh et al., 2019). The mathematics curriculum in Malaysia emphasizes extensive practice to enhance students' comprehension of mathematical concepts (Md-Ali & Veloo, 2021). The objective is to develop a skilled workforce in Malaysia that consists of critical thinkers who are creative, innovative, competitive, versatile, entrepreneurial, self-assured, adept at mastering new digital technologies, and committed to lifelong learning (Tarmizi & Tarmizi, 2010). Learners in South Africa tend to perform inadequately in mathematics when compared to students from other nations. One potential solution is to understand the various learning styles of students during instruction (Sriphai et al., 2011). A study focusing on academic procrastination among students in Indonesia revealed that the most common late submissions were for mathematics assignments (44%), followed by physics (31%) and other subjects (28%) (Chamberlin, 2010). Teachers typically assign math problems from textbooks or reference materials as homework to develop and enhance problem-solving skills, as well as understanding of mathematical theories and concepts (Setiyowati et al., 2020). These assignments are often reviewed in the subsequent class, and students may be required to complete them beforehand. Thus, the alignment of teaching methods with students' learning styles can encourage them to engage thoroughly with math tasks (Fernández-Alonso et al., 2016). This scenario often contrasts with the overall state of education. Global data tends to originate from developing regions. For instance, in South Africa, studies indicate that students' enthusiasm for mathematics is still insufficiently high (Bosman & Schulze, 2018). The well-known Trends in International Mathematics and Science Study (TIMSS), conducted in 2015, highlighted significant deficiencies in student performance in Indonesia, revealing that 27% of 4th-grade students fell short of the expected standards (Beatty et al., 2021).

Learning outcomes are often considered the determinant of education (Batlolona et al., 2019). 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

JURNAL EDUSCIENCE (JES)
p-ISSN : 2303 - 355X | e-ISSN : 2685 - 2217
PUBLISHED BY : LPPM of UNIVERSITAS LABUHANBATU

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: 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 research results to identify VAK learning styles in Sohar students in Oman showed that 36% were visual, 35% auditory, and 29% kinesthetic (Hamdani, 2015).

Additionally, a study by (Leasa et al. 2018) indicated that 88.7% of students favored a singular learning style (unimodal), while 11.3% opted for a combination of various learning styles (multimodal). Among those using unimodal styles, kinesthetic learning was the most common among both male and female students, accounting for 58.6%, while visual learning was the least favored at only 6%. Numerous studies have explored preferred learning styles specifically in Mathematics. Chetty et al. (2019) found that auditory learning was the most preferred, temporary Bearneza, 2023) research revealed that the dominant learning style of students is visual. However, the second dominant learning style, namely auditory, has the highest average performance in mathematics. Contrary to other findings stating that kinesthetic learners are the most common, the kinesthetic learning style is the student learning style with the most significant influence on student learning interest by 84.3% (Setiawati et al., 2023). PUTRİ et al. (2019) observed that visual learners outperformed auditory and kinesthetic learners among public junior high school students in Sragen, Indonesia.

Effective cognitive abilities are essential for students to learn and grasp mathematical ideas (Wan Hussin & Mohd Matore, 2023). The VAK learning style is widely recognized and straightforward for determining an individual's learning preferences (Jamil et al., 2015). One of the most recognized theories regarding learning styles is the VARK model developed by Fleming & Mills (1992), which includes visual, aural, reading/writing, and kinesthetic elements. Fleming & Baume (2006) expanded the original VAK model by adding the R, as he argued that while some learners may be visual, they often benefit more from written content than from images or symbols. Learners can exhibit multimodal tendencies by developing two or more learning styles simultaneously. Consequently, understanding these learning styles can enhance students' comprehension of mathematical principles (Cuevas, 2015). Additionally, they foster a more engaging learning environment for mathematics, promoting interactivity (Nancekivell et al., 2020). The distinct learning styles of students can be observed in their approach to mathematics. Students who prefer visual learning tend to understand math concepts through visual aids like diagrams of formulas (Caligaris et al., 2015). For instance, in geometry, students with a visual orientation may examine shapes using 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 to remember formulas better. Kinesthetic learning style practices often apply math topics in daily life. For example, in algebra, students are given real situations to form algebraic expressions (Ganesan et al., 2020). Therefore, with an effective learning style, students can master math concepts more quickly and easily (Mangwende & Maharaj, 2020).

