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Effect of Concept Mapping on Students' Academic Performance in Algebra at Senior Secondary School Level

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Abstract - This study investigated the effect of concept mapping on students' academic performance in algebra at senior secondary school level. It is intended to use a different form of teaching mathematics in order to provide a solution to the problems that arise in mathematics teaching and learning. As a quasi experimental study which comprised of SS II students in Ogun State, 165 students in four intact classes were involved in the study. A-50 item multiple choice achievement test on algebra (r = 0.93) and 20 item altitudinal questionnaire (0.78) were administered on the selected sample, where the exercise lasted for 12 weeks. Data analysis was done via Mean, Standard deviation and Multivariate Analysis of Covariance (MANCOVA) at α = 0.05 level of significance. The findings revealed that; there is statistically significant effect of concept mapping on students' achievement in algebra, there is no statistically significant effect of concept mapping on students' attitude toward algebra. Based on the findings, it was recommended that concept mapping should be introduced to reduce perpetual underachievement of students in Mathematics in the Nigerian senior secondary schools.

Keywords:- *Concept Mapping, Academic, Attitude, Performance, Algebra.*

I. INTRODUCTION

For teachers, students, and society, mathematics is a vital subject. Individual intellectual qualities such as reasoning, thinking, induction, interpretation, originality, creativity, and discovery are all developed through mathematics. Mathematics is a body of knowledge that is needed for a scientific and technological nation to succeed. According to Ale and Lawal (2010), the line dividing industrialized and developing countries is drawn based on their mathematical attainment and creativity. According to them, mathematics is an undisputed agent of national development and wealth creation. Mathematics education is one of the subjects that have been identified as a major factor in progress and prompting a national emphasis on the topic (Ogena, 2010).

Any nation's economic and technological growth is built on the basis of mathematics. It is believed that without mathematics, no modern technology can exist, which is why mathematics is made a compulsory subject in Nigerian primary and secondary schools (FRN 2014). Thus, Mathematics is supposed to aid in the acceleration of every society's social, economic, and technical growth. However, in the end, these are dependent on successful mathematics teaching and learning in schools. Despite the importance and relevance of mathematics to the students' academic progress, many problems still attach to it which has resulted to unstable performance in Senior Secondary Certificate Examinations. The themes of the current Mathematics curriculum for senior secondary school are based on five-pronged approach as follows: Number and numeration, Algebraic processes, Geometry, Statistics and Introductory calculus (NERDC 2007). Among the themes mentioned, algebraic processes serve as a connecting bridge that connects other themes of mathematics.

Algebra is a subset of mathematics that uses letters rather than numbers to solve problems. Algebra, as a key to mathematics, is one of the subjects in which students fail the most (Usman and Musa, 2019**).** Students' weak Algebra performance can be traced back to mistakes made by students when attempting to solve algebraic problems, which can be formal, logical, or both. The mystery of computational skills and knowledge of procedures for identifying mathematical components, algorithms, and definitions are linked to procedural knowledge, while conceptual errors are linked to conceptual knowledge, which refers to knowledge of the underlying structure of mathematics, the relationships and interconnections of ideas that explain a problem (Eisenhart, Borko, Underhill., Brown, Jones, &Agard, 1993).

Gender studies are popular in algebra as a branch of mathematics (Akinsola and Awofala, 2009). This is because many have suggested that the stereotypically masculine content of mathematics word problems could account for some of the gender disparities in success on such objects, but Arigbabu and Mji (2004) found no evidence to support this theory. It is expected that the educational experience given to students in schools does not discriminate between

men and women. It is important to ensure that male and female students have equal access to mathematics education.

In this sense, students' algebraic success is referred to as their academic achievement in Algebra and their attitude toward Algebra. Academic achievement refers to the consistency of a student's test or evaluation results as compared to those of other students at the same level. The consistency of a student's performance is reflected in their grade or test (Ginga, Muhammed and Usman 2019). A learned predisposition to react positively or negatively to a particular object, circumstance, organization, or individual is known as attitude (Aiken 2000). As a consequence, people's attitudes influence what they do and represent who they are, making attitude a deciding factor in their actions (Lin, Tseng, and Chiang 2017). Although there are several factors that influence students' success, several researchers believe that attitude is a significant factor to consider when attempting to understand and explain variability in student mathematics performance (Mohamed &Waheed, 2011).

