



Effect of Concept Mapping Based Strategy on Secondary School Students' Achievement in Algebraic Equations in Nsukka Education Zone

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Abstract

This research investigated the effect of concept mapping on secondary students' academic achievement in algebra in Nsukka Education Zone. Two research questions and two null hypotheses guided the study. In this study, 50 Senior Secondary School One (SSS1) students across three LGAs were used for the study. The study adopted Quasi-experimental design, specifically; pretest-posttest nonequivalent group design was used. The study examined the effectiveness of concept mapping compared to lecturing method on algebra achievement. One self-constructed instrument called Algebraic Achievement Test (AAT) with an index validity value of 0.77 and Kuder Richardson Formula 20 (K-R 20) was used for the study. Data analysis involved calculating means and standard deviations using Statistical Packages for Social Sciences, Version 23 (SPSS 23) to address research questions, while Analysis of Covariance (ANCOVA) was used to determine if differences between groups were statistically significant at the 95% level. Results indicated that students learning algebra through concept mapping achieved better than those taught using lecturing method. Again, the findings of the study showed that, there was no significant influence of teaching strategy on gender on students' achievement in algebra. It was recommended among others that teachers of secondary schools mathematics should use concept mapping based strategy in teaching algebra to enhance greater achievement in mathematics.

Keywords: Achievement, Gender, Mathematics and Strategy.

Introduction

Mathematics is a core subject required of all students, regardless of whether they study science or arts, up until university level. This mandatory status implies a belief that mathematical knowledge is essential for every member of society. The method of teaching mathematics is crucial in equipping students with fundamental mathematical knowledge, skills, and a problem-solving mindset. Mathematics is instrumental in developing critical thinking, reasoning, and creativity. It is a core body of knowledge essential for a nation's scientific and technological advancement.

Effective mathematics learning requires active student engagement in the development of mathematical ideas. However, traditional teaching methods often prioritize the teacher, limiting students' opportunities to participate in the learning process. This approach discourages critical thinking and promotes rote memorization without meaningful understanding, according to Omoroh and Adir (2019). Consequently, students struggle to grasp mathematical concepts due to the lack of active learning. This highlights the inadequacy of traditional teaching methods in fostering



scientific thinking and conceptual understanding in mathematics.

Mathematics is a fundamental tool used across all fields of study and human endeavor. It plays a crucial role in shaping decisions and actions in areas as diverse as economics, finance, marketing, industry, research, leadership, engineering, and agriculture, to name just a few (Yadav, 2019). A strong foundation in mathematics is crucial for any nation aiming to develop its scientific and technological capabilities. In secondary schools, one of the major subject through which Nigeria education strives to raise a generation of science and technologically oriented citizen is by having the knowledge of mathematics. However, mathematics is one of the core subjects that have helped people in calculating, measuring, numbering and arrangement of their items. Mathematics is crucial for developing critical thinking, logical reasoning and problem-solving abilities. Its applications are widespread across science, commerce, and technology. Despite being a compulsory subject from primary to secondary school, students consistently struggle to achieve satisfactory results in mathematics examinations, as highlighted by Omoro and Adiri (2019).

Achievement refers to successfully completing a task or goal, often requiring substantial effort and skill. It's about reaching one's full potential, accomplishing something challenging, and demonstrating excellence. Academic achievement refers to a person's success in meeting educational goals within a school, college, or university setting (Kihwele & Mkomwa, 2022). Academic achievement in Mathematics is a key mechanism by which teenagers learn about their talents, abilities and competencies which are an essential component of developing Mathematics professional aspiration (Illahi & Khandai, 2015). Mathematical achievement reflects a student's competency in mathematics. It's a product of acquired knowledge, understanding, and skills developed within the subject at a specific level. Despite the subject's importance, it's clear that it hasn't received adequate attention, as evidenced by consistently poor students' achievement. This ongoing issue is a concern for various stakeholders in education, including parents, researchers, teachers, and administrators. Reports from the WAEC Chief Examiner (2016-2021) disclosed that there are consistent areas of weaknesses on the part of the students which may be blamed for their unsatisfactory academic achievement in mathematics in external examinations like WASSCE. The WAEC Chief Examiner emphasizes on the poor achievement

which arises from students' poor knowledge of some topics in Mathematics especially in solving problems in Algebra.

