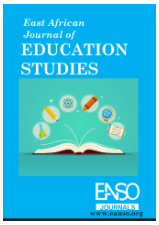

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Original Article

Effect of Learning Styles on Students' Performance in Mathematics at Ullo Senior High School, Jirapa Municipality, Ghana

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Learning Style, Divergent, Assimilative, Accommodating, Convergent, Trigonometric.

ABSTRACT

This research aimed to examine how different students' learning styles impact mathematics performance at Ullo Senior High School in the Jirapa Municipality, Ghana. The research was quantitative and used both descriptive surveys and quasi-experimental designs. Eighty-two (82) participants, including 48 males and 34 females, were selected using simple random sampling. Assimilating, converging, diverging, and accommodating students were distinguished and categorised using Kolb's (2005) learning style inventory. The Pre-test and post-test data in trigonometry were analysed using descriptive statistics and one-way Analysis of Variation (ANOVA). The data collected from the questionnaires was analysed using means and standard deviations. Post-test results revealed a statistically significant improvement in learners' performance. Therefore, it was recommended that the provision of teaching and learning resources, learners' active participation in lessons, and the use of different teaching methods serve the learning style needs of learners.

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INTRODUCTION

The study of mathematics is crucial to the growth of any economy. As Harbor-Peters (2001) pointed out, mathematics is still the fulcrum upon which all genuine scientific endeavours must turn. If mathematics is taught well, students will learn the skills they need to succeed in the real world. Therefore, learning mathematics is essential to the success of the learner in modern society, as indicated in the Core Mathematics Teaching Syllabus (2010). The learner's preferred learning method is a complicated factor that profoundly affects their success. Particularly, learners' success in math is influenced by their learning preferences.

A learner's learning style shows how they focus on what they are to learn to remember complex material (Silas, 2013). Every person has a unique way of learning. So, it is important for mathematics teachers to figure out what will capture students' attention, how to keep it, and how to work with his or her unique processing mode to improve memory and recall. As learning is more effective when students take responsibility for their own learning and give the learning process a purpose (Nzesei, 2015), it is important for teachers to comprehend how students learn differently. Individual students interact with their surroundings when learning. They digest information in their own unique ways and therefore, need learning environments that reflect their learning styles. Therefore, creating learning environments that reflect students' learning styles should be of focus in maximising student learning (Singh, 2017).

Teachers can benefit from learning about their students' preferred learning strategies to better accommodate their needs. Students can benefit more from their teachers if the instructional practices cater to their preferred learning methods so that they retain more of what they are taught (Brady, 2013). Anyamene and Odalanu's (2022) review of the literature revealed that learners' low achievement and motivation are often the results of schools' and teachers' failure to account for individual learning preferences. In many circumstances, neither students nor teachers are aware that learning challenges may not be caused only by the subject matter but also by the individual's learning style. Akinbobola (2015) and Ibeh (2015) maintain that students' academic performance might be enhanced if appropriate learning style factors are considered while creating any learning or instructional process. School mathematics curriculum developers are aware that students have different learning styles and have structured the teaching syllabus to provide space for teachers to cater to their student's individual needs**.**

According to some educators (Davadas & Lay, 2020), many factors cause senior high school students to struggle academically in mathematics. Some of these variables are the students' learning strategies, talents, attitudes, and perceptions. Haciomeroglu (2017) argues that many of these factors that cause students to struggle with mathematics originate from home. The home-based factors make it challenging for educators to implement meaningful change and control. According to Tomlinson (2001), a conducive learning environment that can respond to the learner's unique needs requires teachers to be adaptable, creative, and responsible. Theoretical and empirical reasons exist to support a shift toward instruction that considers each student's unique readiness, interest, and learning profile. However, recent studies suggest that an individual's learning and application styles are crucial factors when considering education as a whole (Joy & Kolb, 2009). Studies over the past indicate that the nature and quality of learning and development resulting from instruction depend on the interactive process between the individual student and the teacher (Adunola, 2011; Ayeni, 2011).

