Mathematics Learning Style and Achievement of Secondary Level Students

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Abstract

This paper investigated the preferred learning style and learning achievement of secondary-level mathematics students across various branches of school-level mathematics, including arithmetic, algebra, and geometry. This paper also analyzed the relationship between preferred learning styles and their learning achievement in mathematics. The study used a survey questionnaire among fifty grade X students from two community schools out of ten in the Bheri Municipality of Jajarkot district. For this study, a learning style questionnaire developed by Cynthia A. Arem based on Neil Fleming's VAK model was adopted, and students' learning achievement was analyzed. The majority of students preferred a visual learning style, followed by kinaesthetic and auditory learning styles, when learning school-level mathematics. The students' preferred learning styles aligned with those of arithmetic, algebra, and geometry. The result shows that there is a relationship between the students' preferred learning style and their academic achievement. According to the study, teachers should tailor their teaching plans to their students' learning styles in order to improve school-level mathematics performance.

Keywords: Preferred learning style, learning achievement, auditory learning style, visual learning style and kinaesthetic learning style

Introduction

Learning is a method of gathering information and knowledge about specific phenomena, as well as a tool for changing people's behavior. "Learning styles" refer to the strategies employed to acquire knowledge. Students' preferred learning methods are their learning styles, which they use in all learning contexts (Hadriana et al., 2019). Teaching styles refer to the behavior, beliefs, and selected instructional methods teachers use to present lessons to students (Chetty et al., 2019). Because there is such a wide range of teachers' teaching and students' learning styles, there will be some overlap and misalignment between the teachers' teaching styles and the students' learning styles (Chetty et al., 2019). Students' learning styles do significantly influence their academic achievement (Jilardi-Damavandi et al., 2011). In the present context, more than 70 learning styles have developed based on students' learning habits (Dantas & Cunha, 2020) on the basis of the students' learning habits.

The students' average achievement score in mathematics at the school level is very poor. NASA (2013) concludes that the average achievement score of Grade 8 students in mathematics is 35%, that learning achievement is lower in algebra (27%), and geometry (34%), and that students' ability to solve complex problems in mathematics is low. The students faced difficulty translating the abstract mathematical content into algebraic terms. The NASA report (2015) states that the average learning achievement in mathematics for grade 3 students was more than 60% in 2012, but in 2015 it was 45% (ERO, 2020). Grade 5 students' average achievement is also less than 60%. Grade 8 students' average achievement in mathematics is lower than others (pp. 9, 24). The aforementioned report indicates a decrease in the students' mathematical learning achievement, highlighting the need for

improvement. In this context, students' learning styles and teachers' teaching styles play a significant role in the student's academic achievement (Bosman & Schulze, 2018). Because a student's learning style is a collection of cognitive, affective, and psychological qualities that serve as generally reliable markers of how a learner sees, interacts with, and responds to the learning environment (Jr. & Cruz, 2020), what learning styles do your students have, and how does the teacher use teaching styles in school-level mathematics? It is essential to find it. So, what is the relationship between students' learning styles and their learning achievement, and how can we develop students' different skills?

If we do not know their learning styles, we have difficulty meaningfully teaching mathematics to students at the secondary level. Teachers will create learning activities (teaching styles) based on the students' learning styles (Kopsovich, 2001). The students' learning styles match the teachers' teaching styles. Teachers' teaching styles should match the students' learning styles. If the teacher's teaching style and the students' learning style diverge, it can adversely affect the students' academic performance. In this context, what strategies can enhance the student's mathematical proficiency? What is the relationship between students' learning styles and teachers' teaching styles? What are the learning styles of students and teachers for secondary-level mathematics in Nepal? Are there any emerging student learning styles or models that incorporate 21st-century skills to enhance mathematical performance? Is a higher-achieving student's learning style different from that of a low-achieving student? In Nepal, these questions have remained unanswered until now. So, the researcher is going to investigate and find the answer to these questions.

This paper examines secondary-level students' preferred learning style and learning achievement. Specifically, the study aimed to address the following two research questions:

1. What are the preferred learning styles of the students in learning mathematics (arithmetic, algebra, and geometry)?
2. What is the relationship between students' preferred learning style and learning achievement?

Literature Review

This section examines some of the most relevant research on students' learning styles and their academic performance in secondary-level mathematics. This section includes the existing knowledge, the knowledge-gaining process, and updates to the knowledge that has been practiced.

The researchers reviewed the learning styles of students, the teaching styles of teachers, and the learning achievements of students in secondary-level mathematics.

