



Impacts of Concept Mapping Strategy on Performance of Students of Different Ability Levels in Algebra in Kogi State, Nigeria

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ABSTRACT

This study investigated the effect of concept-mapping strategy on the performance of secondary school students of different ability levels in algebra in Kogi State, Nigeria. A quasi-experimental-control design comprising pretest and posttest was used and sample consisted of two hundred and forty (240) SS II students from six intact classes in six schools selected by multistage cluster sampling procedure from all senior secondary schools with a total population of 18,306 SS II students in Kogi state Nigeria. These subjects were divided into three ability levels: low, medium and high. One (1) hypothesis was formulated to direct the study. Algebraic Performance Test (APT) was used to collect data from the sampled schools. Data collected were analyzed using two ways Analysis of Variance (ANOVA) and post hoc Scheffe's Test at $P \leq 0.05$ level of significance. The result indicated that, there are significant differences in the mean performance score in algebra between subjects in experimental and those in control groups such that the difference between the mean score of students in each ability level in experimental group and those in control group is significant and also the mean score of medium ability level students in experimental group is higher than that of the high ability level students in control group. Based on the research findings, it is recommended among other that the use of concept mapping strategy for teaching mathematics should be encouraged by government in our secondary schools to improve high, medium and low ability level students' performance in the study of algebra.

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INTRODUCTION

Mathematics teaching in Nigeria has continued to generate a great deal of interest. The fact that the average Nigerian child seems to under-achieve in mathematics is a source of serious concern to educationists, parents and the general public. Mathematics occupies a central place in the Nigerian educational system.

The importance of mathematics to nation building has led the Federal Government of Nigeria to make mathematics a core subject to be offered by secondary school students in Nigeria as stipulated in the National Policy on Education (FRN, 2013).

Anagolu (2006) observed that students have problems on how to study mathematics. These problems arise as a



result of a lot of problems facing the effective teaching and learning of mathematics at all levels of Nigerian educational institution. Okafor (2008) identified poor teaching methods as the major factor contributing to the poor performance of students in mathematics. It is an acknowledged fact that the mathematics classroom in senior secondary schools in Nigeria has been associated with traditional patterns of teaching and learning, a teachers-centered approach with greater emphasis on lecture method and a situation in which learners are passive listeners that have remained unchanged leading to persistence memorization of mathematical facts devoid of meaningful learning (Okoli, 2008).

However, the National Policy on Education stipulated that education activities shall be learner centered for maximum self-development and self-fulfillment. The need to devise alternative effective instructional strategy that work in line with the desire of this policy is the purpose of this study. The researcher therefore, seeks to determine the impact of concept mapping strategy on the performance in algebra of secondary school students of different abilities levels.

According to Novak (2000) Concept mapping is a tool for representing the interrelationships among concepts in an integrated, hierarchical manner. On the other hand, Juall and Moyet (2005) maintained that concept mapping is an educational technique that uses diagrams to demonstrate the relation of one concept to another. This is done by linking a central concept to other ones which help the learners understand the central concept better. The construction of concept mapping involves: focusing on a theme and then identify related key words or phrases, ranking the concepts (key words) from the most abstract and inclusive to the most concrete and specific, clustering concepts

that function at similar level of abstraction and those that interrelate, arranging concepts into a diagrammatic representation, and linking concepts with linking lines and label each line with a proposition. Concept mapping activities in algebra as carried out in this study were in line with these steps. More so, academic performance in relation to concept mapping is another variable in this study that needs to be highlighted.

Academic Performance according to Uba (2000) is about knowledge and skills possessed by an individual as a result of instruction or specific curricular that has been administered. It is a quantitative indication of the positive result of behavior accruing from the study of school subjects. Concept mapping strategy has been seen to improve students' academic performance (Adeneye & Adeleye 2011; Akeju, Rotimi & Kenni, 2011). But on the contrary, it was not (Ajaja, 2011). This study determined whether or not concept mapping strategy could improve academic performance of SSII students of different ability level in the study of algebra.

Ability level is the classification of students into categories based on their performance in a test or examination. The indices of categorization are students scores obtained from the test or examination. Experts such as Ajewole and Okebukola in Lakpini (2005) and Talca (2007) has identified three types of ability levels in relation to teaching learning situation. These are low, medium and high ability levels. Low ability level learners as indicated by Ofonime (2007) are those whose academic potentials are judged below class average while their performance is described as poor Also, medium ability level learners are those who can only record average academic performance not because they are not capable of doing better but partly because they cannot put in extra effort to attain



better performance hence, contend themselves to classroom learning without trying to reach out to other information (Tylor, 2001; Eledea, 2002 & Awe, 2003). High ability level learners as pointed out by Ofonime (2007) are those whose academic potentials are above class average and their performance described as good.

The mode of categorization of students into each of the ability level based on test scores varies from expert to expert. The categorization mode adopted for this study was that of Talca in which students with scores between 0 – 49 were placed as low ability level, those between 50 – 64 as medium ability level and 65 – 100 as high ability level. The choice of the model was based on the fact that it corresponds with WAEC and NECO grading system.