In recent years, educators in the field of mathematics have paid increasing attention to individual learning styles and their impact on their mathematical achievement (Adeniji, 2015). The correlation between students' preferred methods of learning and their mathematical abilities has been the subject of much study (Silas, 2013).

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Researchers sought to determine whether one learning style is better than another (Ma & Ma, 2014) or whether certain countries have learning style preferences (Middleton et al., 2013). Research findings indicate that students' study habits are influenced by their preferred learning styles (Esian-Donkor & Bentil, 2017). Dunn et al. (2009) demonstrated that learning styles affect academic achievement and influence students' behaviour and attitude toward learning.

Although there has been a great deal of research into students' learning styles in Ghana, not much has been done on the effects of learning styles on students' mathematics performance in senior high schools in the Jirapa Municipality. Hence, investigating the effects of the learning styles on students' mathematics performance at Ullo Senior High School in the Jirapa Municipality will open a new window into the way students learn to improve their performance in mathematics.

Research Questions

- What are the learning styles of Ullo SHS students in learning mathematics?
- What is the effect of the identified mathematics learning styles of Ullo SHS students on their performance?

Hypothesis

H_0: There is no significant difference in the students' learning styles and performance in Mathematics.

THEORETICAL REVIEW

According to Curry (1990), till now, 21 models of learning styles have been researched in educational literature. One of the most popular frameworks for identifying a person's preferred method of learning is Kolb's (1984) model, which is grounded in the "Experiential Learning Theory," and it serves as a point of departure for this study. The model proposed by Kolb (1984) suggests that new knowledge is formed through the integration of experience. According to David Kolb's Experiential Learning Theory model (Kolb, 1984), which served as the basis for the development of the learning styles inventory, learning is a dialectic process that integrates experience and concept, observations, and action and takes place in a wide range of contexts and throughout an individual's life.

Kolb (1984) proposed a learning style inventory derived from experiential learning theory and argued that people's learning styles are stable over time and thus, unlikely to change. The learning cycle that forms the basis for Kolb's four-stage model shows how experience can be transformed into concepts through reflection, which can then be used as a guide for active exploration and the selection of new experiences. Kolb (1984) outlines four stages of learning: concrete experience (CE), reflective observation (RO), abstract concept formation (AC), and active experimentation (AE). Kolb (1984) identified four distinct learning styles: the divergent learner, the assimilating learner, the accommodating learner, and the converging learner.

Learners with an assimilating learning style, according to Kolb (1984) and Kolb et al. (2001), have the dominant learning capacities of abstract conceptualisation (AC) and reflective observation (RO). This approach to education is particularly effective when it comes to taking in a wide variety of concepts and distilling them into clear, concise statements. Individuals who learn best through this mode enjoy reading, listening to lectures, exploring analytical models, and taking time to reflect on what they have learned in informal settings. Converging learners, as described by Kolb (1984), excel primarily using abstract conceptualisation (AC) and active experimentation (AE). Finding real-world applications for abstract concepts is where this learning style shines. Convergent learners are more comfortable tackling technical challenges and tasks than social and interpersonal issues. Individuals with this learning style thrive in classroom settings that allow them to play with and test out a variety of learning tools, including simulations, laboratory projects, and real-world applications.

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According to Kolb et al. (2001), students with diverging learning styles rely primarily on either concrete experience (CE) or reflective observation (RO). To learn effectively, those with this learning style need to be able to step back and examine situations from various angles. A student who learns in a more divergent fashion excels in creative environments like brainstorming sessions. They focus on the arts because they are people-oriented, creative, and emotional. According to Kolb et al. (2001), an accommodative learner relies primarily on two methods: concrete experience (CE) and active experimentation (AE). These students benefit most from "hands-on" instruction and opportunities to use their knowledge in practical ways. They take pleasure in seeing their plans through and taking on a difficult task.