According to Ginga, Muhammed and Usman (2019) poor mathematics output is attributable to a lack of teaching materials, mathematics phobia, teaching system, and insufficient teaching facilities, which include equipment and instructional materials for successful teaching.

Teachers' factor, which consists of mastery of the subject matter, instructional techniques and methods, classroom management, communication skills, and personality, was described as one of three suspected factors influencing underachievement in mathematics by Mcguire (as cited in Joefel 2014). The second consideration is the students' study habits, time management, attitude and interest in mathematics. Third are environmental factors such as parents, values, attitude, classroom setting and peer group. It was recommended by Mcguire (as quoted in Joefel 2014), teachers are also the key contributors and have the greatest effect on student achievement; thus, teachers should go beyond and beyond to reach out to students, assisting them in developing critical thinking analysis. In light of the foregoing, teaching strategies that emphasize realistic ways of teaching and learning mathematics, as well as modern technologies and critical thinking within the framework of active learning, are needed. Concept mapping is one such technique.

A technique for visually representing the structure of knowledge, concepts, and their relationships is concept mapping. The word "concept mapping" comes from the term "concept map." Concept maps, according to Rao (2015), are diagrammatic representations that display meaningful relationships between concepts as propositions connected together by terms, circles, and cross links. As a result, concept mapping is a structured process centered on a subject or construct of interest that involves input from one or more participants and results in an interpretable pictorial view of their ideas and concepts, as well as how they are associated (Yusuf, 2009 In the 1960s, Novak came up with the concept of concept mapping as a way to visually reflect the structure of data (Oviewe and Lukmon 2017). The method revealed connections between various sets of data. A concept map (also known as a Knowledge Graph) is made up of network nodes (points or vertices) and links (edges or arcs), with each node representing a concept and each connection representing a relationship between concepts (Novak 1991). One-way, two-way, or non-directional connections could be used. The key distinction between mind maps and idea maps is that the former has only one core concept, while the latter can have many (Lanzing 1997). Ideas are organized hierarchically in concept charts, with super ordinate concepts at the top and subordinate concepts at the bottom, which are less inclusive than higher ones. Cross ties are used to connect various parts of the hierarchy of concepts, indicating synergies of similar concepts, new interpretations of old ideas, and some degree of imaginative thinking. Constructivist theory (Vygotsky, 1978) defines learning by idea mapping as a hands-on task that promotes experiential learning. Concept maps are rooted in constructivism (Ariaga, B. A., & Nwanekezi, A. U. 2018).

According to Stoica, Moranu, and Miron (2011), constructivist learning theory suggests that in order to be recognized and gain value, new information should be incorporated into existing frameworks. By making this process clear and asking the learner to pay attention to the relationships between concepts, concept mapping stimulates it. The relationships or inter-relationships of a new concept/idea with current or already established concepts/ideas are described diagrammatically and in a hierarchical order in the concept mapping instructional strategy (Smith & Dwyer, 1995). Students' achievement and interest in a topic may be boosted by a hierarchical presentation of ideas that progress from basic to complex. Concept mapping is a teaching and learning strategy that establishes a bridge between how people learn knowledge and sensible learning (Karayuku 2010).

Concept Mapping, according to Chawla and Singh (2015), is a unique way of representing knowledge, with three features: (a) a list of concepts, (b) lines that represent the relational ties between these concepts, and (c) labels for these linking relationships.

Awofala (2011) opined that another way to build the requisite "mind-on" atmosphere that distinguishes coherent mathematics instruction from a set of discrete activities is to use concept mapping. To facilitate practical learning, concept mapping combines visually learning with spatial representation of information. According to Ahmed (2010), concept maps can be used as an advanced organizer to improve learners' achievement, provide teachers with a meaningful and practical structured approach, aid in the development of deep meaningful teaching moving towards critical thinking rather than surface approaches, and enable students to reflect on their own misunderstandings.