Algebra is a branch of mathematics that uses letters to represent numbers and solve problems. It's a core component of mathematics, yet it's a topic where many students struggle to understand the solutions (Usman and Musa, 2019). Students' difficulties with algebra often stem from errors in problem-solving, which can be related to procedural knowledge (computational skills and rule application) or conceptual knowledge (understanding underlying mathematical concepts of Algebra) is essential for developing critical thinking, problem-solving, and communication skills are crucial for everyday life. As the language of mathematics (Iji, Abakpa, & Takor, 2015), algebra is fundamental to overall academic success and real-world applications. Despite its importance, students continue to struggle with algebra, leading many to avoid higher-level mathematics courses (Udonsa & Udonsa, 2015). Given algebra's role in science, technology, arts, and humanities, improving algebra instruction is a key to enhancing overall mathematics achievement. Despite the importance of algebra, students consistently struggle with it, as evidenced by poor achievement in algebra-related questions on the WAEC exams (2016-2021). Oledede (2014) linked this issue to ineffective teaching methods in mathematics. This study aims to determine if using concept mapping as a teaching strategy can improve students' algebra achievement.

Concept mapping is a teaching method rooted in Ausubel's learning theory, which posits that new knowledge is best acquired when connected to existing understanding. According to Novak and Gowin (1984), concept maps visually represent how ideas are related to one another within a subject. By organizing information hierarchically, concept maps help students grasp key concepts and their connections. This approach encourages meaningful learning over rote memorization, allowing teachers to identify misconceptions and provide targeted instruction. Omoroh and Adiri (2019) suggest that concept maps can be used effectively throughout the learning process. As students create concept maps, they develop a holistic understanding of the subject matter rather than viewing information in isolation. Concept maps offer several advantages, including clear visual representation, effective communication of complex ideas, student-centered learning, enhanced teacher-student interaction,



and improved long-term retention of information (Ozomadu & Edeoga, 2022).

Literature review revealed that (Mazer, 2017) used concept mapping in electromagnetic in physics and found it scientifically effective. Also (Shamaki, 2015) got a significantly better result when concept mapping was used to teach biology. Khadijat (2017) investigated concept-mapping method in SS2 chemistry and got a significant result.

Since none of the studies within the reach of the researcher has carried out a research on concept-mapping based strategy on students' achievement in algebraic equations, thus the need for this study to see the best way these students' can be taught to bring out their best.

Research Questions

The following research questions guided the study;

1. What are the mean achievement scores of students taught algebraic equation using concept mapping based strategy and lecturing instructional strategy?
2. What is the influence of gender on the mean achievement scores of students taught algebraic equations using concept mapping based strategy and conventional instructional strategy?

Hypotheses

The following hypotheses were formulated to guide the study and was tested at 0.05 level of significance.

Ho₁: There is no significance difference on the mean achievement scores of students taught algebraic equation using concept mapping based strategy and lecturing instructional strategy

Ho₂: There is no influence of gender on the mean achievement scores of students taught algebraic equations using concept mapping based strategy and conventional instructional strategy

Design of the Study

The study adopted pretest-posttest quasi-experimental design, which involves measuring participants before and after an intervention without randomly assigning them to groups. Existing classroom groups were used to avoid disrupting the regular school schedule.

Area of the Study

The Nsukka, Uzo-Uwani, and Igbo-Etiti Local Government Areas are all included in the Nsukka Education Zone of Enugu State, where the study was conducted.