Students learning styles

Every individual is different, and their learning styles are also different, because Dantas and Cunha (2020) stated that there are more than 70 learning styles. Experts have carried out many studies related to learning styles, and many opinions have also been raised on learning styling. According to Hawk and Shah (2007), at least six types of well-known learning style models exist. Examples of learning style models include the Gregorc Learning Style Model, Kolb Experiential Learning Model, Felder and Silverman Learning Style Model, Dunn and Dunn Model, VARK Model, and RASI Model (Hawk & Shah, 2007). The VAK model became popular among these six learning-type models due to its face validity, simplicity, and convenience (Xia, 2020). Students who fit the VAK learning style model fall into one of three categories. Visual learners, also known as aural learners, are those who learn by sight, such as by reading and analyzing charts, diagrams, or recordings. Hearing lectures, for example, is an example of learning by listening to learners who can read and write.

Kinaesthetic learners, learning activities include physical exercises and movements, as well as direct learning.

Various literary works contain sections that pertain to the learning styles and achievements of students. The researcher discusses some related studies on students' learning styles and achievements here.

Chetty et al. (2019) conducted a quantitative study on how learning styles and teaching styles determine students' academic performances. The study found that the majority of the students preferred the individual learning model, and the teaching style had a significant impact on the students' learning styles and learning achievement.

Pradhan (2021) conducted a qualitative study of mathematics teachers and students who study Learning Strategy in Mathematics Instruction: Teachers' Perceptions and Practices for the School Level. The research findings indicate that assessment for learning strategy (AFL) helps to improve the learning and teaching of mathematics, motivate the students, and develop a positive attitude toward learning mathematics.

Kusumawati, Nayazik, and Hajaro (2021) examine David Kolb's learning style and students' mathematical representation abilities. They found that students with an assimilator learning style have higher mathematical representation, students with a convergent learning style have medium mathematical representation, and students with a divergent learning style have low mathematical representation. It shows that teachers should motivate the students to follow the assimilator learning style and conduct the teaching and learning activities in association with this learning style.

Lawal and Ojoawo (n.d.) investigated how learning style, school type, and discipline correlate with mathematics achievement in Alimosho Local Government, Lagos State, Nigeria. The research found that the majority of students are visual, audio, and kinaesthetic

learners, respectively. They conclude that there is a stronger positive correlation between visual and kinaesthetic learning styles and students' mathematical achievement, compared to auditory learning styles.

Schuze and Bosman (2018) conducted a quantitative study of 240 South African learners from one secondary school. They stated that individual learning styles were positively correlated with the students' mathematical learning achievement. Significant positive inter-correlations were found between individual learning styles, auditory learning styles, kinaesthetic learning styles, and group learning, indicating that multi-modal learners excelled in mathematics.

In their research paper "Mathematics learning strategies of high school students in Nepal", Khanal, Panthi, Kshetree, Acharya, and Belbase (2021) discovered that Nepalese high school students employ nine types of learning strategies. 25% of students used peer learning strategies; another 21%, 14%, 11%, 9%, 2%, and 2% used elaboration, help-seeing, effort management, rehearsal, organization, study management, metacognition, and critical thinking learning strategies, respectively. In mathematics learning, Nepalese high school students preferred meta-cognition and critical thinking learning strategies the least.

Teachers Teaching Styles and Students' Learning Styles

Traditional teaching methods have changed dramatically over the past century due to social, cultural, and technical advancements. Since the 1950s, psychologists have studied the characteristics of various styles, including cognitive, thinking, teaching, and learning styles, as well as their effects on performance in both academic and non-academic situations (Gafoor, 2017). Five distinctive teaching styles have emerged as the primary tactics used by modern teachers in the classroom. The Authority Style, Delegated Style, Facilitator Style, Demonstrator Style, and Hybrid Style are examples of leadership styles (Grasha &

Yangarber-Hicks, 2000). We cannot rely on student variance since teaching approaches change at the class level rather than at the subject level. We can't take advantage of within-teacher variation. As a result, we undertook a detailed analysis to determine whether school sorting is a factor in the outcomes (Cardino & Ortega-Dela Cruz, 2020) and found no evidence of teacher, student, or instructional style selection within the institution. Teacher's teaching styles and students learning styles and strategies should be matched for the better performance in mathematics (Khanal, 2011, 2015).

Students' Learning Styles and Achievement in Mathematics

Mathematics achievement is a crucial indicator of a country's educational system's performance. Demographic variables such as gender, culture, age, and school topic influence learning styles. Hence, learning styles and achievement are not straightforward. As a result, a learning style that works well for English or history may not work well for mathematics (Chetty et al., 2019). The lack of research is evident in the areas of learning styles and academic achievement. Educational psychologists must understand how different learning styles affect students' academic performance in different nations in order to design effective learning and academic achievement interventions (Gafoor, 2017). The philosophy of mathematics education is concerned with how to teach mathematics to students in an effective and genuine manner. Rahman and Ahmar (2017) found that women dominate visual and auditory learning styles. There is no correlation between learning style factors, genders, and the interactions of learning styles with learning achievement.