A Strong Concept Map Has The Following Characteristics:

- A design map is typically based on a single central idea.
- The main theory is subdivided into general principles.

- General terms can be further subdivided into more basic concepts, which can be further subdivided into levels.
- Concepts are nouns that describe events of things. Each concept should be a single concept with only one appearance in the chart.
- Specific principles are explained by the use of examples.
- Linking terms are used to demonstrate relationships between concepts (usually verb, adverbs, verb phrases, or prepositions).
- Cross-linkages are used to link concepts on the map in two separate directions. The greater the number of cross-links, the greater the scope of understanding. Linkage lines can cross.
- Taken separately, any two concepts and their connecting word can form a complete thought.

II. STATEMENT OF THE PROBLEM

Many students find it challenging to learn mathematics, and they often fail to excel. This may be due to the fact that their learning methods do not enable them to establish adequate understanding of fundamental mathematics concepts. Students' shortcomings in Algebra theme range from word problems leading to simple linear equations, algebraic graph, reading/answering from the graph, interpretation/solution to word problems, translation of word problems into mathematical expressions, inequality, and graphical solutions to quadratic equations, according to reports from the WAEC Chief Examiners (Mathematics) from May/June 2008 to May/June 2018 SSCE. Mathematics result analysis from those periods (May/June 2008 to May/June 2018 SSCE) also shows that students' performance in mathematics has been fluctuating; it is not stabling increasing or decreasing. The result of this examination is also used as prerequisite for admission into institutions of higher learning where students could go to pursue courses in their areas of interest (Uche, 2013)

One of the areas of mathematics in which students have big problems is algebra as a bridge between themes. Individuals and nations benefit from recognizing Algebra and using it correctly to solve daily problems. Despite the importance of algebra in the growth of science and current efforts in mathematics instruction, students continue to perform poorly in this field (Usman and Musa 2019). Meanwhile, due to students' poor results, teaching and learning algebraic literacy in classrooms continues to involve various interactive assignments, approaches, and instructional methods (Azuka, Jekayinfa, Durojaiye & Okwuoza, 2013).

Quadratic equations have been a central subject not only in secondary curricula around the world, but also in the historical history of Algebra, according to Didis and Erbas (2015). The quadratic equation, on the other hand, serves as a link between mathematical topics like linear equations, simultaneous equations, functions, and polynomials, as well as other related topics. Despite math's high ranking in the Nigeria education system, it's disheartening that methods and techniques for teaching and learning this topic at both the primary and secondary levels are unlikely to be put to good use, encouraging learners' participation and providing supervised practice, helping them to retain concepts and solve problems (Achor, Imoko & Uloko 2009).

Aforementioned issues may not be exclusively due to the method of teaching, but how students are taught has a significant impact on their success. However, evidence has abound in recent years showing that the concept mapping approach greatly improved students' mathematics achievement compared to conventional approaches, had no gender impact, and encouraged students' classroom engagement and interest (Nwoke, Iwu & Izoma 2015). As a result, research into implementing an alternative teaching method is needed in order to provide a solution to this issue. As a result, the researcher wanted to look into the impact of concept mapping on students' algebra success at the senior secondary schools level in Ogun State Schools.

III. RESEARCH QUESTIONS

The following research questions were formulated to guide the study:

1. What is the effect of concept mapping on students' achievement in algebra?
2. What is the effect of concept mapping on students' attitude toward algebra?

IV. NULL HYPOTHESES

Based on aforementioned research questions, the following hypotheses were generated.

H_{o1} There is no statistically significant effect of concept mapping on students' achievement in algebra

H_{o2} There is no statistically significant effect of concept mapping on students' attitude towards algebra

V. METHODOLOGY

The study employed a quasi-experimental pretest, posttest nonequivalent control group design. The study population for study comprised public senior secondary schools in Ogun State. The population includes both male and female students and other members of public senior secondary schools in Ogun State. Simple random sampling technique was used to select two divisions out of the four education blocs in Ogun State while four public senior secondary schools were randomly selected for the study. Two schools each were assigned to the experimental group (Concept mapping) and control group. The experimental group received treatment based on concept mapping strategy while the control group was taught using traditional method, both groups covered the same content material which lasted for 12 weeks. One arm in each of the sampled schools was used and intact class was adopted for the study since random assignment of the students' to the groups was not achieved.