Population and Sample of the Study

The population of the study comprised all 1,778 SSS1 students in the Public Secondary Schools in Nsukka Education Zone. The sample size for the study comprised 50 Senior Secondary School Students one (SSS1) chosen from 2 Secondary Schools which comprised 23 male and 27 female students across Nsukka and Igbo-Etiti Local Government Areas respectively. In selection of the two schools, multi-stage sampling procedure was used. At first stage; purpose sampling technique was used to select all Public coeducation schools in the zone since gender was a variable in this study and it aided to ensure the uniformity across gender line. At the second stage; Simple random sampling technique of balloting without replacement was used to draw one school in each of the 2 Local Government Areas and this was done by folded paper to ensure each school has equal chance of been selected. At the third stage; simple random sampling technique by toss of coin was used to assign each school to experimental and control groups. At the fourth stage; simple random sampling technique by balloting without replacement was used to draw one stream/arm in each of the selected schools. This was also done by folded papers to give each stream/arm equal chance of been selected, hence the study adopted intact class arrangement to avoid disruption of the school lessons time table.

Instrument for Data Collection

A self-constructed instrument called Algebraic Achievement Test (AAT) was used to collect data for the study. The instrument was content validated with the use of table of specification by three specialists. The reliability index of the instrument was found to be 0.77.

Experimental Procedure

The experiment which lasted for five weeks had its first week used to train research assistants, and sought for permission from principals to carry out research in their respective schools. The research treatment commenced in the second week and had duration of four weeks. The pre-test and posttest Algebraic Achievement Test (AAT) questions were administered to both experimental groups A and B

respectively. The data collected for the pre-test and posttests on the instrument were analyzed separately for the two groups, which were used to answer the research questions and hypotheses for the study. The total duration for the experiment was five weeks.

Control of Extraneous Variables

- **Teacher Variable:** In order to ensure total errors that would have arisen from teacher variable, the researcher organized four days training on how to use the lesson notes for all the 4 research assistants that were to participate in the study before the commencement of the experiment. The training took care of the teacher’s individual differences by giving them the various pattern of instruction to be used for the study.
- **Intact-group Variable:** Since the participants in intact classes were nonequivalent control groups, Analysis of Covariance (ANCOVA) was used for data analysis to take care of the initial differences between the groups in order to eliminate the errors of nonequivalence.
- **Variable Instructional Procedure:** This was controlled by ensuring that the instructional procedure was the same for the teachers in all the schools used for the study. The same lesson notes covering the same content was provided for the teachers in experimental group A and control group B.
- **Treatment Bias:** Students in both groups (experimental group A and control group B) were not informed or made to understand

anything about the research process so that they would not exhibit their natural behaviours during the experiment. In addition, the test question papers were withdrawn from the students and research assistants immediately after the pre-test to avoid students becoming ‘test wise’.

- **Irregular Participation and Experimental Mortality:** In order to ensure that the students participate fully and that they did not ‘kill’ the purpose of this experiment, the research assistants ensured that roll call of the students was taken in each sampled schools before the commencement of each lesson and after the sessions. Students were advised not to miss any of the lesson periods. With this, the researcher was able to control irregular participation and experimental mortality.

Data Analysis Technique

The Statistical Packages for Social Sciences, Version 23 (SPSS 23), were used to conduct the analysis. To summarize the information, the data was analyzed using descriptive statistics, more especially, the standard deviation and mean. Analysis of Covariance (ANCOVA) was achieved at a significance level of 95% in order to test the research hypotheses, any null hypothesis with less than 0.05 level of significance was rejected while any null hypothesis with greater than 0.05 level of significance was not rejected.

Result

This section outlines the findings from the data analysis, corresponding to the study's research questions and hypotheses.