MATERIALS AND METHODS

Research Design

The study adopted a one-group pre-test-post-test quasi-experimental design to investigate the effects of learning styles on students' mathematics performance, informed by a quantitative methodology. Quantitative research entails collecting and analysing numerical data to describe, explain, predict or control a phenomenon of interest (Gay et al., 2009). The positivist worldview served as the philosophical model for this research. The positivist epistemological stance relies on objective facts and empirical observation rather than one's own biased beliefs (Bryman, 2011).

Population and Sample Procedure

The study population was 1008, with a sample frame of 410. The study used two sampling procedures: purposive sampling and simple random sampling. The participating school's mathematics performance over the years has been very poor. Hence, the school was purposefully selected for the study. Furthermore, a simple random sampling technique was used to select four intact classes from among the nine from two classes. This gave a total of 82 sample participants. Students in Form 2 were selected because students in Form 3 were busy studying for their final exams when the researcher arrived at the school, and their activities could have obscured the progress of the research. Students in Form 2 would also have completed more of the mathematics curriculum by this point than their Form 1 counterparts.

Instruments

Two instruments, namely the Structured Learning Style Questionnaires or the Learning Style Inventory and the Trigonometric Achievement Test (TAT), were used to collect data for the study.

The study adapted Kolb's (2005) Learning Style Inventory (LSI) to categorise students' preferred learning styles. Kolb's LSI consisted of 32 items on the inventory of one's learning habits, with eight items on each of his four learning modalities. The survey instrument was a 4-point Likert scale, with 1 representing a strong disagreement, 2 representing a disagreement, 3 representing an agreement, and 4 representing a strong agreement. Students were instructed to mark each option according to their level of agreement to complete the inventory. Each student was then assigned to one of four learning style groups based on where they scored highest: convergent, divergent, assimilative, or accommodating.

To determine if students' mathematics performance varied significantly according to their preferred learning strategies, a pre-test and post-test on trigonometry were developed. Since trigonometry is a mandatory part of the senior high school mathematics curriculum and students typically struggle with it, tests on the subject were administered. Ten items in the trigonometry achievement test were designed for the participants for both the pre-test and the post-test. The questions were self-constructed to reflect concepts of the topic trigonometry in the Core Mathematics curriculum. The items were developed based on the profile dimensions indicated in the curriculum and Bloom's taxonomy of learning domains. The items were given to experts, such as mathematics teachers

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and lecturers, to make inputs and ensure content and face validity. Participants' responses to the test items were scored, grouped, and coded as follows: 1 = 1–5; 2 = 6–10; 3 = 11–15; 4 = 16–20; 5 = 21–25; 6 = 26–30. The scores of the participants were coded because of the large size of the sample (82) as well as the high value of the total score (30). A mean score above 3.5 (i.e., [1 + 2 + 3 + 4 + 5 + 6]/6 = 3.5) shows the better performance of a student in the test, while a mean score below 3.5 indicates low performance. The test questions required students to demonstrate their knowledge and ability to apply that knowledge in real-world scenarios through short answers. Every item on the test had to be answered in the spaces provided. Each item ended with a notation of how many points were awarded for that item.

Data Collection Procedure

The researcher first sought permission from the headmaster of the participating school. The school's headmaster gave the researcher permission to administer the questionnaires to participants in person. Using Kolb's (2005) Learning Style Inventory, all of the participating students were divided into four groups during the first week of the study, each corresponding to a different learning style. Students were then given a pre-test to gauge their trigonometry knowledge. The researcher spent two weeks teaching Trigonometry to each learning style group using the most effective methods for each style. The fourth week was dedicated to the post-test for the various learning styles, and all participants' test scores were recorded.

The researcher has been a high school mathematics teacher for some time, so he successfully taught trigonometry to the four different learning styles over two weeks. Different approaches to teaching math were used for each of the four distinct learning styles. The majority of the questions were presented to the entire learning style group in the form of scenarios posed by the researcher. They reacted according to their preferred mode of learning. Both types of students routinely checked with one another to double-check their answers before providing them to the researcher. However, students who were converging and assimilating were able to answer without relying on the input of others.