Students who understand mathematical concepts and content effectively can complete the teacher's tasks well without procrastinating (Ingram et al., 2019). However, students are not interested in math

JURNAL EDUSCIENCE (JES)
p-ISSN : 2303 - 355X | e-ISSN : 2685 - 2217
PUBLISHED BY : LPPM of UNIVERSITAS LABUHANBATU

tasks due to a lack of mathematical understanding. Therefore, they cannot re-explain or apply concepts 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). 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 can 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; Leasa et al., 2020). Education cannot be fully achieved without learning habits that match learners' knowledge. Learning styles and habits go together in learning and helping instructors support individual students toward better learning (Garizábalo-dávila et al., 2024). Thus, this study aims to compare students' learning outcomes and learning styles using trigonometric comparison material 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 Table 1.

Table 1. Research Design

Independent variable	Dependent variable
X1	
X2	Y
X3	

The research participants were 77 grade 10 science students at YPKPM Ambon Christian High School. The learning style groups were Visual Group (23 students), Audiotorial Group (411 students), and Kinesthetic Group (13 students). The research was conducted for three months. 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 given a learning style questionnaire consisting of 22 statements, with details of 8 numbers for visual statements, seven for auditorial statements, and seven for kinesthetic statements. Before the learning outcomes test and learning style questionnaire are used, validators must validate them (3 Pattimura University Mathematics Education Lecturers). In addition, this instrument was tested on several high school students in Ambon, and its validity was 0.621 and reliability was 0.823.

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 in the form of numbers obtained through a questionnaire with 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 three 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 conducted to determine whether the group's variants' prices were homogeneous or relatively similar. The homogeneity of variant prices was calculated at the beginning of data analysis activities. This was done to ascertain whether the homogeneity assumption in each data category had been fulfilled. 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 visual, auditorial, and kinesthetic learning style group. $H0$: 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, H1 is rejected, or Sig.> α (α=0.05) Ho is rejected, and H1 is accepted or Sig. < α From the research, 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 from more than two 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 regarding visual, auditorial, and kinesthetic learning styles. $H1$: there is a substantial difference in learning outcomes of trigonometric comparison in right triangles regarding visual, auditorial, and kinesthetic learning styles. Basic decision making: Ho is accepted, H1 is rejected, or Sig.> α (α=0.05) Ho is rejected, and H1 is accepted or Sig. < α.

RESULTS AND DISCUSSION

Result

The following data were obtained based on descriptive statistical data processing results. 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 Pretest and post-test hypothesis test results from each learning style group are 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
	Kolmogorov 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."The Homogeneity 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

JURNAL EDUSCIENCE (JES)
p-ISSN : 2303 - 355X | e-ISSN : 2685 - 2217
PUBLISHED BY : LPPM of UNIVERSITAS LABUHANBATU

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 is 0.2 > α and Post-test 0.2 > α., so 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 hypothesis test results for differences in Pretest and post-test learning outcomes for 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	H_0
Auditorial	0,468	H_0
Kinesthetic	1	H_0

Data Table 6 indicates that the significance level for the three learning styles is below alpha. According to the decision-making process, we accept H0, which means there is no meaningful difference in learning outcomes related to trigonometric comparison material in right triangles among students with visual, auditory, and kinesthetic learning styles.

Post Hoc Test Results

Based on the Pretest and post-test hypothesis tests, the following table presents the post hoc test results of the Prerequisite Tests of Normality and Homogeneity classes. In the prerequisite test and the post-test using the Kolmogrov-Smirnov test, it can be seen that the results of the prerequisite test for 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.