This brief review outlined the various learning styles that students employ when studying school-level mathematics. Some claimed that students' learning achievement was dependent on their learning style, while other researchers found no correlation between students' learning style and their own. Previous research focused on learning styles in general

mathematics, without specifically addressing arithmetic, algebra, or other branches of school-level mathematics. In this context, this study explores the types of learning styles of school-level learners and the relationship between students' learning styles with regard to arithmetic, algebra, and geometry in school-level mathematics.

Theoretical Framework

In this study, the researchers have considered constructivism, connectivism and experiential learning theories.

Constructivist Learning Theory

Learning how to learn is the central part of the educational process. Constructivism is a learning theory that refers to the idea that learners construct knowledge themselves through their efforts (Hein, 1991). Constructivists motivate students to share their ideas, expand their knowledge by using their experiences, think critically about new ideas and experiences, reflect upon changing some of their ideas, and create a meaningful learning environment (Huang, 2002; Jonassen, 1999). A constructivist view of learning focuses on learners constructing, reconstructing, and deconstructing their understanding of world phenomena, as well as reflecting on those experiences. For this, students must ask questions, explore, and assess what they know. Constructivist theory states that knowledge is not transmitted from one person to another, but rather that it occurs through the process of learning by doing. Glasserfeld (1980) bases constructivism on the idea that learners actively construct their own knowledge, not as passive recipients. It assumes that students construct knowledge based on their previous experiences and interactions with the environment, and that the constructivist teacher acts as a facilitator rather than a knowledge provider. What method do they use to learn mathematics? What are the learning styles of the students? The students' understanding of style construction depends on their individual learning styles.

Connectivism

Connectivism is a new learning theory that emphasizes integrated and collaborative learning using technology. George Siemens is the founder of this theory, and according to Siemens (2004), "Connectivism is the theory of the digital age (p. 3)." Connectivism argues that learning occurs through network connection, in which individuals share their interests, knowledge, perspectives, expertise, and opinions in an online or virtual environment. It emphasizes an integrated approach to learning and defines it as actionable knowledge. According to Siemens (2004), learning depends on the diversity of opinions, and learning is the process of connecting special sources of information to develop a new concept. Siemens (2005) emphasizes that learning might be done with non-human tools and that the capacity to know something new is more critical than the previous one. Connectivism refers to new developments in digital technology that are suitable for other aspects of learning, such as learning in the conventional environment or classroom, distance learning, and e-learning. According to Kop and Hill (2008), the distribution of knowledge across a network of connections, also known as connective knowledge, necessitates the ability to build and navigate these networks for learning. Connectivism presents itself as a pedagogical approach that affords learners the ability to connect via social networking or collaboration tools. Therefore, this study is related to connections. The main components of virtual learning are some basic connective features, such as the digital age, collaborative approaches, and social networking.

Experimental Learning Theory

Learning theory describes the learning process or how students learn (McCarthy, 2010), and he describes the four learning approaches, which are personality, information processing, social interaction, and instructional preference. Kolb's explains and develops the

experiential learning theory with a four-stage learning model: concrete experience (CE), reflective observation (RO), abstract conceptualization (OC), and active experimentation (AE) (Healey & Jenkins, 2000). Experience is the heart of learning, and experiential learning happens through informal, non-formal, and formal processes (Hedin, 2010). According to the above arguments, the researchers used Kolb's Learning Style Inventory to collect data and explain the students' learning styles in school-level mathematics.

Methods and Procedure

A post-positive paradigm served as the study's guide. The researcher conducted the study using a descriptive-correlational survey design. For this study, the researcher selected Bheri Municipality of Jajarkot as the research site. Ten community schools are located in Bheri Municipality, and among them, researchers randomly selected two community schools and fifty students from these sampled schools. The researcher selected twenty-five students from each school. For this study, the students' learning style is an independent variable, and their learning achievement in mathematics is a dependent variable.