Table 1: Mean Achievement Scores of students taught algebraic equation using concept mapping based strategy and those taught using conventional instructional strategy

Group	N	Pretest		Post-test		Mean Difference
		\bar{x}	SD	\bar{x}	SD	
Control Group	22	23.00	5.407	35.64	7.774	12.64
Experimental Group	28	22.07	4.268	36.79	6.540	14.72

Note: N = Number of Respondents, \bar{X} = Mean, SD = Standard deviation

The mean achievement scores for students who learned algebraic equations through a concept mapping-based approach and those who learned the material through a lecturing teaching strategy are shown in Table 1. The mean achievement scores of students in the

experimental group (concept mapping based strategy) were (\bar{x} =22.07, SD=4.268) at the pretest and (\bar{x} = 36.79, SD = 6.540) at the posttest, according to the table. In contrast, students in the control group (lecturing instructional strategy) had (\bar{x} = 23.00, SD = 5.407) at



the pretest and ($\bar{x} = 35.64$, $SD = 7.774$) at the posttest. Additionally, the experimental group's students had higher mean accomplishment scores than the control groups, as seen by their respective mean difference achievement scores of 14.72 and 12.64 for the two

groups. Additionally, it may be inferred that students in the control group had more variety in their individual achievement scores than those in the experimental group, based on the posttest standard deviations of 6.540 and 7.774 for the corresponding experimental and control groups.

Table 2: Analysis of Covariance (ANCOVA) of the Difference in the Mean Achievement Score of students taught algebraic equation using concept mapping based strategy and those taught using conventional instructional strategy

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	705.194 ^a	4	176.299	4.573	.003	.289
Intercept	2442.269	1	2442.269	63.348	.000	.585
PREtest	5.755	1	5.755	.149	.701	.003
GROUP	30.896	1	30.896	.801	.375	.017
GENDER	556.217	1	556.217	14.427	.000	.243
GROUP * GENDER	182.181	1	182.181	4.725	.035	.095
Error	1734.886	45	38.553			
Total	68252.000	50				
Corrected Total	2440.080	49				

a. R Squared = .289 (Adjusted R Squared = .226)

Table 2 displays the results of the ANCOVA comparing the average achievement scores of students taught algebra using concept mapping versus lecturing method. The statistical analysis indicates that there is no discernible difference between pupils taught algebra through concept mapping and those taught using lecturing methods in terms of achievement. $p=.801$, $F(1, 45) =.375$. This is because the test result's associated probability (Sig.) value of .375 is higher than the 0.05 level of significance. Therefore, the initial assumption (null hypothesis) that there was no significant difference in achievement between students taught algebra with concept mapping and those taught

lecturing method was not disproven. Based on statistical analysis, there was little variation in the two groups' achievement, with the teaching method accounting for only 1.7% of the range in results. In conclusion, there was no statistically significant difference in the average algebra scores between students taught using concept mapping and those taught using lecturing methods. This implies that students of the experimental group who were taught algebraic equation using concept mapping based strategy do not differ significantly in their achievement scores with those of the control group who were taught algebraic equation using lecturing instructional strategy.

Table 3: Mean analysis of the achievement score of male and female students' taught algebraic equations using concept mapping based strategy and those taught using conventional instructional strategy

Gender	N	Pretest		Posttest		Mean Difference
		\bar{x}	SD	\bar{x}	SD	
Female	27	22.74	4.776	39.19	5.122	16.45
Male	23	22.17	4.858	32.87	7.576	10.70

Note: N = Number of Respondents, \bar{X} = Mean, SD = Standard deviation

The average achievement scores for male and female algebra students taught using concept mapping and lecturing techniques are shown in Table 3. The mean achievement score for male students was (\bar{x} =

22.17, $SD = 4.858$) at the pretest and (\bar{x} = 32.87, $SD = 7.576$) at the posttest, while the mean score for female students was (\bar{x} = 22.74, $SD = 4.776$) at the pretest and (\bar{x} = 39.19, $SD = 5.122$) at the posttest, as indicated by



the table. Furthermore, the average achievement score difference for male and female students was 10.70 and 16.45, respectively, indicating that the mean achievement score gap was greater for the female students. Additionally, it may be inferred that male students exhibited greater variety in their individual performance scores compared to female students based on the posttest standard deviations of 5.122 and 7.576 for male and female students, respectively.