JURNAL EDUSCIENCE (JES)
p-ISSN : 2303 - 355X | e-ISSN : 2685 - 2217
PUBLISHED BY : LPPM of UNIVERSITAS LABUHANBATU

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

This study's three post-test data from each learning style obtained were not normally distributed. Therefore, the difference test was conducted on these three learning styles using the Mann-Whitney test to see differences in learning outcomes. The Mann-Whitney test sorts 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 Auditorial	-0,224	0,823	$H0$	
2	Visual Kinesthetics	-0,64	0,519	$H0$	$H0$
3	Auditorial Kinesthetics	-0,67	0,544	$H0$	

In the table above, each group's significance values are less than the significance level. The final decision shows no significant difference in learning outcomes of trigonometric comparison in right triangles regarding 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. This is because students are not given specific guidance on how or what their learning style is. Ineffective learning styles cause students to be less interested in Mathematics, leading to unsuccessful learning because students need a sufficient basis of knowledge. Study Table 2 shows that students with auditory learning styles are higher than visual and kinesthetic. This is in contrast to the results of previous studies, where students with kinesthetic learning styles provide higher learning outcomes than students with audio learning styles, mathematics learning outcomes of students with kinesthetic learning styles and students with visual learning styles and mathematics learning outcomes of students with visual learning styles and students with audio learning styles (Rahayu & Cahyadi, 2019).

Discussion

The previous results highlight the significance of employing various teaching techniques or applying diverse educational models to cater to distinct learning preferences and enhance students' performance in math. It is essential for educators to comprehend these learning preferences and connect them to their teaching environments to facilitate these outcomes. By examining learning styles, students can benefit and concentrate on their studies, leading to better educational results and increased satisfaction. Research by Khan & Javed Iqbal (2016) and Ganyaupfu (2013) indicates that the

JURNAL EDUSCIENCE (JES)
p-ISSN : 2303 - 355X | e-ISSN : 2685 - 2217
PUBLISHED BY : LPPM of UNIVERSITAS LABUHANBATU

interactive teacher-student approach is the most effective method of teaching. This method includes elements of cooperative learning, such as Think-Pair-Share, Jigsaw (Cardino & Ortega-Dela Cruz, 2020), and Numbered Head Together (Leasa et al., 2017), In contrast, traditional teacher-centered approaches, primarily lecture-based strategies, are the least effective. Additionally, while repetitive practice doesn't seem to enhance student performance, it offers instructors an alternative way to teach mathematics (Ganyaupfu, 2013).

The findings also suggest that one of the longstanding issues facing math teachers in the United States is how to enhance student performance in mathematics. Since the 1960s, various international assessments have consistently indicated that students in the US fall short compared to their peers in other developed nations in math proficiency (Ma & Ma, 2014). The key facilitator of learning is the teacher, who plays a vital role in promoting various learning styles to boost students' math performance. The unique learning preferences of individual students necessitate that teachers recognize and modify their math teaching approaches accordingly (Istiqlal et al., 2024; Safitri et al., 2023, 2024; Safitri & Ansyari, 2024). One significant reason students struggle to grasp the learning materials effectively is tied to the teaching styles utilized by their educators rather than the diversity of the students' learning preferences (Newton & Miah, 2017; Leasa et al., 2024). Therefore, it is crucial for teachers to discern the learning pattern of each student to devise improved teaching and learning strategies tailored to the specific characteristics of each style (Sun et al., 2023; Jamaludin, 2024)

Learning styles, viewed as a single idea, are very popular in today's educational settings, especially in primary schools across England and Wales. However, this contrasts with the concept of learning styles in the fields of educational and cognitive psychology, where theories and practices related to them are rigorously analyzed and debated by scholars. This particular learning style identified is known as VAK. Numerous advisors from local governments, along with headteachers, are actively endorsing VAK in primary education. Many educators in primary schools are implementing VAK-style questionnaires to assess students, categorizing them as visual, auditory, or kinesthetic learners. This approach has gained traction not only in schools but also at the university level, where it is presented to students pursuing degrees in teacher training and education studies. The terms visual (V), auditory (A), and kinesthetic (K) have become quite familiar, recognized by educators, trainees, and others in many contexts, and they carry some weight. Nevertheless, an important issue needs to be addressed. As previously mentioned, while VAK is prevalent in primary education, it does not align with the standard understanding of learning styles. Delving deeper, we uncover an intriguing realm of accelerated and brain-based learning, marked by pseudoscience, jargon, and questionable neuroscience, which seems to be acknowledged—perhaps rather naïvely—by the Department for Education and Skills (DfES) (Sharp et al., 2008).

