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Exploring Learning Strategies and Algebra Achievement: A Study of Senior Secondary School Students in Adamawa State, Nigeria

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Abstract

Algebra achievement is a cornerstone of a student's academic success, but the effective teaching and learning of algebra pose significant challenges in the educational landscape. A student's learning strategies is seen through the consistent methods they employ to acquire knowledge, which play a pivotal role in this process. Equally critical is the development of problem-solving skills, which are essential for nurturing mathematical logical reasoning. This study sheds light on a pressing issue—senior secondary school students in Adamawa State, Nigeria, are struggling with interpreting algebraic problems, and this calls for immediate attention. The primary objective of this research is to explore the intricate relationship between learning strategies and achievement in interpreting algebraic problems among these students. A carefully selected cohort of 273 senior secondary school students, aged 15 to 17, residing in the Hong local government area of Adamawa State, formed the basis of this study. To discern the students' learning strategies, this study utilized a 12-item Kolb's learning strategy inventory. Simultaneously, students' achievement in interpreting algebraic problems was measured using a 6-item algebraic problem-solving test. The findings illuminate an interesting connection between students' learning preferences and their ability to interpret algebraic equations, with most students favouring the assimilating and converging learning strategy. Remarkably, this preference correlates with exam scores ranging from 75 to 80 percent in the domain of interpreting algebraic problems. These results, therefore, present a compelling argument for educators to reconsider and adapt their teaching methods. This study carries implications that extend beyond its specific context. By revealing the interplay between learning strategies and algebra achievement, it offers educators, administrators, and policymakers a valuable resource for refining pedagogical approaches.

Keywords: Learning Strategies, Algebra, Algebraic Problems, Mathematics Education, Secondary School

Introduction

Mathematics is a discipline that demands a diverse range of knowledge and skills essential for individuals to navigate their daily lives. Proficiency in quantitative abilities holds significant importance in modern academics and is a key prerequisite for success across a spectrum of tasks (Pandey, 2017). Unfortunately, numerous students encounter difficulties with algebra, which can lead to waning interest in the subject and, in some cases, a disheartening abandonment of mathematical learning (Yeh et al., 2019). The most recent National Assessment of Educational Progress (NAEP) for senior secondary schools, conducted in 2019, revealed that the mathematics score (232) was lower than that of 2017 (263) but demonstrated improvement from the score in 2014 (243).

Conversely, in 2015, students in their final year achieved lower math scores (102) compared to their scores in 2013 (113), as reported by Hussar et al. (2020). These fluctuations may be attributed to the teaching methodologies employed by educators and how their attitudes have influenced students' learning trajectories, particularly in the realm of mathematics. In the academic year 2020-2021, students were only able to cover half of the typical algebra curriculum (Sawchuk & Sparks, 2020). Furthermore, a prevailing sentiment among educators is that students are currently less prepared for the workforce and are making slower progress in mathematics than in previous years (Loewus, 2021).

Nonetheless, as highlighted by Ahn & Edwin (2018), a deeper understanding of students' learning styles equips teachers to effectively teach mathematics and make it more engaging for their students. The challenge often lies in the inadequacy of course materials to address the abstract nature of algebra and the absence of inspiring educators, rendering algebra notably more challenging to grasp (Reju & Jita, 2018). Furthermore, the intricacies of the algebraic learning process are not readily attainable through distance education (Widada et al., 2019). Alarmingly, the National Achievement Test (NAT) results for senior schools, as disclosed in the Ministry of Education's (MOE) report, indicate a subpar level of achievement, particularly in algebra, underlining the difficulty of acquiring algebraic thought processes (Gonzales, 2019). These trends are further corroborated by the 2019 international mathematics results, which reveal a notably low performance in algebra within Adamawa State.