In this study, a learning style questionnaire developed by Cynthia A. Arem based on Neil Fleming's VAK model was adapted. The questionnaires consisted 30 items to categorize respondents into visual, auditory, and kinaesthetic (VAK) learners. The questionnaire had three rating scales: seldom/never, sometimes, and often, which provided the numbers 1, 2, and 3, respectively. The researchers developed mathematics achievement test based on the specific grid of grade X mathematics curriculum of the curriculum development center and conducted a test with the sample students by the first author in the sample school. The test items include 50 marks for knowledge, comprehensive application, and a higher ability level, which covered arithmetic, algebra, and geometry portions. The adopted questionnaire was reliable and valid because the Cronbach's α was greater than 0.70. Researcher sought input

from two mathematics teachers for the validation of the mathematics achievement test. Researchers calculated the Spearman's rho correlation (split-half method) of the achievement test item to assess its reliability, and found a positive correlation of r = 0.675. This shows that the questionnaire and achievement test were valid and reliable.

In this study, the first author administered the learning style questionnaire to the students by gaining the permission from the school administration and collected them. The author conducted the mathematics test with the sampled students and checked the answer sheets and recorded the marks obtained by the sample students. The researchers employed a widely used statistical package for social science (SPSS, version 27) for data analysis (Cohen, Manion, & Morrison, 2019). This study used a sample size of 50, less than 2000, and employed the Shapiro-Wilk test to verify the normality of the questionnaire and the learning achievement of the students.

Table 1

Normality Test of Data

Tests of Normality

	Shapiro-Wilk		
	Statistic	df	Sig.
Students Learning Achievement	.969	50	.202
Questionnaire Items (30)	.923	50	.003

The significant value of all 30 items in the questionnaire is less than the p-value (0.003 < 0.05), which indicates that the questionnaire data were not normal. Similarly, the students' learning achievement in mathematics was considered normal as the sign value exceeded the p-value (0.202 > 0.05). However, non-parametric statistical data analysis

methods were employed to analyze the data, which were frequency, percentage, mean, and Spearman correlation.

Results

The results of the study are presented in the following sections based on the research questions.

Students' preferred learning style

The research question is: What are the preferred learning styles of students in mathematics (arithmetic, algebra, and geometry)? The researcher presented the categorical data to investigate the students' preferred learning styles and analyzed the three sectors of arithmetic, algebra, and geometry. Table 2 presents the results of the data analysis.

Table 2

Students Learning Style Based on Different Branch of School Level Mathematics

Descriptive Statistics

Learning Style	N	Arithmetic Mean	Algebra Mean	Geometry Mean	Mathematics Mean
Visual	50	2.6160	2.5300	2.5020	2.549
Auditory	50	2.3020	2.2040	2.1400	2.215
Kinaesthetic	50	2.4960	2.3420	2.3620	2.4

Table 2 summarizes the student's preferred learning style in mathematics, showing a mean of 2.616 visual, 2.302 auditory, and 2.496 kinaesthetic responses in arithmetic. Similarly, in algebra, the mean responses of the students were 2.530 in visual, 2.342 in kinaesthetic, and 2.204 in auditory. Like in geometry, the mean responses of the students were 2.502 in visual, 2.362 in kinaesthetic, and 2.140 in auditory. The total average responses

of the students in arithmetic, algebra, and geometry were 2.549 in visual, 2.400 in kinaesthetic, and 2.215 in auditory. Based on these data, the students' preferred learning styles in arithmetic, algebra, geometry, and mathematics were consistent, with the majority preferring a visual learning style, followed by a kinaesthetic learning style, and the least preferring an auditory learning style. The result indicates that the students' most preferred learning style is visual, followed by kinaesthetic, and lastly, auditory.

The researcher also calculated each student's unique learning style, and table 3 presents the frequency of each individual learning style.

Table 3

Learning Style Distribution by Branch of Mathematics

Branch	Arithmetic		Algebra		Geometry		Total	
	Frequency	%	Frequency	%	Frequency	%	Frequency	%
Visual	31	62	39	78	37	74	35	70
Auditory	6	12	5	10	3	6	5	10
Kinaesthetic	13	26	6	12	10	20	10	20
Total	50	100	50	100	50	100	50	100

Table 3 indicates the learning styles of the students according to arithmetic, algebra, and geometry. The same students responded to three branches of school-level mathematics. In arithmetic, 31 (62%), 13 (26%), and 6 (12%) students preferred visual, kinaesthetic, and auditory learning styles, respectively. Similarly, 39 (78%), 5 (10%), and 6 (12%) students preferred visual, kinaesthetic, and auditory learning styles in algebra. Likewise, in geometry, 37 (74%), 3 (6%), and 10 (20%) students were visual, kinaesthetic, and auditory learners. Table 3 summarizes the students' preferred learning styles in mathematics: 35 students (70%)

had a preferred visual learning style, 5 students (10%) preferred an auditory learning style, and 10 students (20%) preferred a kinaesthetic learning style. The result indicates that the students' most preferred learning style is visual, followed by kinaesthetic, and lastly, auditory. The results above indicate that the students' preferred learning styles were similar.

