

Learning Styles and Academic Achievement of Distance e-Learning University Mathematics Students: A Case of a University in Zimbabwe

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ABSTRACT

This article reports on a study to determine whether there was a relationship between the learning styles and academic performance of university mathematics students learning through distance e-learning. 26 students studying for a Bachelor of Science degree in Mathematics and Statistics at a university in Zimbabwe participated in the study. The study revealed a statistically significant relationship between the students' learning styles and academic performance. The researcher recommended that the methods used in instructing distance learners should be designed and structured to accommodate all students despite their different learning styles. The learning content should be provided in multiple formats, allowing students to share and discuss concepts. The researcher also recommended an intentional mismatch between the mode of instruction and the students' learning styles. The mismatch helps to make the students versatile. Online workshops and seminars on using e-learning methods were also recommended to equip the students with study skills that suit their learning styles.

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1. INTRODUCTION

Distance e-learning entails students and their instructor being separated in space, time, or space and time. There is little or no physical interaction among peers and between the students and their instructor. Learning takes place online through different learning modes, including webinars, videos, audio, and written notes. Some scholars describe distance e-learning as virtual, computer-assisted, and web-based learning (Anderson, 2008). The learning situation forces the students to align their study habits to the demands of the modes of instruction. However, previous research revealed a significant relationship between students' study habits and learning styles (Akdemir & Koszalka, 2008; Assefa *et al.*, 2019; Brozik & Zapalska, 2006; Çakiroğlu, 2014).

There are as many models and definitions of learning styles as the number of researchers in the field. Coffield *et al.* (2004, as cited in Mkonto, 2015) identified seventy-one models of learning styles. However, all the definitions found in the reviewed literature point to learning styles being how individual learners receive, process, comprehend, and retain instruction. Kolb and Kolb (2013) gave a unique definition of learning styles. They defined learning

as a cyclic process of creating knowledge through grasping and transforming experiences. For this reason, they referred to their learning styles model as the experiential learning styles model. According to Kolb (1985), grasping is a process of taking in new information and transforming experiences in interpreting and acting on the information. Kolb posited that a learner grasps information through concrete experiments (CE) and abstract conceptualization (AC). The information is transformed through active experimentation (AE) and reflective observation (RO). During the learning process, the learner goes through four stages or dimensions. The dimensions are experiencing, reflecting, thinking, and acting. Having defined learning as a process, Kolb and Kolb (2013) then defined students' learning styles as unique ways individual learners pass through the learning cycle stages. According to them, individual learners dominate at certain stages of the learning cycle and dormant at others, resulting in individual differences. They classified learners into the following four classes: *Accommodators* (dominant in experimenting and doing), *assimilators* (dominant in thinking and reflecting), *divergers* (dominant in experimenting and reflecting), and *convergers* (dominant in thinking and doing).



Kolb and Kolb (2013) emphasized the need for instructors to know their students' learning styles as they enter a learning venture. They suggested that learning should build on the learners' experiences. The point was further stressed by Zull (2011), who proclaimed that learners' prior knowledge exists in their brains as neuronal networks, which cogent instructions cannot erase. According to Zull (2011), effective instruction activates the learners' prior experiences and allows them to re-examine and adapt their previous experiences in light of new ideas. Mkonto (2015) noted that some learners possess multiple learning styles, which they use in different learning contexts. Mkonto further observed that no learning style is inferior. According to Mkonto, both the instructor and the learner should be aware of the learner's learning styles. The knowledge helps the instructor adopt a more balanced teaching style accommodating varying learning styles. On the other hand, it assists the learner to know his or her strengths and weaknesses and take ownership of the learning process.

Despite the numerous studies on students' learning styles, scholars still debate whether learning styles and academic achievement are related. Benbunan-Fich and Hiltz (2003) recommended a study to establish a relationship between the two variables. The current study responded to the recommendation. It sought to determine the nature of the relationship between the learning styles and academic performance of a group of Mathematics students enrolled in a distance e-learning program. The Mathematics students were enrolled for a Bachelor of Science degree.

The following hypotheses guided the research:

H_0 : The mathematics students' learning styles and their academic performance are statistically independent.