In addition, the convergent learners desired additional practice problems and information on how a particular problem was solved. When working with students who have a converging learning style, the researcher took on the role of a mentor, providing them with hands-on instruction and constructive criticism through a demonstration approach. These students engaged in independent work on their assignments. The students with diverging learning styles wanted to know the reasoning behind the solution to a problem. The researcher encouraged the student participants to use whatever strategy they found most effective for solving the problems at hand, so long as they reached the correct conclusion and presented their rationale.

Kolb et al. (1993) indicated that open-minded students enjoy making plans, completing assignments, and taking part in experiential learning activities. In almost every class session, the researcher posed questions to the students in this group to provide their analysis of a question they were given. The students participated in group projects that required them to solicit and evaluate the input of their peers. Assimilating students often ask probing questions during a lesson's presentation, so the researcher played the role of an expert by walking them through the steps necessary to solve the problem at hand before assigning them independent work. Assimilating students often ask probing questions during a lesson's presentation, so the researcher played the role of an expert by walking them through the steps necessary to solve the problem at hand before assigning them independent work.

Data Analysis

The Statistical Package for Social Sciences (SPSS) version 23 was used to analyse the data. Descriptive statistics such as frequency and percentage were used to identify students' learning styles. Descriptive statistics (mean and

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standard deviation) and inferential statistics (ANOVA) were further used to analyse the responses from the Trigonometric Achievement Test (TAT). The ANOVA was used since there were more than two independent groups (learning styles) and one dependent variable (scores of learners).

RESULTS

The Different Learning Styles Used by Students in Mathematics

Four-point Likert scale-type statements were provided based on Kolb's (2005) Learning Styles Inventory (32 items) for participants to indicate their level of agreement with the statements to identify the learning styles of Ullo Senior High School students in mathematics. Descriptive statistics (frequency and percentage) were applied to participants' responses, and the results are presented in *Table 1*.

The results in *Table 1* show that 29 students, representing 35.4%, were accommodating learners, while 20 students, representing 24.4%, were assimilating learners. Also, 18 students, representing 22.0%, were converging learners, and 15 (18.3%) were divergent learners. This implies that the majority of the students employed accommodating learning styles in learning mathematics, as indicated in *Table 1*.

Table 1: Mathematics Learning Styles of Students in Ullo Senior High School

Learning Style	F	%
Assimilating	20	24.4
Converging	18	22
Diverging	15	18.3
Accommodating	29	35.4

Source: Field data (2022)

Effect of the Identified Learning Styles on the Senior High School Students on their Performance in Mathematics?

Mathematics pre-test and post-test scores were compared to identify the effect of learning styles on student outcomes. *Table 2* shows the descriptive statistics (mean and standard deviation scores) of student's pre-test results on the different learning styles employed in learning the concept of Trigonometry in Mathematics.

Table 2: Pre-test results of learners with different learning styles.

Learning Styles	N	M	SD
Assimilating	20	1.35	0.59
Converging	18	2.22	0.81
Diverging	15	1.87	1.25
Accommodating	29	1.86	1.55

Source: Field data (2022)

The results in *Table 2* show that all the participants in the four learning styles had scores below the average mean score of 3.5 in the pre-test. This shows that students performed poorly in learning the concept of trigonometry based on their pre-test results. The assimilating learning style learners (M = 1.35, SD = 0.59) and the converging learning style learners (M = 2.22, SD = 0.81) are less dispersed. Furthermore, the performance of diverging (M = 1.87, SD = 1.25) and accommodating learning style learners (M = 1.86, SD = 1.55) is spread out.

After teaching participants Trigonometry based on their learning styles as a form of intervention, descriptive statistics (mean and standard deviation) were further used to analyse participants' responses, and the results are presented in *Table 3*.