CONCLUSION

Based on the findings and discussions of the study, the following conclusions can be drawn: 1) From the questionnaire responses, there were 23 students, making up 29.9%, identified as having visual learning preferences, 41 students, or 53.2%, who learn better through auditory methods, and 13 students, equating to 16.9%, who prefer kinesthetic learning; 2) The average performance for students with visual learning preferences is 70.09, for those with auditory styles is 71.72, and for kinesthetic learners is 69.29; 3) There are no notable variations in the learning outcomes related to trigonometric comparisons in right triangles when looking at visual, auditory, and kinesthetic learning styles. The implications of this research are anticipated: 1) Mathematics teachers should be aware of their students' preferred learning styles, especially those who are performing at lower levels; 2) Schools should enhance their facilities and resources to support diverse learning styles present among students; 3) Researchers are encouraged to broaden their studies on learning styles across different educational institutions.

Various student learning styles have been recognized concerning their approach to learning Mathematics. Three primary learning styles are observed in students: visual, auditory, and kinesthetic. Visual learning stands out as the most prevalent style among Mathematics learners, followed by auditory and kinesthetic approaches. The extent of academic procrastination in Mathematics among students is relatively low. Furthermore, the research indicated that both visual and kinesthetic learning methods have a notable impact on students' tendencies to procrastinate academically in Mathematics. Thus, it is important to enhance awareness of different learning styles through excellent school programs to educate students on identifying their preferred learning styles and practicing them effectively, which will subsequently improve the overall quality of learning in mathematics. With regard to implications, this study recommends advancing current programs in educational institutions by teaching students how to recognize their learning preferences for better engagement in Mathematics and minimizing academic procrastination.

This research has specific limitations since it solely concentrates on assessing VAK learning styles through questionnaires focused on tenth-grade students in Mathematics. As a result, the findings cannot necessarily be applied to other subjects within the school curriculum. Additionally, this study is restricted to examining one independent variable: the relationship between students' learning styles and academic procrastination in Mathematics. Therefore, other influencing factors affecting students' learning outcomes related to procrastination in mathematics must still be investigated. Future research could explore various elements contributing to academic procrastination in Mathematics, aiming to enhance students' motivation and self-efficacy in this area.

REFERENCES

Adeleke, M. A. (2007). Strategic improvement of mathematical problem-solving performance of secondary school students using procedural and conceptual learning strategies. *Educational Research and Review*, *2*(9), 259–263.

Algani, Y. M. A. (2022). Role, need and benefits of mathematics in the development of society. *Journal for the Mathematics Education and Teaching Practices*, *3*(1), 23–29.

Batlolona, J., Laurens, T., Leasa, M., Batlolona, M., Kempa, R., & Enriquez, J. J. (2019). Comparison of Problem Based Learning and Realistic Mathematics Education to Improve Students Academic Performance. *Jurnal Pendidikan Progresif*, *9*(2), 185–197. https://doi.org/10.23960/jpp.v9.i2.201921

Bearneza, F. J. D. (2023). Students' Learning Styles and Performance in Mathematics: Basis for the Development of Teaching Materials. *International Journal of Innovative Science and Research Technology*, *11*(3), 987–998.

Beatty, A., Berkhout, E., Bima, L., Pradhan, M., & Suryadarma, D. (2021). Schooling progress, learning reversal: Indonesia's learning profiles between 2000 and 2014. *International Journal of Educational Development*, *85*, 1–16. https://doi.org/10.1016/j.ijedudev.2021.102436

Bosman, A., & Schulze, S. (2018). Learning style preferences and mathematics achievement of secondary school learners. *South African Journal of Education*, *38*(1), 1–8. https://doi.org/10.15700/saje.v38n1a1440

Bringula, R., Reguyal, J. J., Tan, D. D., & Ulfa, S. (2021). Mathematics self-concept and challenges of learners in an online learning environment during COVID-19 pandemic. *Smart Learning Environments*, *8*(1), 1–23. https://doi.org/10.1186/s40561-021-00168-5