H_1 : The mathematics students' learning styles and their academic performance are not statistically independent.

2. RELATED LITERATURE

The reviewed literature revealed some previous studies on the relationship between students' learning styles and their academic performance (Battalio, 2009; Cobrera & Torres, 2021; Çakıroğlu, 2014; Dağ & Geçer, 2009; Daño, 2017; DeTure, 2004; Mkonto, 2015; Neuhauser, 2002; Popescu, 2010; Zapalska & Brozik, 2006). In some of the studies, a significant relationship was found between the students' learning styles and their achievements. For instance, Çakıroğlu (2014) studied the learning styles and academic performance of sixty-two sophomore students enrolled in an online introductory programming course at Karadeniz Technical University in Turkey. The results revealed a significant relationship between the learning styles of the students and their academic performance. Popescu (2010) examined the relationship between the success of web-based instructional systems and the students' learning styles. In the study, Popescu found that accommodators benefited more than others from the web-based instruction. Cobrera and Torres (2021) studied the relationship among learning styles, study habits, and academic performance of senior high school students at St Dominic College of Asia. They found a significant correlation between the students' learning styles and study habits.

However, the researchers did not find a significant correlation between the students' learning styles and academic performance in the study. In another study, Battalio (2009) used the index of learning styles (ILS) developed by Felder and Soloman (1997) to identify students' learning styles in an online undergraduate technical communication course. The study went on to examine if there was a relationship between the undergraduate students' learning styles and their academic performance in the course. The study's results revealed that reflective learners benefited more than the other students, and a significant relationship was found between the students' learning styles and their achievement in the course.

However, in some of the studies found in the literature, no significant relationship was found between students' learning styles and their academic performance (Childress & Overbaugh, 2001; Daño, 2017; DeTure, 2004; Neuhauser, 2002; Schellens & Valcke, 2000). In a recent study, Daño (2017) examined the learning styles, study habits, and academic performance of first-, second-, and third-year nursing students at Cebu Normal University in the Philippines. The results revealed no statistically significant relationship between the students' learning styles and academic performance.

Most studies on the relationship between students' learning styles and academic performance were based on Kolb's experiential learning styles model. The current researcher felt that the model was not specifically tailored to suit mathematics learning perfectly. The researcher opted for a model developed by Silver *et al.* (2000). The model could be applied specifically to the learning of mathematics.

3. THEORETICAL FRAMEWORK

As stated earlier, the learning styles of the mathematics students who participated in this study were determined using a learning styles model developed by Silver *et al.* (2000). Silver *et al.* (2000) suggested a learning styles model with four classes of Mathematics learners. According to them, the four classes are *mastery mathematics learners*, *understanding mathematics learners*, *self-expressive mathematics learners*, and *interpersonal mathematics learners*. The characteristics of the Mathematics students in each of the four classes are given in Table I.

4. METHOD AND MATERIALS

This study was a case study of 26 students enrolled to learn Mathematics through open distance e-learning (ODEl) at a university in Zimbabwe. The group comprised eighteen females and eight males. All the students had passed Mathematics at Advanced level with at least a grade E (pass). The students learned online during the semester through videos, audio, verbal chats, and written notes. Online tutorials were done in both synchronous and asynchronous settings.

A Mathematical Learning Styles Inventory (MLSI) developed by Strong *et al.* (2004) was used to determine the students' dominant learning styles. The inventory was in

TABLE I: CHARACTERISTICS OF MATHEMATICS LEARNERS ACCORDING TO SILVER *et al.* (2000)

Class of learners	How they view mathematics	Preferred ways of learning	Their expected learning difficulties
Mastery mathematics learners	Doing calculations and computations.	Step-by-step demonstrations and repetitive instruction.	Solving non-routine problems. Abstract thinking. Following verbal explanations.
Self-expressive mathematics learner	Solving non-routine problems	Explorations and visualisations. Non-routine problem-solving. Creating images	Performing step-by-step computations. Following routine drill-and-practice instruction.
Understanding mathematics learners	Giving explanations, reasons, and proofs	Finding patterns, categories, and reasons behind mathematical operations.	Collaborating with peers. Following routine drill-and-practice instruction.
Interpersonal mathematics learners	Application of mathematical operations to real-life	Cooperative learning. Real-life application of concepts in everyday life.	Performing individual work. Abstract thinking. Solving non-routine problems. Solving out-of-context problems.