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Table 3: Post-test results of learners in the different learning styles

Learning Styles	N	M	SD
Assimilating	20	2.15	0.99
Converging	18	4.50	1.20
Diverging	15	3.33	1.72
Accommodating	29	3.86	1.65

Source: Field data (2022)

The mean score of the four learning styles groups in the post-test ranged from 2.15 to 4.50, while the standard deviation ranged from 0.99 to 1.72. The results in Table 3 show that the converging learning style learners (M=4.50, SD=1.20) and the accommodating learning style learners (M = 3.82, SD = 1.65) had mean scores greater than the average score of 3.5 in the post-test, which reveal their improved performance in learning the concept of Trigonometry in mathematics. This implies that the accommodating learning style learners performed better than the converging learning style learners. However, the assimilating learning style learners (M=2.15, SD=0.99) and the diverging learning style learners (M=3.33, SD=1.72) had mean scores of less than 3.5 revealing their poor performance in learning the concept of Trigonometry in mathematics, though the scores of the assimilating learning style learners are less spread out than the diverging learning style learners.

H_0: There is no significant difference in the students' learning styles and performance in Mathematics.

The results in *Table 4* show the Analysis of Variance (ANOVA) results of students' pre-test means scores of their learning styles in learning Trigonometry at a .05 significant level.

Table 4: ANOVA results of the pre-test mean scores of students' learning styles on their performance

Sources of Variation	SS	Df	MS	F	P
Between Groups	7.4	3	2.47	1.804	.153
Within Groups	106.84	78	1.37		
Total	114.24	81			

Source: Field data (2022)

The results in *Table 4* show that there was no statistically significant difference (p >.05) between students' learning styles and their academic performance in trigonometry, F (3, 78) = 1.804, p =.153. This shows that the pre-test scores did not differ significantly across the various learning strategies. Pre-test results were comparable across all four groups. As a result, the pre-test scores did not differ significantly across the various learning strategies. After the intervention, analysis of variance (ANOVA) results of the students' post-test means scores of their learning styles in learning the concept of trigonometry at a significant level of .05. was analysed as shown in *Table 5*.

Table 5: ANOVA statistics of the post-test means scores of students' learning styles on their performance

Sources of Variation	SS	Df	Mean Square	*F*	*P*
Between Groups	57.930	3	19.310	9.383	.000
Within Groups	160.521	78	2.058		
Total	218.451	81			

Source: Field data (2022)

The results in Table 5 show that there was a statistically significant difference (p < .05) between the students' learning styles and their academic performance in Trigonometry, F (3, 78) = 9.383, $p < .05$. As a result, there was a statistically significant difference between the

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students' mathematics performance and their preferred learning styles.

In addition, the researcher used the Scheffe test ratio to determine which sets of means differed statistically significantly at the .05 level. Table 6 shows the results of the comparison of six sets of means from the post-test mean scores using the Scheffe test ratio at a .05 significant level.

Table 6: Comparisons of pairs of means in the post-test

Mean	Scheffe Test	Pair of the mean being Compared	Conclusion
$\bar{x}_1$=2.15 And $\bar{x}_2$=4.50	F_1= 2.35 Fcritical=2.72	Assimilating and Converging ($F_1 <$ Fcritical)	Learners who were Assimilating and those who were Converging did not differ significantly in their performance.
$\bar{x}_1$=2.15 and $\bar{x}_3$=3.33	F_2= 1.18 Fcritl=2.72	Assimilating and Diverging ($F_2 <$ Fcritical)	The performance of the Assimilating and Diverging learners did not differ significantly.
$\bar{x}_1$=2.15 and $\bar{x}_4$=3.83	F_3=1.68 Fcrit=2.72	Assimilating and Accommodating ($F_3 <$ Fcritical)	Performance between the Assimilating and Accommodating students was not significantly different.
$\bar{x}_2$=4.50 and $\bar{x}_3$=3.33	F_4= 1.17 Fcrit= 2.72	Converging and Diverging ($F_4 <$ Fcritical)	There was no statistically significant difference in performance between Converging and Diverging students.
$\bar{x}_2$=4.50 and $\bar{x}_4$=3.83	F_5=0.67 Fcrit= 2.72	Converging and Accommodating ($F_5 <$ Fcritical)	There was no significant difference in the Converging and Accommodating learners' performance.
$\bar{x}_3$=3.33 and $\bar{x}_4$=3.83	F_6= 0.49 and Fcrit= 2.72	Diverging and Accommodating ($F_6 <$ Fcritical)	The performance of the Diverging and Accommodating students did not differ significantly.