Caligaris, M., Rodríguez, G., & Laugero, L. (2015). Learning Styles and Visualization in Numerical Analysis. *Procedia - Social and Behavioral Sciences*, *174*, 3696–3701. https://doi.org/10.1016/j.sbspro.2015.01.1101

Cardino, J. M., & Ortega-Dela Cruz, R. A. (2020). Understanding of learning styles and teaching strategies towards improving the teaching and learning of mathematics. *Lumat*, *8*(1), 19–43. https://doi.org/10.31129/LUMAT.8.1.1348

Chamberlin, S. A. (2010). Mathematical Problems That Optimize Learning for Academically Advanced Students in Grades K-6. *Journal of Advanced Academics*, *22*(1), 52–76. https://doi.org/10.1177/1932202X1002200103

Chetty, N. D. S., Handayani, L., Sahabudin, N. A., Ali, Z., Hamzah, N., Rahman, N. S. A., & Kasim, S. (2019). Learning styles and teaching styles determine students' academic performances. *International Journal of Evaluation and Research in Education*, *8*(4), 610–615. https://doi.org/10.11591/ijere.v8i3. 20345

Cuevas, J. (2015). Is learning styles-based instruction effective? A comprehensive analysis of recent research on learning styles. *Theory and Research in Education*, *13*(3), 308–333. https://doi.org/10.1177/1477878515606621

Dunn, R. (1983). Learning Style and its Relation to Exceptionality at Both Ends of the Spectrum. *Exceptional Children*, *49*(6), 496–506. https://doi.org/10.1177/001440298304900602

Egara, F. O., & Mosimege, M. (2023). Effect of flipped classroom learning approach on mathematics achievement and interest among secondary school students. *Education and Information Technologies*, 1–20. https://doi.org/10.1007/s10639-023-12145-1

Fernández-Alonso, R., Suárez-Álvarez, J., & Muñiz, J. (2016). Deberes y rendimiento en matemáticas: Papel del profesorado, la familia y las características del alumnado. *Revista de Psicodidactica*, *21*(1), 5–23. https://doi.org/10.1387/RevPsicodidact.13939

Fleming, N., & Baume, D. (2006). Learning styles again: VARKing up the right tree. *Educational Developments*, *7*(4), 4–7. https://doi.org/10.7748/ns.6.2.51.s64

Gamage, K. A. A., Dehideniya, D. M. S. C. P. K., & Ekanayake, S. Y. (2021). The role of personal values in learning approaches and student achievements. *Behavioral Sciences*, *11*(7), 1–23. https://doi.org/10.3390/bs11070102

Gamboa Mora, M. C., Vera-Monroy, S. P., Mejía-Camacho, A., & Guerrero Rueda, W. J. (2021). Perception channels and cognitive styles: opponents, followers or learning allies? *Heliyon*, *7*(2), 1–8. https://doi.org/10.1016/j.heliyon.2021.e06242

Ganesen, P., Osman, S., Abu, S., & Kumar, J. A. (2020). The Relationship Between Learning Styles and Achievement of Solving Algebraic Problems Among Lower Secondary School Students. *International Journal of Advanced Science and Technology*, *29*(9S), 2563–2574.

Ganyaupfu, E. M. (2013). Teaching Methods and Students' Academic Performance. *International Journal of Humanities and Social Science Invention ISSN (Online*, *2*(9), 2319–7722.

Garizábalo-dávila, C., Ospino-mendoza, E., Marin-hamburger, Y., Garizábalo-dávila, C., & Ospino-mendoza, E. (2024). ScienceDirect ScienceDirect An Empirical Analysis of Learning Styles and

Generic Competencies in University Students : Case of and Health Services An Empirical Analysis of Learning Styles Generic Administration Students in the City of Case Barranquilla , . *Procedia Computer Science*, *231*, 623–628. https://doi.org/10.1016/j.procs.2023.12.174

Hamdani, D. Al. (2015). Exploring Students' Learning Style at a Gulf University: A Contributing Factor to Effective Instruction. *Procedia - Social and Behavioral Sciences*, *176*, 124–128. https://doi.org/10.1016/j.sbspro.2015.01.452

Hsiao, H. S., Lin, C. Y., Chen, J. C., & Peng, Y. F. (2018). The influence of a mathematics problem-solving training system on first-year middle school students. *Eurasia Journal of Mathematics, Science and Technology Education*, *14*(1), 77–93. https://doi.org/10.12973/ejmste/77902