Prior to the commencement of the treatment, the research assistants that served as the facilitators for concept mapping group were trained by the researcher on how to build and link concepts manually and electronically using a computer software (Cmap 6.0) deriving keywords from the

mathematics text books. The facilitators later trained students the key features of the concept maps and how to build and map concepts manually (free hand sketching) deriving keywords from their mathematics text books. After the training, students took part in pre-achievement and pre-attitude tests before the commencement of the treatment. During the treatment, after the introduction of the topic, the facilitator will show the students the flash cards that contain the concepts words and asked the students to read out the word on each flash card. Then the facilitator reads the word on each flash card and asks the students about what they think of each word. Students are to explain what they think about each of the concept words. They are to mention more examples of concept words indicating whether the words are object or event words. The facilitator reads out common link words on another set of flash cards. Then ask the students to explain what comes to their minds about each of these words and what the words can be used for. The facilitator later explains that the words are used together with concepts words to form meaningful sentences. Hence they are called Link Words. The students are then asked to list more examples of link words. Students to explain what comes to their minds with one another, on hearing the teacher reading out each link word and explain what the words are used for. They are given more examples of link words. The facilitator reads out a set of proper noun words from another set of flash cards and asks students to explain what comes to their minds on hearing each of the words and what the words are used for. He then points out that the words are proper nouns which are names of specific places, people, objects or events and that they are used to label specific events or objects. On the other hand, they are used to label regularities in objects or events. The facilitator leads the students in constructing simple short sentences from a list of objects and event words on the chalkboard by using appropriate link words to join concept words together. The facilitator explains that when two or more concept words are linked together to produce a new idea, then a proposition is formed. Students are to construct simple propositions from the list of concept words and link words on the chalkboard. With the aid of concept map on the chalk board, the facilitator explains and work examples of the focus topic for the students.

The instruments used for the study were Achievement Test in Algebra (ATA) and Attitude questionnaire in Algebra (AQA). ATA which consisted of 50 items multiple choice questions on selected topics in Algebra with four options that comprised three distracters and one key while AQA is an instrument developed by the researcher that elicits information from the students on their attitude towards Algebra. The AQA is made up of two sections A and B. Section A collected information on students name, school, school location and Gender while section B comprised 20 items (positive and Negative statements) requesting students to indicate their attitude towards the study of algebra based on four point modified Likert scale of Strongly Agree, (4), Agree (3), Disagree (2) and strongly disagree. The instruments were administered to both experimental and control groups before and after the treatment. The instruments were given to experts in Mathematics Education for some structural corrections, adjustments and suggestions to enhance the final production ahead of administration. The instruments ATA and AQA were subjected to reliability test using the Kuder-Richardson's formula K- R 21 and Cronbach's Alpha with the coefficient of reliability found to be 0.93 and 0.78 respectively. This score suggested that the instruments were found to be useful and consistent for the purpose for which they were prepared.

The data collected was subjected to statistical tool of Mean, Standard Deviation and Multivariate Analysis of Covariance (MANCOVA) using SPSS to test the efficacy of experimental group over control group. An alpha level of 0.05 was used to test the hypotheses.

VI. FINDINGS

Research Question 1: What is the effect of concept mapping on students' achievement in algebra?

Table 6: *Mean and Standard Deviation of student's achievement Scores in Algebra*

METHOD	Mean	Std. Deviation	N
CONCEPT MAPPING	26.0238	3.49518	84
TRADITIONAL	19.5926	4.83161	81

Table 6 shows that students taught with concept mapping strategy had the higher mean score (Mean = 26.02, S.D = 3.49) while the students taught with traditional method had the lowest mean score (Mean = 19.59, 4.83) in the post-test of algebraic achievement test. To ascertain whether the observed effect was significant, null hypothesis 1 was tested.