TABLE II: DESCRIPTIVE STATISTICS OF THE DOMINANT LEARNING STYLES OF THE MATHEMATICS STUDENTS

Dominant learning style	Frequency			Mean score	Standard deviation	Cronbach's alpha
	Male	Female	Total			
Mastery mathematics students	2	6	8	12.4	4.19	0.8238
Self-expressive mathematics students	3	7	10	8.2	3.03	0.7898
Understanding mathematics students	2	4	6	10.1	4.22	0.8248
Interpersonal mathematics students	1	1	2	10.6	4.35	0.8293

TABLE III: RESULTS FOR THE ANALYSIS OF VARIANCE AMONG THE GROUPS

Source	Sum of squares	Degrees of freedom	Mean squares	F
Between groups	678.5	3	226.17	3.13
Within groups	1587.4	22	72.15	
Total	2265.9	25		

the form of a questionnaire with 40 questions. The students responded by awarding points to each question depending on their best choice. The responses were on a Likert scale ranging from 0 to 2 (0 for disagree, 1 for agree, and 2 for strongly agree). The questionnaire had a Cronbach's alpha value of between 0.7898 and 0.8293.

The questionnaire was administered to the students just after admission to the university. The participants were given an explanation of how to complete the questionnaire, and they were given enough time to complete it. The students were informed of the purpose of the study and their right to choose to participate in the study or not. All the twenty-six students who enrolled in the Bachelor of Mathematics and Statistics degree program during the first semester of 2021 at the university chose to participate. They were asked to complete a consent form.

In order to determine the students' academic performance, both formative and summative assessments of the students' performance were done. Formative assessment was done through two written assignments per course

given to the students during their first semester. The two assignments contributed 20% of the final course mark. The summative assessment was done through final examinations at the semester's end. The students studied four courses during the semester. The courses were Calculus 1, Linear Mathematics 1, Applied Statistics, and Probability Theory 1.

An examination paper was given for each of the four courses. The examination contributed 80% of the final mark. The students' average marks for the four courses were used in this study. For analysis, the average mark for each student was put in one of the following three categories—low (0%–49%), average (50%–74%), and high (75%–100%).

In order to establish whether there were significant differences among the scores of the four learning style groups, the researcher analyzed variance (ANOVA). The relationship between the students' learning styles and academic performance was tested using the Chi-square test. Both ANOVA and Chi-square tests were done at a 5% significance level. A statistical software called Statistical Package for Social Sciences (SPSS) was used to organize the data and calculate the values for the tests.

5. RESULTS

5.1. Mathematics Students' Dominant Learning Styles

Table II shows the descriptive statistics of the learning styles of the students who participated in this study.

TABLE IV: CLASSIFICATION OF STUDENTS' ACADEMIC PERFORMANCE ACCORDING TO THEIR LEARNING STYLES

	Academic performance						Mean score (%)
	Low		Average		High		
	Male	Female	Male	Female	Male	Female	
Mastery mathematics students	1	4	1	1	0	1	48.25
Self-expressive mathematics students	0	1	2	2	1	4	69.80
Understanding mathematics students	0	0	1	0	1	4	76.33
Interpersonal mathematics students	1	0	0	1	0	0	57
Total	2	5	4	4	2	9	

In order to determine whether significant differences existed among the groups of students, an analysis of variance (ANOVA) was done. The results are shown in Table III.

According to the results obtained, the value of F obtained through calculation ($F_{cal} = 3.13$) was greater than the table value ($F_{3,22}(0.05) = 3.05$). Based on the two values of F, the researcher concluded that there were statistically significant differences among the groups.

5.2. Mathematics Students' Academic Performance

The performance of the students was classified into three categories (Low: 0% to 49%, Average: 50% to 74% and High: 75% to 100%). Table IV shows the number of students in each category by sex and learning style.