In the current educational system, students are also tired and stressed, which causes them to spend less time on academic tasks like assignments or engaging with teachers or other students (Adonis, 2020). Numerous studies have examined the difficulties that high school students face with algebraic issues (Sugiarti & Retnawati, 2019; Jupri, 2016; Pramesti & Retnawati, 2019). The secondary level curriculum places a lot of stress on giving students the opportunity to improve their algebraic understanding and competency as well as their problem- solving and rational decision-making skills, all of which will help them deal with changes and challenges in their everyday lives (Curriculum Development Centre, 2003). According to Elizabeth Julius (2018), algebra is one of the major branches of pure mathematics; it is concerned with the study of the rules of operation, relations, constructions, and the concepts arising from them such as polynomials, equations, and algebraic structures. It is also an aspect of mathematics which involves the use of letters and numbers (Usman & Musa, 2015). It's generally accepted that algebraic concepts and abilities are essential for students to improve their critical thinking and problem-solving abilities in context. (Adeleke, 2007).

Algebra is often presented to students once they have mastered the principles of arithmetic and have a basic grasp of it (Curriculum Development Centre, 2003). Algebra is one of the difficult topics to learn and comprehend in mathematics. The problem with algebra is that the majority of students find the ideas and fundamentals to be excessively difficult to apply to actual life circumstances (Sangit, 2007). The claims made by many writers make this clear. They have a misunderstanding about algebra, which makes it difficult for them to translate arithmetic figures into algebra (Indraswari et al., 2018). In order to answer problems in algebra, students should first determine the unknowns, or variables, and the connection between them. The majority of students, however, find it difficult to identify the variables and how they interact. The inability of these students to master algebra has a critical impact on their ability to answer algebraic problems (Mehraj Bhat, 2014).

As mathematicians have long been devoted to the art of problem-solving, students can significantly benefit from grasping its importance in their pursuit of solutions to complex and challenging problems. This holds especially true when dealing with algebraic problem solving, as emphasized by Royani & Agustina (2019). The process of problem resolution involves a deliberate adherence to a logical sequence encompassing both cognitive and behavioral facets. Notably, the esteemed Canadian psychologist Albert Bandura posited in 1986 that individuals endowed with strong problem-solving abilities are more adept at achieving their goals and executing tasks efficiently. Conversely, Royani and Agustina (2019) advocate for educational institutions to place a high priority on equipping students with problem-solving skills. Recognizing that individuals possess distinct learning modalities influenced by their cognitive, linguistic, motor, and social proficiencies, it becomes clear that nurturing problem-solving capabilities should be a cornerstone of education.

An individual's chosen learning approach, often referred to as their learning method, is influenced by their attitudes and behaviors (Mumford & Honey, 1996). Given that each student possesses a unique learning style, there is a diverse array of learning methods. The preferred learning method of students significantly impacts their ability to acquire new knowledge and understanding. It enables them to engage with and comprehend specific subjects more effectively. Research into learning methods indicates that students who employ a variety of techniques during the learning process tend to achieve excellent academic outcomes. Learning methods hold a pivotal role in an individual's life (Nahil & Aljaberi, 2015). Once an individual has identified their preferred learning method, they can effectively employ it throughout the learning journey, resulting in enhanced learning experiences that are faster, more efficient, and yield better results.

Studies have explored the connection between several variables and instructional strategies, including gender, class level, discipline, and math proficiency (Nahil Aljaberi, 2015). Thus, this study aims to investigate the relationship between the learning methods of senior secondary students and their academic achievement in solving algebraic problems in Hong, Adamawa State. The study's objectives are to determine the preferred learning preferences of senior secondary school students in Hong, Adamawa State and to assess the mean difference in achievement scores between students taught algebra using learning strategies and those taught without learning strategies in Hong, Adamawa State.

Methodology

This is a quantitative research study employing a correlational design. The primary objective of this research is to examine the relationship between the learning strategies adopted by senior secondary school students and their performance in solving algebraic problems. The study focuses on the target population of senior secondary school students in the North East region of Nigeria, specifically within Adamawa State's Hong Local Government Area. The entire population for this study encompasses all senior secondary school classes within the selected area. A total of 17 government senior secondary schools located in the Hong Local Government Area were chosen to participate in the survey. The sample for this study was randomly drawn from the senior section (SS)-1 and 2 students of these government schools, totalling 273 students. Since the research's core aim is to investigate the learning strategies employed by students and their subsequent performance in solving algebraic problems, only respondents who have been exposed to essential algebraic concepts, such as factorization and linear equations, were chosen to participate in the survey.