Hu, J., Peng, Y., Chen, X., & Yu, H. (2021). Differentiating the learning styles of college students in different disciplines in a college English blended learning setting. *PLoS ONE*, *16*(5), 1–26. https://doi.org/10.1371/journal.pone.0251545

Ingram, J., Andrews, N., & Pitt, A. (2019). When students offer explanations without the teacher explicitly asking them to. *Educational Studies in Mathematics*, *101*(1), 51–66. https://doi.org/10.1007/s10649-018-9873-9

Istiqlal, M., Istiyono, E., Widihastuti, Sari, D. K., Danni, R., & Safitri, I. (2024). Construction of Mathematics Cognitive Test Instrument of Computational Thinking Model for Madrasah Aliyah Students. *Nazhruna: Jurnal Pendidikan Islam*, *7*(2), 475–492. https://doi.org/10.31538/nzh.v7i2.4425

Jamaludin. (2024). Physics Concept Understanding Training Based on Multirepresentation and Inclusion for Students of SMP Negeri 81 Central Maluku. *Unram Journal of Community Service*, *5*(4), 497–503. https://doi.org/10.29303/ujcs.v5i4.766

Jamil, N. I., Baharuddin, F. N., & Maknu, T. S. R. (2015). Factors Mining in Engaging Students Learning Styles Using Exploratory Factor Analysis. *Procedia Economics and Finance*, *31*(15), 722–729. https://doi.org/10.1016/s2212-5671(15)01161-2

K Dayanand, A. (2020). Hypothesis Types and Research. *International Journal of Nursing Science Practice and Research*, *4*(2), 78–80.

Khan, J., & Javed Iqbal, M. (2016). Effects of learning style on achievement of distance learners. *Dialogue (Pakistan)*, *11*(3), 296–309.

Laurens, T., Batlolona, F. A., Batlolona, J. R., & Leasa, M. (2018). How does realistic mathematics education (RME) improve students' mathematics cognitive achievement? *Eurasia Journal of Mathematics, Science and Technology Education*, *14*(2), 569–578. https://doi.org/10.12973/ejmste/76959

Leasa, M., Batlolona, J. R., Enriquez, J. J., & Kurnaz, M. A. (2018). Determination Of Elementary Students' Learning Styles Reviewed From Gender Aspects. *Journal of Education and Learning (EduLearn)*, *12*(3), 478–486. https://doi.org/10.11591/edulearn.v12i3.8978

Leasa, M., Corebima, A. D., & Batlolona, J. R. (2020). The effect of learning styles on the critical thinking skills in natural science learning of elementary school students. *Elementary Education Online*, *19*(4), 2086–2097. https://doi.org/10.17051/ilkonline.2020.763449

Leasa, M., Corebima, A. D., Ibrohim, & Suwono, H. (2017). Emotional intelligence among auditory, reading, and kinesthetic learning styles of elementary school students in Ambon-Indonesia. *International Electronic Journal of Elementary Education*, *10*(1), 83–91. https://doi.org/10.26822/iejee.2017131889

Leasa, M., Pelamonia, J., Talakua, M., & Rafafy, J. (2024). Emotional Literacy of Elementary School Teachers : A Study on Science Learning with Problem-Based Learning (PBL) and Homogeinity

Psycho Cognition (HPC) Program. *KnE Social Sciences*, *2024*, 432–444. https://doi.org/10.18502/kss.v9i31.17605

Lin, W., Yin, H., Han, J., & Han, J. (2020). Teacher–student interaction and chinese students' mathematics learning outcomes: The mediation of mathematics achievement emotions. *International Journal of Environmental Research and Public Health*, *17*(13), 1–17. https://doi.org/10.3390/ijerph17134742

Ma, V. J., & Ma, X. (2014). A comparative analysis of the relationship between learning styles and mathematics performance. *International Journal of STEM Education*, *1*(1), 1–13. https://doi.org/10.1186/2196-7822-1-3

Makgato, M., & Mji, A. (2006). Factors associated with high school learners' poor performance: a spotlight on mathematics and physical science. *South African Journal of Education*, *26*(2), 253–266.