5.3. Relationship between the Students' Learning Styles and Their Academic Performance

A chi-square test was conducted so as to determine whether the students' learning styles and academic performance were statistically independent. The test revealed that the Chi-square value obtained by calculation ($X^2_{cal} = 12.86$) was greater than the value obtained from the Chi-square table ($X^2_6(0.05) = 12.6$). The results of the Chi-square test revealed that students' learning styles and their academic performance were statistically dependent. A significant relationship existed between the students' learning styles and their academic performance.

6. DISCUSSION

The results of this study indicated that the largest number of students who participated were *self-expressive mathematics learners*. They were followed respectively by *mastery mathematics learners* and *understanding mathematics learners*. *Self-expressive mathematics learners* constituted 38.46% of the total participants. Although self-expressive mathematics learners were the majority, they were not the best in academic performance. Their mean score of 69.8% was in the average category. Silver et al. (2000) state that self-expressive mathematics learners prefer learning through explorations and visualizations. As

they learn, they create images that help them make sense of the concepts learned. I believe the *self-expressive mathematics learners* could have failed to excel due to the 'drill and practice' methods used during the e-learning process.

The category of students with the least number of students was the *interpersonal mathematics learners* category. Out of twenty-six students who participated in the study, two (7.69%) were in this category. Although they had the least participants in this study, their mean score of 57% was neither the lowest nor the highest of the four categories. It was slightly above the lower boundary of the average category. As put forward by Silver et al. (2000), *interpersonal mathematics students* prefer working in groups. They enjoy applying learned concepts to real-life situations. They face challenges when they perform individual tasks.

In this study, *understanding mathematics learners* were the leading performers in terms of academic achievement. Their mean score was 76.33%. Maybe the students' performance was a result of the methods of teaching used during the semester. Using videos, audio, webinars, and written notes forced the students to work individually. There was very little interaction among peers. *Understanding mathematics learners* preferred such a learning environment. However, the learning environment could have affected the performance of mastery mathematics learners. Their mean score was 48.25%. It was below the 50% mark. *Mastery mathematics learners* preferred repetitive instruction characterized by demonstrations. Unfortunately, the instructions were given online, and they demanded that the students work mostly as individuals.

The study found a statistically significant relationship between the students' learning styles and academic performance. I believe the results could indicate that the methods used to instruct the students were not varied enough to accommodate different learning styles. The results obtained in this study agreed with those obtained by Çakıroğlu (2014) in a study carried out at Karadeniz Technical University in Turkey. Although Çakıroğlu used Kolb's experiential learning style model in determining the students' learning styles, the study found a significant relationship between students' learning styles and their academic performance. However, the results of this study contrasted with those obtained by Cabrera and

Torres (2021) and those obtained by Neuhauser (2002). Neuhauser (2002) did not find a significant relationship between learning styles and learning outcomes in a study comparing the grades of students learning through online and face-to-face methods. Similarly, Cabrera and Torres (2021) found no relationship between learning styles and students' academic performance at St Dominic College in Asia.

7. CONCLUSION AND RECOMMENDATIONS

The results of this study led to the conclusion that there was a statistically significant relationship between the learning styles of mathematics students and their academic performance. If the learning methods remain unchanged, the learning styles of the mathematics students can be used to predict their academic performance.

Based on the study's results, the current researcher recommended that the methods used in giving instruction to distance learners should be designed to ensure that all the students, despite their varying learning styles, benefit in one way or another. Students should get opportunities to perform both individual and group tasks. Course content should be in multiple formats, allowing students to share and discuss concepts as peers. A learning style inventory administered to students upon admission provides instructors with valuable information on the students' learning styles. The information helps instructors to design learning instruction that suits all the students. Information also assists in predicting and preparing for the problems that the students are likely to face in the learning process. Online workshops and seminars are essential in assisting distance e-learners in utilizing the available learning resources despite their differences in learning styles. However, to produce versatile students, there was a need for all the students to be exposed to different modes of distance e-learning. It would force the students to explore different ways of learning.

8. LIMITATIONS OF THE STUDY

The study was a case study of students studying for a Bachelor of Science degree in Mathematics and Statistics at a university in Zimbabwe. The results of the study may not be generalized to students in different settings.

CONFLICT OF INTEREST

The author declares that he does not have any conflict of interest.

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