Two distinct instruments were employed in this research study. Firstly, the researchers utilized Kolb's Learning Method Inventory version 3.2 to discern the learning strategies of senior secondary school students. This instrument was adapted from the one previously employed by Bhat (2018). The Kolb's Learning Method Inventory is a self-descriptive questionnaire comprising 12 items and relies on a forced-choice format with four specific response options. Respondents assigned numerical values of "1, 2, 3, and 4" to their preferred answers. A score of 4 indicates the best way of learning, while the smaller the number, the less the preference for the stated learning method, with 1 representing the least preferred choice.

Secondly, the assessment of students' achievement in solving algebraic problems was conducted using a test method adapted from research conducted by Sikukumwa (2017). This achievement test encompasses five questions, all of which present non-routine problems. The questions were presented in printed form and were meticulously constructed to encompass various challenges related to important aspects of algebra, including factorization, basic arithmetic operations involving algebra, and linear equations. These questions were all drawn from the SS II Mathematics syllabus, ensuring their relevance to the study. Respondents were expected to employ the Polya model presented in Figure 1 as a structured approach to address and respond to the questions in a step-by-step manner.

To analyze the survey data, the researchers utilized SPSS software version 20, employing both descriptive and inferential statistics.

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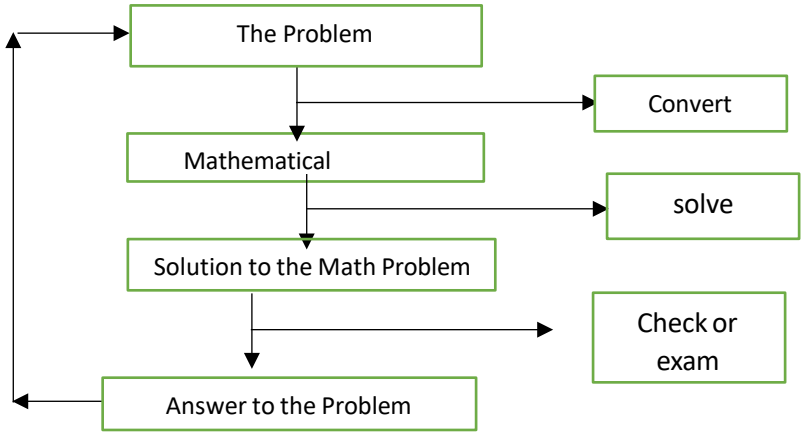

Figure 1. Polya's problem solving steps

Polya says that the purpose of problem solving is to find a solution to a challenging situation, overcome a challenge, and achieve a desired goal when there are no recognized methods for doing so. Additionally, according to Polya, the approach used to solve a problem can be used regardless of the problem's or question's nature. In other words, these procedures can be used in a variety of settings and circumstances (Polya, 1945).

Problem solving is considered to be the basis of learning and teaching mathematics, which requires us to establish harmony, consistency, and accommodation of teaching methods with the learning methods and characteristics of the learner. Therefore, identifying the learning method has become obligatory for better teaching methods in algebra in order to equip the learner with problem solving skills (Louange, 2007). Figure 2 illustrates the relation between the learning method, teaching method, and problem solving.

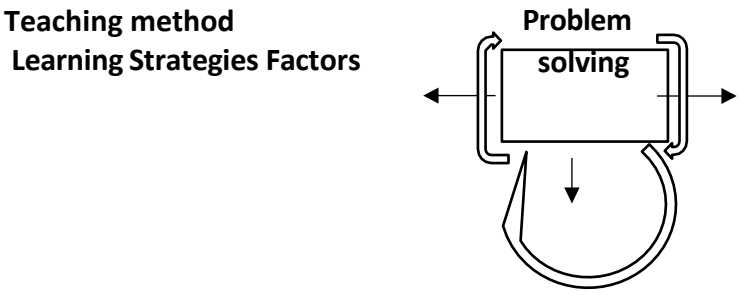

Figure 2. The relation between the learning strategies, teaching method, and problem solving.