Mathematics is one of the compulsory entry requirements for admission into tertiary institution in Nigeria. One is expected to credit mathematics to qualify an individual for admission. It is an acknowledged fact that quite a large number of students were losing admission chances on yearly basis into tertiary institutions because of deficiency in mathematics which is a great worry to students, parents, mathematics educators and the society in general. Top on the list of factors identified by researchers for this state of affairs is the methods of instruction adopted by secondary school mathematics teachers and that teachers do not use to consider ability level in the teaching of mathematics assuming that students are all the same in their ability to learn. It was noted that instructional strategy is an important variable that affect students' performance and attitude towards algebra. Algebra is a branch of mathematics which students perceived as being hard and that they had little confidence in succeeding in it (Doerr, 2004). To this effect the study investigated the impacts of concept mapping strategy on the performance of

low, medium and high ability level students in selected topics in algebra when compared with those taught using conventional lecture methods.

Objectives of the Study

This study was design to determine the difference in academic performance that exist (if any) among SS II secondary school students of low, medium and high ability level exposed to concept mapping strategy compared to those exposed to conventional lecture method in algebra among.

Research Questions

In addressing the problem at hand, this research question was raised for answering:

What impact does concept mapping strategy has on academic performance in algebra among low, medium and high ability level students when compare to those taught with lecture method?

Null Hypotheses

From the research question, this hypothesis was formulated for testing at 0.05 level of significance:

H₀ : There are no significant differences in the mean performance score in algebra among low, medium and high ability level students exposed to concept mapping strategy and those exposed to lecture method.

RESEARCH METHODOLOGY

The study used quasi-experimental design involving pre-test and post-test in order to investigate the impact of concept mapping strategy on senior secondary students' performance in algebra on different abilities. A quasi-experimental research design was utilized because random assignment of subjects to the experimental and control groups was not allowed or not possible for the study rather,



intact classes were assigned to experimental and control groups. Secondary school classes exist as intact groups and school authorities do kick against any attempt to dismantle and reconstitute them for the purpose of research since this will disrupt school academic calendar. The pretest was conducted to show the equivalency of the subjects studied in terms of their performance in algebra before the treatment. The posttest was also conducted for the experimental and control groups to determine the impact of the treatment on the performance of the subjects in algebra in various ability levels.

The target population of this study comprised all the Senior Secondary two (SSII) students totaling 18,306 from 278 established public schools across the three senatorial districts of Kogi State, Nigeria for 2017/2018 academic session. The multistage cluster sampling procedure was used in selecting the sample for the study. This involved six intact arm of classes from six schools in six local LGAs randomly selected from 21 Local Government Areas (LGAs) in the state. From the average scores of students in their SSII first and second term mathematics examination, using Talca (2007) categorization of students into ability level, students with scores from 0 to 49 in each of the six arms of classes were placed as low ability level, those with scores from 50 to 64 as medium ability level and those with scores from 65 – 100 as high ability level.

The six selected intact arms of classes were assigned randomly into experimental and control groups. The three arms that made up the experimental sample (N=130) consist of 27 high ability level students, 41 medium ability level students and 62 low ability level students. The three arms that made up the control sample (N=110) consist of 25 high ability level students, 34 medium ability level

students and 51 low ability level students. This give a total sample size (N=240) which is viable for this study in line with Tuckman (1975) and Sambo (2008) who recommended that sample size of minimum of 30 subjects is viable for experimental study of this nature.

Data collection was through the use of a 50-item multiple-choice objective test questions with one key and four distracters tagged Algebraic Performance Test (APT) used for both pre-test and posttest. They included the same items with some variations in numbering and wording and the options interchanged. It was constructed by the researcher to measure student academic performance in algebra covering the selected topic covered in the study. Table of specification based on the topics selected for the study was constructed for the development of this instrument and marking scheme was used for scoring the test. To score the students' responses to each question in APT, two (2) marks were given to correct response while zero (0) awarded for incorrect or no responses.

The content of APT were assessed and corrected by two mathematics educators (Lecturers) who are professors in mathematics education from science education department and a specialist in English Language from English department, all from Ahmadu Bello University Zaria. Final copy of the instrument was produced with strict adherence to the observation made by the experts. The AAQ was administered on a sample of 40 students in a school that was not part of the study whose students demography in terms of age and class level were similar to the students involved in the main study. The reliability coefficient of APT was 0.72 using test retest method.

Two instructional strategies were used for the treatment administration processes which are Concept Mapping



Strategy (CMS) and Lecture Method. The Concept Mapping Strategy (CMS) which was an adoption of Hall (2011) concept mapping model was used to teach experimental group on some selected algebraic concepts considered to be difficult to students in the WAEC chief examiner's report 2017 such as: factorization of algebraic expression, quadratic equation and simultaneous linear equation by the researcher. This was done for a period of three weeks of 90 minutes lessons twice daily using Yin, Vanides, Ruiz-Primo, Ayala and Shavelson (2005) model of implementing concept mapping activities in the classroom which include the following steps:

Step 1— Introduction: Train the students if they have never created an open-ended type of concept mapping. The researcher drilled the students on how to construct concept mapping on a practice topic they are quite familiar with as they have never engaged in concept mapping construction. They were then given time to practice the construction of concept mappings on their own using a concept list related to the material taught in class provided by the teacher.