Source: Field Data (2022)

The results in Table 6 reveal that the Scheffe Test ratios for all the post-test pairs of means (F_1 , F_2, F_3 , F_4 , F_5, and F_6) were less than the F critical (3, 78) = 2.72 at a significant level of .05. This means there is no statistically significant difference between any of the six sets of means. As a result, despite having different approaches to learning, the six sets of learning styles were remarkably similar in terms of overall performance.

DISCUSSION

Kolb's (2005) learning style inventory was used to determine the participants' preferred information intake and retention methods. Based on a straightforward explanation of the learning cycle, Kolb's four-stage model (assimilating, converging, diverging, and accommodating) demonstrates how thinking about and talking about one's experiences leads to the formation of new concepts that can be used to direct further exploration and the selection of additional ones. The findings of the study revealed that the majority of the students employ the accommodating learning style 29 (35.4%), followed by the assimilating learning style 20 (24.4%), and the converging learning style 18 (22%). Divergent learning style learners aged 15 (18.5%) were found to be the least. This research's findings contrast with Silas's (2013) study, which revealed that 15 students had a diverging learning style, 16 were convergent, 17 were assimilative, and 15 were accommodating.

On the effect of students' learning styles on their performance in mathematics, the findings of the study indicated that there was no statistically significant difference ($p > .05$) between the learners' performance and their learning styles in the pre-test. Pre-test results were comparable between the four groups representing the different learning styles. The results of the mean scores of the post-test after the intervention revealed that the converging learning style learners (M = 4.50, SD = 1.20) performed better with a high mean

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score (greater than 3.5) than the other learning style learners, with the assimilating learning style learners (M = 2.15, SD = 0.99) receiving the lowest mean scores. These results collaborate with the findings of Silas (2013), who indicated that converging and accommodating learners perform better than assimilating and diverging learners.

There was a statistically significant difference (p.05) in students' performance in mathematics based on their preferred methods of learning, as determined by an analysis of variance of their post-test mean scores. The results confirmed the findings of Silas (2013) and Esian-Donkor et al. (2019), who indicated that learners' learning styles significantly affect their academic performance. Converging and accommodating learners, as identified by Kolb (2005), are curious about the impact of their ideas in real life. The study participants who demonstrated a convergent and accommodating learning style were allowed to do so. The students' exceptional performance in mathematics may be attributable to the teaching methods used with the convergent and accommodating students.

CONCLUSION AND RECOMMENDATIONS

Students' participation in mathematics classroom teaching and learning activities affected their performance positively in the trigonometry achievement test. Their post-test scores were higher than their pre-test scores. Teachers can better meet their students' learning goals by considering their needs in preparing their lesson plans and pedagogical approaches to their students' learning styles if they have a firm grasp on those styles.

It is recommended that mathematics teachers plan mathematics lessons that involve different teaching strategies to meet the needs of learners' learning styles. Thus, mathematics instructors should get the requisite experience and training in adapting lessons to accommodate a variety of students' preferred methods of learning in the mathematics classroom. Also, mathematics teachers should provide the opportunity for learners to participate in or engage in mathematical activities in the classroom. This will reveal the best way for the learner(s) to learn mathematics. The classroom environment should be conducive enough to incorporate the varied views of learners, which will enable the mathematics teacher to uncover their learning styles. It is suggested that further studies be conducted on the effect of teachers' teaching methods on students' learning styles and performance in mathematics.

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