Carmo and his colleagues (2006) Learning methods are a useful tool to help both students and teachers know how to enhance the way in which learning and teaching are done because it has been shown that people learn in different ways and exhibit distinct preferences when learning new subjects (Carmo et al., 2006). Kolb pointed to the process of selecting and socialization that lead to homogeneity disciplinary culture so that it is not affected by other variables. He emphasized that with time sciences students become more analytical and less creative.

Results and Discussion

The students' teaching strategies were determined using a 12-item questionnaire, which were categorized into four categories based on Kolb's methods of learning namely Feeling (Concrete Experience), Watching (Reflective Observation), Thinking (Abstract Conceptualization) and Doing (Active Experimenting). These are known as the learner's primary learning modes. A frequency distribution analysis was carried out to identify the participants' individual primary learning modes. Table 1 shows the analysis of Kolb's four learning modes.

Table 1:
Kolb's Participants' different learning strategies

	Number	Minimum	Maximum	Mean	Standard Deviation
Concrete Experience	273	12	39	25.66	7.120
Reflective Observation	273	12	41	31.30	6.472
Abstract Conceptualization	273	12	41	32.22	6.571
Active Experimenting	273	12	41	31.33	6.422

Based on the summary in Table 1, The Abstract Conceptualization mode has the highest mean value of 31.22, with a standard deviation of 6.571. The Reflective Observation mode records a mean value of 31.30, with a standard deviation of 6.571; the Active Experimenting mode also shows the same mean value of 31.33, but with a different standard deviation of 6.422. The Concrete Experience mode registers the least mean score of 25.66, with a standard deviation of 7.120 and has been represented on Figure 3.

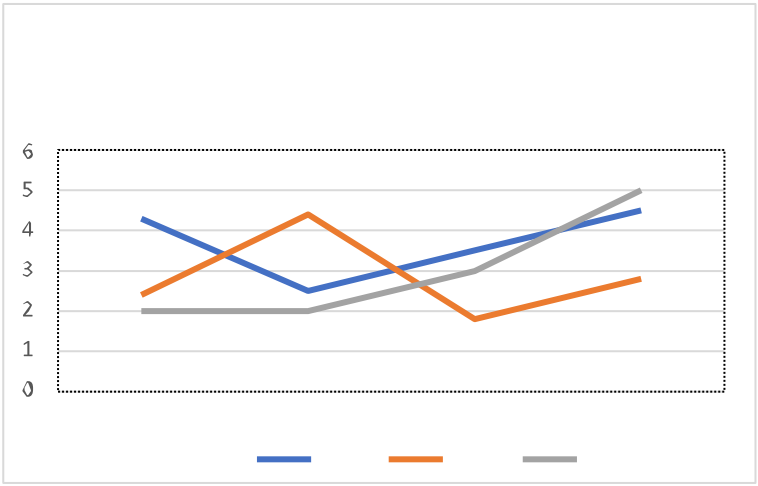

Figure 3. Kolb's participants' different learning strategies from table 1

Table 2:
Frequency distribution of Kolb's Learning Methods

Learning method	Number	Frequency
Assimilator	**107**	**31.2%**
Converge	**85**	**25.6%**
Diverge	**70**	**10.0%**
Accommodator	**55**	**17.3%**

The assimilator learning method has the apex frequency distribution (31.2%). According to Table 2 summary, 107 students in the senior secondary school population of Adamawa state, out of a total of 273 respondents, were found to have the assimilator learning method. The assimilator learning method is the most preferred method of knowledge acquisition, according to the descriptive analysis of the modes. With a percentage of 25.6%, or 85 students, out of the 273 participants in the study, the Converge learning method received the second-highest score. Only 70 students, or 10.0% of all respondents, chose the Diverge learning method, making it the least favoured method of learning among senior secondary school students. The accommodator learning method is the most desired method of learning. According to the aforementioned frequency chart, 55 students, or 17.3 percent of all responders, are accommodators and has been represented on Figure 4.