Hypothesis 2

The statistical analysis (ANCOVA) that looks at how gender affects the achievement gap in algebra between students taught algebraic equation using lecturing method and those taught utilizing concept mapping is shown in Table 2. The achievement of male and female students in algebra differs statistically significantly regardless of whether they were taught using concept mapping or lecturing methods $F(1, 45) = .000, p=14.427$. This is because the result is being tested at a significance level of 0.05, and the associated probability (Sig.) value of 0.000 is less than the set level of significance of 0.05. Therefore the second hypothesis, according to which gender has no bearing on achievement in mathematics, was disproved. Statistical analysis indicated that gender significantly influenced algebra achievement, accounting for 24.3% of the variation in scores between male and female students. In summary, there is a significant difference in algebra achievement between male and female students, regardless of whether they were taught using concept mapping or lecturing methods.

Discussion

The findings of this study revealed that the mean achievement scores of students in the experimental group (concept mapping based strategy) were found to be less than students in control group (lecturing method) at pretest. In contrast, however, the mean achievement scores of students in the experimental group (concept mapping based strategy) were found to be higher than the control group (lecturing method) at the posttest. It could be inferred that students in the control group had more variety in their individual achievement scores than those in the experimental group, based on the posttest standard deviations for the corresponding experimental and control groups. From the test of hypothesis one, the statistical analysis indicates that there is no significance difference between students taught algebra equations through concept mapping and those taught algebra

equations using lecturing methods in terms of achievement in favour of those exposed to concept mapping teaching strategy. The difference in their individual achievement score might have been attributed to the fact that, students found concept mapping teaching strategy more engaging and hence the students' higher achievement scores.

The finding of the study is in agreement with Shamaki (2015) who got a significantly better result when concept mapping was used to teach biology. This agreement might be as a result of administration of proper teaching instruction by different teachers. Teachers who communicate instruction to learners in a proper way are liable to cause the learners some impactful academic achievement that might accelerate their learning abilities.

The result of the findings has shown that the mean achievement score for male students was found to be slightly higher at posttest than at pretest. Likewise the mean achievement score for female students was found to be higher at posttest than at pretest. Further analysis of the results showed that the mean achievement score for female students was found to be higher than their male counterpart at posttest, indicating that the mean achievement score gap was greater in favour of the female students. It could be inferred that male students exhibited greater variety in their individual performance scores compared to female students based on the posttest standard deviations for male and female students, respectively. From the test of hypothesis 2, the statistical analysis (ANCOVA) that looks at how gender affects the achievement gap in algebra equations between students taught lecturing method and those taught utilizing concept mapping indicated that achievement of male and female students in algebra differs statistically significantly regardless of whether they were taught using concept mapping or lecturing methods.

This study is in disagreement with Khadijat (2017) whose result showed that male students achieve better than their female counterparts when taught algebraic equations concept mapping strategy with those taught algebraic equations using lecturing method. It is obvious that the issue of gender has always been a contentious one in the learning of mathematics by the secondary students. This disagreement could be as a result of teaching strategies employed by different teachers who might possess different teaching styles, which could be depending on their academic experience and exposure which could translate to what they teach and hence the noticeable difference.



Conclusions

Following the findings of this study on effect of concept mapping based and lecturing method instructional strategies on secondary school students' achievement in algebraic equations in Nsukka Education zone, it was concluded that teaching strategies have significant effects on academic achievement of students in mathematics. It was further found that there was no significant moderating influence of teaching strategies on gender on students' achievement in mathematics.

Recommendations

Based on the findings of this study, the following recommendations are made to mathematics teachers and school administrators:

1. Mathematics teachers should improve their students' achievement in algebra by adopting concept mapping based strategy.
2. School administrators should ensure strict supervision of Mathematics teachers so as to enable them adopt the use concept mapping based strategy other than lecturing method in delivering mathematics lessons.

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