Malepa-Qhobela, M., & Mosimege, M. (2022). A framework to assist mathematics teachers in integrating problem solving in secondary school classrooms. *Issues in Educational Research*, *32*(4), 1486–1508.

Mangwende, E., & Maharaj, A. (2020). Barriers to Mathematics Teachers' Use of Their Knowledge of Students' Learning Styles in Mathematics Teaching: A Case of Secondary Schools in Zimbabwe. *Eurasia Journal of Mathematics, Science and Technology Education*, *16*(1), 1–15. https://doi.org/10.29333/ejmste/109198

Maruta, S. I. (2021). Effects of Polya and Bransford-Stein Models on Retention in Trigonometry among Senior Secondary School Students in Kano State, Nigeria. *Kano Journal of Educational Psychology (KaJEP)*, *3*(1), 2021.

Mazana, M. Y., Montero, C. S., & Casmir, R. O. (2018). Investigating Students' Attitude towards Learning Mathematics. *International Electronic Journal of Mathematics Education*, *14*(1), 207–231. https://doi.org/10.29333/iejme/3997

Md-Ali, R., & Veloo, A. (2021). the Issues and Challenges of Mathematics Teaching and Learning in Malaysia Orang Asli Primary Schools From Teachers' Perspectives. *Malaysian Journal of Learning and Instruction*, *18*(2), 129–160. https://doi.org/10.32890/mjli2021.18.2.5

Nancekivell, S. E., Shah, P., & Gelman, S. A. (2020). Maybe they're born with it, or maybe it's experience: Toward a deeper understanding of the learning style myth. *Journal of Educational Psychology*, *112*(2), 221–235. https://doi.org/10.1037/edu0000366

Newton, P. M., & Miah, M. (2017). Evidence-based higher education - Is the learning styles "myth" important? *Frontiers in Psychology*, *8*(3), 1–9. https://doi.org/10.3389/fpsyg.2017.00444

Özgen, K., Tataroğlu, B., & Alkan, H. (2011). An examination of brain dominance and learning styles of pre-service mathematics teachers. *Procedia - Social and Behavioral Sciences*, *15*, 743–750. https://doi.org/10.1016/j.sbspro.2011.03.176

ÖZKAYA, M., KALAÇ, S., & KONYALIOĞLU, A. C. (2022). The effect of positive error climate on affective domains in mathematics teaching. *International Journal of Assessment Tools in Education*, *9*(Special Issue), 236–257. https://doi.org/10.21449/ijate.1121828

PUTRİ, M. E., . M., & SAPUTRO, D. R. S. (2019). The Effect of Application of REACT Learning Strategies on Mathematics Learning Achievements: Empirical Analysis on Learning Styles of Junior High School Students. *International Journal of Educational Research Review*, *4*(2), 231–237. https://doi.org/10.24331/ijere.518065

Rahayu, S., & Cahyadi, R. (2019). Experimentation of NHT And TPS Learning Model Using CTL Approach Towards Mathematics Learning Outcomes Viewed from Student Learning Styles. *International Journal of Trends in Mathematics Education Research*, *2*(4), 215–218. https://doi.org/10.33122/ijtmer.v2i4.140

Rao, N. J. (2020). Outcome-based Education : An Outline. *Higher Education for the Future*, *7*(1), 5–21. https://doi.org/10.1177/2347631119886418

Rijken, P. E., & Fraser, B. J. (2023). Effectiveness of project-based mathematics in first-year high school in terms of learning environment and student outcomes. *Learning Environments Research*, 1–23. https://doi.org/10.1007/s10984-023-09477-7

Sachdeva, S., & Eggen, P.-O. (2021). Learners' Critical Thinking About Learning Mathematics. *International Electronic Journal of Mathematics Education*, *16*(3), 1–18. https://doi.org/10.29333/iejme/11003

Safitri, I., & Ansyari, R. (2024). The Calibration of Science Achievement Test Based on Integrated Islamic Curriculum. *8th International Conference on Education and Multimedia Technology (ICEMT)*, 329–336. https://doi.org/10.1145/3678726.3678727