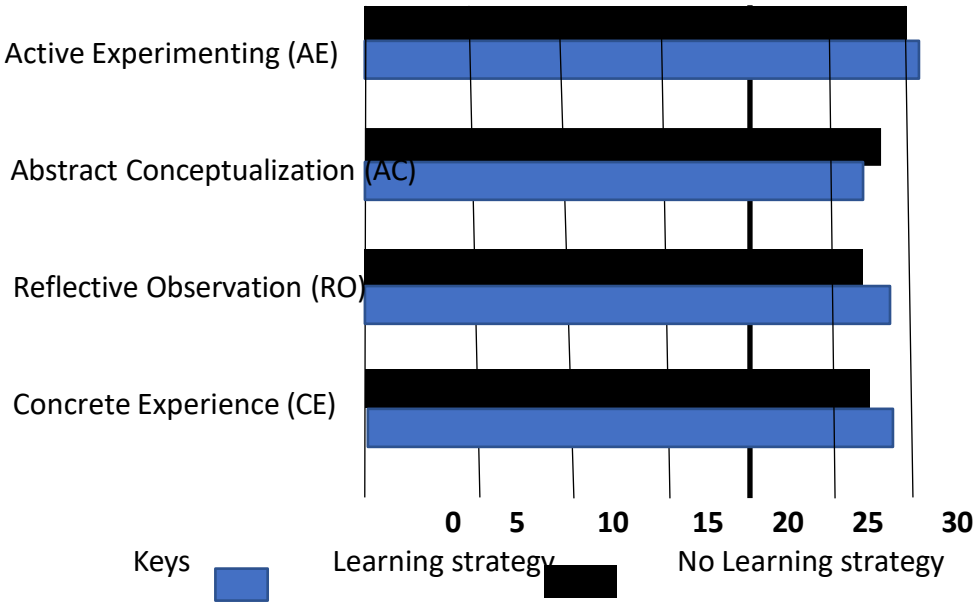

Figure 4. Kolb's learning modes from Table 2

The steps for solving algebraic questions were carefully followed during class sessions, where students were instructed on how to use learning processes. The Algebra Achievement Test (AAT) is the tool used to gather data. Two specialists, one from the mathematics department of the Adamawa State College of Education in Hong and the

other from the Government Senior Secondary School in Hong, verified it. The researcher created choices A– D for the 30 multiple-choice questions that made up the AAT. Using Kuder's formula-20, Richardson's internal consistency on the algebraic achievement test (AAT) was found to be 0.75 (KR20).

Furthermore, the researcher prepared two different sets of lesson plans that were used in learning strategies on how to solve algebraic problems during the study. One set of lesson plans is based on a learning strategy that was used for the experimental group, and the other set is based on the no-procedure that to be used for the control group. The prepared lesson plan sets were used by the research assistants who participated in the study's schools. Data collected were analyzed using mean and standard deviation to answer research questions, and analysis of covariance was used to test the null hypotheses at the 0.05 level of significance. Table 3 shows mean and standard deviation of students taught the learning strategy on how to solve algebraic problems and those taught without procedure on how to solve algebraic problems were compared before and after the tests.

Table 3.
Mean and standard deviation

Teaching methods	n	Pre-test Mean Score	SD	Post-test Mean Score	SD	Mean Gain
Learning strategy	65	25.00	6.43	65.23	15.34	38.45
No Learning strategy	61	27.10	6.20	45.00	14.21	17.23
Mean Difference		2.10		20.23		21.23

Table 3 revealed that the learning strategy group with 65 students had a pre-test mean score of
25.00 and a standard deviation of 6.43. Procedure on how solve algebraic problem was required in the post-tests. The learning strategy has the highest mean score of 65.23 with a standard deviation of 15.34. The no learning strategy group has 61 students with a mean score of 27.10 and a standard deviation of 6.20 at the pre-test level and a mean score of 45.00 with a standard deviation of 14.21 at the post-test level. In summary, the mean gain between pre-test and post- test is higher in the learning strategy than without learning strategy procedure. As a result, the mean difference between no procedure and procedure is 2.10 before and 20.23 after, with a gain of 21.23. It shows standard deviation of students taught the learning strategy on how to solve algebraic problems and those taught without procedure on how to solve algebraic problems were compared before and after the test.