H_{o1} There is no statistically significant effect of concept mapping on students' achievement in algebra.

This hypothesis was tested using the multivariate analysis of covariance (MANCOVA) statistical technique at $p < 0.05$ significance. The result of the MANCOVA is shown in tables 2 and 3

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Table 2: Table showing the multivariate tests of students' performance

Effect		Value	F	Hypothesis df	Error df	Sig.
Intercept	Pillai's Trace	.582	110.030[b]	2.000	158.000	.000
	Wilks' Lambda	.418	110.030[b]	2.000	158.000	.000
	Hotelling's Trace	1.393	110.030[b]	2.000	158.000	.000
	Roy's Largest Root	1.393	110.030[b]	2.000	158.000	.000
PREACHIVEMENT	Pillai's Trace	.072	6.090[b]	2.000	158.000	.003
	Wilks' Lambda	.928	6.090[b]	2.000	158.000	.003
	Hotelling's Trace	.077	6.090[b]	2.000	158.000	.003
	Roy's Largest Root	.077	6.090[b]	2.000	158.000	.003
PREATTITUDE	Pillai's Trace	.014	1.133[b]	2.000	158.000	.325
	Wilks' Lambda	.986	1.133[b]	2.000	158.000	.325
	Hotelling's Trace	.014	1.133[b]	2.000	158.000	.325
	Roy's Largest Root	.014	1.133[b]	2.000	158.000	.325
METHOD	Pillai's Trace	.332	39.236[b]	2.000	158.000	.000
	Wilks' Lambda	.668	39.236[b]	2.000	158.000	.000
	Hotelling's Trace	.497	39.236[b]	2.000	158.000	.000
	Roy's Largest Root	.497	39.236[b]	2.000	158.000	.000

Source: Field data

The Wilks' Lambda associated with the instructional method was significant (($F_{(2,163)} = 39.27$, $p < 0.05$) which necessitated further probes into between subjects.

Table 3: Tests of Between-Subjects of effects instructional strategies and students performance

Source	Dependent Variable	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	POSTACHIEVEMENT	1951.340[a]	5	390.268	23.543	.000
	POSTATTITUDE	656.460[b]	5	131.292	2.659	.024
Intercept	POSTACHIEVEMENT	915.459	1	915.459	55.225	.000
	POSTATTITUDE	8413.069	1	8413.069	170.379	.000
PREACHIVEMENT	POSTACHIEVEMENT	202.659	1	202.659	12.225	.001
	POSTATTITUDE	.533	1	.533	.011	.917
PREATTITUDE	POSTACHIEVEMENT	1.483	1	1.483	.089	.765
	POSTATTITUDE	109.079	1	109.079	2.209	.139
METHOD	POSTACHIEVEMENT	1270.698	1	1270.698	76.655	.000
	POSTATTITUDE	144.853	1	144.853	2.934	.089
Error	POSTACHIEVEMENT	2635.726	159	16.577		
	POSTATTITUDE	7851.177	159	49.378		
Total	POSTACHIEVEMENT	90863.000	165			
	POSTATTITUDE	546304.000	165			
Corrected Total	POSTACHIEVEMENT	4587.067	164			
	POSTATTITUDE	8507.636	164			

Source: Field data

The F-value associated with Pre-Achievement Test (Covariate) was found to be significant. [$F_{(1,163)} = 202.66$; $p<.05$]. This confirms that the students in the two groups were significantly different in the Algebraic achievement level before the application of the treatment.

The result in table 3 showed that there is statistically significant effect of concept mapping strategy on students' achievement in Algebra.

[$F = 376.17$; $p<.05$]

Therefore, the null hypothesis which states that there is no statistically significant effect of concept mapping on students' achievement in Algebra is hereby rejected. The study revealed that there is a differential effect of concept mapping and traditional method on students' achievement in algebra.

Research Question 2: What is the effect of concept mapping on students' attitude toward algebra?