Students learning style and achievement

To address the second research question, what is the relationship between students' learning styles and their learning achievement in school-level mathematics? Here, the correlation between students' learning styles and their learning achievement was calculated.

Table 4

Correlation Between Students' Learning Style and Learning Achievement

Correlations

		Visual	Auditory	Kinaesthetic	Achievement
Visual	Pearson Correlation	1			
	Sig. (2-tailed)				
Auditory	Pearson Correlation	.214	1		
	Sig. (2-tailed)	.135			
Kinaesthetic	Pearson Correlation	.411**	.279*	1	
	Sig. (2-tailed)	.003	.049		
Achievement	Pearson Correlation	-.016	.209	.107	1
	Sig. (2-tailed)	.911	.146	.460	

*. Correlation is significant at the 0.05 level (2-tailed).

The visual learning style correlated negatively (r = -0.016) with students' learning achievement in mathematics, whereas the auditory and kinaesthetic learning styles correlated positively (r = 0.209, 0.107). This is in accordance with the summary of the correlation

matrix between students' learning style and learning achievement. The researcher summarized the findings as follows: students' learning style and learning achievement showed a positive correlation in the kinaesthetic and auditory learning styles, while there was a negative correlation in the visual learning style.

Discussion

The study found that students' preferred learning styles in arithmetic were visual ($\overline{X}$ =2.616), kinaesthetic ($\overline{X}$ =2.496), and auditory ($\overline{X}$ =2.302). Similarly, the majority of students preferred a visual learning style ($\overline{X}$ = 2.530), followed by a kinaesthetic learning style ($\overline{X}$ =2.342), and auditory ($\overline{X}$ =2.204) in algebra. In learning geometry, the majority of the students preferred visual learning style ($\overline{X}$ =2.502), followed by kinaesthetic learning style ($\overline{X}$ = 2.362), and auditory learning style ($\overline{X}$ = 2.140). Aggregated all the three branches of school-level mathematics learning style, the student's mean response was ($\overline{X}$ =2.549) in visual, ($\overline{X}$ =2.400) in kinaesthetic, and ($\overline{X}$ =2.215) in auditory, which indicates that the majority of the students preferred visual learning style. The findings of this study were similar to those of Chetty et al. (2019), Effendi and Amelia (2020), and Lawal and Ojoawo. They discovered that the majority of students favored the visual learning style, followed by the auditory learning style, while the kinaesthetic learning style was the least preferred. This finding contradicts the findings of this study, as the second preferred learning style is kinaesthetic, and the least preferred learning style is auditory. Students prefer the visual learning style when learning secondary-level mathematics.

This study found that the students auditory and kinaesthetic learning styles had a positive correlation (r = 0.209, 0.107), and the students visual learning style and their learning achievement in mathematics had a negative correlation (r = -0.016). Schulze and Bosman's (2018) study, which found a positive inter-correlation between students' learning

style and math achievement, but a negative correlation with visual learning style, supported the findings of this study. Altun's (2019) research revealed a significant difference between students' learning styles and their learning achievements, a finding that contradicts the findings of this study. Similarly, Adu, Pylman, and Adu (2020) discovered that students with a visual learning style demonstrated superior performance in mathematics. Lawal and Ojoawo concluded that there is a positive correlation between visual and kinaesthetic learning styles and students' mathematical learning achievement. These findings stand in stark contrast to the results of this study. The connectivism learning theory focused on digital learning, which matched the students preferred learning style, but the teaching style, learning materials, and learning environment didn't support the students learning taste. As a result of these mismatches, the student's learning achievement was negatively correlated with their visual learning style. Teachers should receive training on the learning styles of their students and tailor their instructional activities accordingly. The teaching style had an impact on students learning strategies and learning achievement (Chetty et al., 2019). Secondary mathematics education should incorporate visual media and hands-on learning activities.

Conclusion

In learning mathematics, the majority of secondary-level students preferred a visual learning style, followed by kinaesthetic and auditory learning styles. The preferred learning style across various branches of school-level mathematics closely aligns with the overall mathematical results. There is a positive correlation between students learning achievement and kinaesthetic and auditory learning styles, but a negative correlation between students learning achievement and visual learning styles. The majority of students preferred a visual learning style, and its correlation with learning achievement is negative. The researcher conducted the study in two schools with a sample of 50 students; therefore, the researcher

should not generalize the findings. This study suggests that teachers should tailor their teaching plans to the learning styles of their students and assess their academic achievement.

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