Table 4.
Analysis of Covariance (ANCOVA) for Mean Achievement Scores of Algebra Students Taught with and without a Learning Strategy in Solving Algebraic Problems

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Revised Plan	9955.432 *	2	3326.765	21.384	.000
Interlope	23654.325	1	20073.333	21.695	.000
Pre-test	63.166	1	63.166	.360	.533
Studying Approach	7060.244	1	7060.244	42.770	.000
Error	28274.550	143	197.724		
Total	465044.000	146			
Corrected Total	38120.082	145			

* R Squared = 0.239 (Adjusted R Squared = 0.228)

The results of the analysis in Table 4 show that there is a significant difference in learning strategies' impact on students' academic achievement after the post-test (F = 42.77, df = 1, 145, P = 0.00). Since the computed p-value (0.00) is less than 0.05 level of significance, therefore, the null hypothesis of no significant effect is rejected, which means there is a significant effect of learning strategies on students' academic achievement in favour of how to solve algebraic problems.

The four learning modes that make up Kolb's model of learning methods each explain a student's preferred method of learning, and they vary between individuals in terms of how they handle, classify, perceive, and organize information. Therefore, the 12-item questionnaire is made to recognize various learning methods, including Active Experimentation, Abstract Conceptualization, Reflective Observation, and Concrete Experience. The average score for the learning method called Abstract Conceptualization is the highest at 31.44. This indicates that the Abstract conceptualization (AC) mode is preferred by the majority of students as the main method for learning algebra.

Rather than passively absorbing information, students prefer to engage in critical analysis of concepts. By aligning their teaching methods with each student's preferred learning style, educators can enhance the relevance of algebra lessons in the classroom. They can design math exercises that foster active participation and open dialogue among students. Additionally, teachers should encourage their students to explore creative problem-solving approaches. The instructor can then introduce the essential concepts and theorems of the current learning module, followed by challenging algebraic problems that necessitate the application of acquired knowledge and the cultivation of critical thinking skills. This approach can significantly enhance students' capacity for logical, abstract, creative, and critical thinking, thereby contributing to their overall cognitive development.

Conclusion

The findings of this study suggest that, in order to help students reach their full potential in developing mathematical problem-solving skills, particularly those related to the study of algebra, it is essential to identify their ideal learning preferences. The research also demonstrates Kolb's model of learning techniques, which states that among senior secondary school students, Abstract conceptualization, Reflective Observation,

and Active Experimentation styles are favored in that sequence. The General Conceptualization mode had the greatest average value of all the learning styles in Kolb's model.

This shows that most students want their algebra courses to cover more broad topics. The study's conclusions show that more students prefer the abstract conceptualization learning method, which has an impact on the connection between learning strategy and achievement in answering mathematical problems. It suggests that students are capable of handling the various difficulties presented by the new learning development. Additionally, the students' mathematical academic achievement is significantly influenced by their algebraic skills. This means that a deficiency of algebraic knowledge or a low level of algebraic knowledge may result in poor academic achievement in mathematics, whereas having enough algebraic knowledge or developing high-level skills in algebra results in positive academic outcomes or excellent scores in mathematics.

By examining the learning preferences of 273 senior secondary school students in Adamawa State, this study reveals intriguing findings. It identifies the dominant learning strategies and their impact on exam scores for interpreting algebraic problems, providing valuable information for educators and policymakers. With a focus on Adamawa State, Nigeria, this study highlights the specific needs and challenges faced by students in this region. Its findings can be a valuable resource for educators and policymakers in tailoring interventions to improve algebra education and student outcomes.

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