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Table 4: Mean and Standard Deviation of students attitudinal Scores in Algebra

METHOD	Mean	Std. Deviation	N
CONCEPT MAPPING	57.8333	7.27073	84
TRADITIONAL	56.3210	7.09371	81

Table 4 shows that students taught with concept mapping had the higher mean score (Mean = 57.83, S.D = 7.27) while the students taught with traditional method had the lowest mean score (Mean = 56.32, 7.09) in the post-test of students attitudinal questionnaire toward algebra. To ascertain whether the observed effect was significant, null hypothesis 2 was tested.

H_{o2} There is no statistically significant effect of concept mapping on students' attitude towards algebra

This hypothesis was tested using the multivariate analysis of covariance (MANCOVA) statistical technique at $p< 0.05$ significance. The result of the MANCOVA is shown in table 2 and 3

The F-value in table 2 associated with Pre-Attitude Test (Covariate) was found to be insignificant. [$F_{(1,163)} = 109.08$; $p>.05$]. This confirms that the students in the two groups were not significantly different in the attitudinal level toward Algebra before the application of the treatment.

The result in table 3 showed that there is no statistically significant effect of concept mapping strategy on students' attitude toward Algebra.

[$F = 144.85$; $p>.05$]

Therefore, the null hypothesis which states that there is no statistically significant effect of concept mapping on students' attitude toward Algebra is not rejected. The study revealed that there is a no differential effect of concept mapping and traditional method on students' attitude toward algebra.

VII. DISCUSSION

This study investigated the effect of concept mapping on students' performance in Algebra at senior secondary level. The study revealed that concept mapping improves students' performance in Algebra compare to traditional method of teaching and students' attitude toward learning of Algebra does not attached to any particular instructional strategy. Students attitude are shaped by the teachers' propensity, decisions made by the teacher in interpreting the curriculum, mode of disseminating instructions and the impact of conceptually oriented mathematics instructional materials with consistency. According to Awofala (2011) concept mapping approach was more successful than the traditional teaching method in improving students' achievement on multiple-choice assessments.. The findings of this study was substantiated by the studies of Adediran, Ochu and Atoo (2018), Alshamari (2018), Ariaga & Nwanekezi (2018), Onyejekwe, Uchendu & Nmom (2018), Lawal, Aminu and Gambo (2017), Oviawe and Lukmon (2017), Kayakuru (2010) who show that the students taught using concept mapping method performed better than students taught using the traditional method.

VIII. CONCLUSION

Aside from the fact that Algebra plays prominent role towards attainment of teaching and learning of mathematics, it is also serve as a bridge between mathematics themes. Its importance to everyday activity also cannot be over emphasized. This study investigated the effects of concept mapping strategy on students' performance in algebra. The findings from the study revealed that; there is statistically significant difference in students' achievement in algebra and there is no statistically significant difference in effect of students' attitude Algebra.

IX. RECOMMENDATIONS

Considering the problems identified and based on the findings of this study, thus the followings are recommended:

- Secondary school teachers should be encouraged and inspired to abandon conventional methods of teaching mathematics, especially Algebra concepts.
- Teachers and educators in mathematics at all levels should explore the use of concept mapping as a mode of instruction in the classroom.
- Mathematics teachers at the secondary school level are urged to adopt more activity based strategy of instruction like concept mapping that have potential of improving students' performance in Mathematics.
- Since concept mapping enhances the meaningful learning of Algebra, there is therefore the need to further train teachers on the use of this instructional strategy.
- Seminars for mathematics teachers should be held on a regular basis with the aim of equipping them with the skills and strategies necessary to use concept mapping effectively in the teaching and learning of mathematics.
- Curriculum planners and policymakers should embrace and promote the use of concept mapping in high school mathematics teaching and learning.
- Government agencies and related stakeholders responsible for the management and growth of the country's education sector should make resources available to promote the adoption and implementation of concept mapping in mathematics instruction in our secondary schools.

X. SUGGESTIONS FOR FURTHER STUDIES

This study investigated the effects of concept mapping on students' performance in Algebra. Based on the findings of this study, the following recommendations for further research were made:

- Further studies are needed to unravel the insignificant of concept mapping effect on students' attitude.

- Further studies are invited to replicate this study in another population for cross validation

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