Safitri, I., Muti'ah, R., & Sriono. (2023). Identification of Character Values of Public and Private Junior High School Students in Rantau Selatan District. *The IAFOR International Conference on Education*, 717–727. https://doi.org/https://doi.org/10.22492/issn.2189-1036.2023.59

Safitri, I., Rosnawati, R., & Ansyari, R. (2024). Estimasi Kesalahan Pengukuran dalam Penilaian Sidang Skripsi: Generalizability Theory Analysis. *Afeksi: Jurnal Penelitian Dan Evaluasi Pendidikan*, *5*(1), 162–168. https://doi.org/https://doi.org/10.35672/afeksi.v5i1.220

Setiawati, N., Irene, S., Thomas, O., Alexandro, R., & Putra, K. N. (2023). The Effect of Visual Auditory, Kinesthetic Learning Styles on Students' Learning Interest at Christian Junior High School. *Indonesian Journal of Educational Research and Review*, *6*(2), 466–478. https://doi.org/10.23887/ijerr.v6i2.66319

Setiyowati, A. J., Triyono, T., Rachmawati, I., & Hidayati, N. (2020). Academic Procrastination of High School Students in East Java. *PSIKOPEDAGOGIA Jurnal Bimbingan Dan Konseling*, *9*(1), 46–52. https://doi.org/10.12928/psikopedagogia.v9i1.17907

Sharp, J. G., Bowker, R., & Byrne, J. (2008). VAK or VAK-uous? Towards the trivialisation of learning and the death of scholarship. *Research Papers in Education*, *23*(3), 293–314. https://doi.org/10.1080/02671520701755416

Smit, R., Hess, K., Taras, A., Bachmann, P., & Dober, H. (2023). The role of interactive dialogue in students' learning of mathematical reasoning: A quantitative multi-method analysis of feedback episodes. *Learning and Instruction*, *86*, 1–18. https://doi.org/10.1016/j.learninstruc.2023.101777

Sriphai, S., Damrongpanit, S., & Sakulku, J. (2011). An investigation of learning styles influencing mathematics achievement of seventh-grade students. *Educational Research and Reviews*, *6*(15), 835–842. https://doi.org/10.5897/ERR11.162

Sun, X., Norton, O., & Nancekivell, S. E. (2023). Beware the myth: learning styles affect parents', children's, and teachers' thinking about children's academic potential. *Npj Science of Learning*, *8*(1), 1–11. https://doi.org/10.1038/s41539-023-00190-x

Tarmizi, R. A., & Tarmizi, M. A. A. (2010). Analysis of mathematical beliefs of Malaysian secondary school students. *Procedia - Social and Behavioral Sciences*, *2*(2), 4702–4706. https://doi.org/10.1016/j.sbspro.2010.03.753

Wan Hussin, W. A. S., & Mohd Matore, M. E. E. (2023). The influence of learning styles on academic procrastination among students in mathematics. *Frontiers in Psychology*, *14*, 1–12. https://doi.org/10.3389/fpsyg.2023.1239933

Wang, X. S., Perry, L. B., Malpique, A., & Ide, T. (2023). Factors predicting mathematics achievement in PISA: a systematic review. In *Large-Scale Assessments in Education* (Vol. 11, Issue 1). Springer US. https://doi.org/10.1186/s40536-023-00174-8

Weintrop, D., Beheshti, E., Horn, M., Orton, K., Jona, K., Trouille, L., & Wilensky, U. (2016). Defining Computational Thinking for Mathematics and Science Classrooms. *Journal of Science Education and Technology*, *25*(1), 127–147. https://doi.org/10.1007/s10956-015-9581-5

Yeh, C. Y. C., Cheng, H. N. H., Chen, Z. H., Liao, C. C. Y., & Chan, T. W. (2019). Enhancing achievement and interest in mathematics learning through Math-Island. *Research and Practice in Technology Enhanced Learning*, *14*(1), 1–19. https://doi.org/10.1186/s41039-019-0100-9

Zales, J. P., & Vasquez, R. S. (2022). Learning styles and achievement in geometry. *South Florida Journal of Development*, *3*(4), 5542–5548. https://doi.org/10.46932/sfjdv3n4-117