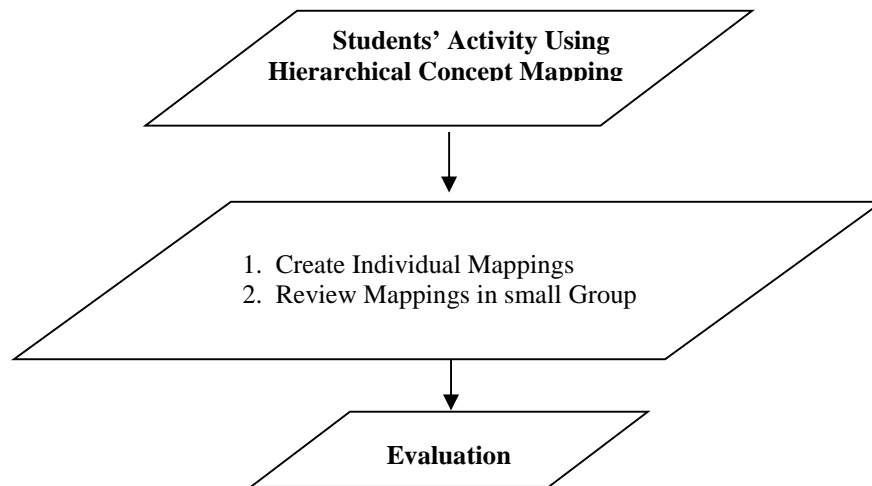
Step 2— Students Activity Using Hierarchical Concept Mapping:

Activity 1: Ask students to create their own individual mappings on the topic under discussion first using hierarchical model. This is to elicit the personal understanding of each student.

Activity 2: Organize students into small groups to discuss their individual concept mapping and have students share their concept mappings with partners, find similarities and differences in their mappings and try to reconcile them into a single mapping. These made them to articulate their thoughts and learn from each other.

Activity 3: Let the small group concept mappings be discussed in a whole class. This is done by asking the representative of each group to present and explain their concept mappings to the whole class. A whole-class mapping was created based on these discussions to document class progress. This was compared to the one constructed by the teacher on the topic such as the one presented in the appendix to widen the students' scope of understanding.

Step 4— Evaluation: Ask students questions on the lesson taught to know the students' level of understanding and get feedback on the level of attainment of lesson objectives.



Flow Chart of Concept Mapping Implementing Model in the Classroom

Source: Researcher (2016)



The group contains the low, medium and high ability level subjects. The control groups were also taught the same concepts by the researcher using lecture method for a period of three weeks of 90 minute lectures twice daily. Both the experimental the control group contain the low, medium and high ability level subjects.

However, descriptive statistics were used to analyze data to answer the research questions while Inferential statistics was used to analyze data to test the formulated null hypothesis for the study at 0.05 level of significance using Statistical Package for Social Sciences (SPSS). The research question was answered by means of mean and standard deviation. This is because the data collected in respect of them were interval data. Two way analysis of variance (ANOVA) and Scheffe's test were used to test the formulated null hypothesis.

DATA PRESENTATION AND RESULTS

The data obtained from the administration of APT were analyzed by means of descriptive and inferential statistics to answer the research questions and test the null hypotheses respectively using version 20 of the Statistical Packages for Social Sciences (SPSS) as follow:

RQ: What impact does concept mapping strategy has on academic performance in algebra among low, medium and high ability level students when compare to those taught with lecture method?

To analyse data to answer the research question, mean and standard deviation of students' scores in the three ability levels in the posttest were calculated as presented in Table 1.

Table1: Posttest Mean Performance Score and Standard Deviation of Low, Medium and High Ability Level Students in Experimental and Control Groups

Ability level	Group	N	Mean (\bar{x})	SD	Mean Diff
High	Experimental	27	41.39	3.48	7.39
	Control	25	34.00	2.36	
Medium	Experimental	41	34.02	2.30	7.11
	Control	34	26.91	2.14	
Low	Experimental	62	24.30	5.75	12.14
	Control	51	12.16	5.85	

In Table 1, the mean performance score difference between experimental and control group in high, medium and low ability levels as presented in the last column of the table were infavour of experimental group in every ability level. This showed that the experimental group in each of the three ability level performed higher than the control group. In order to establish if the differences are statistically significant, inferential statistics was used to test the null hypothesis.

Hypothesis Testing

To test the formulated null hypothesis, Two-Way analysis of variance and Scheffe's Test, were used as presented in Tables 2 and 3.

H₀ : There are no significant differences in the mean performance score in algebra among low, medium and high ability level students exposed to concept mapping strategy and those exposed to lecture method.



To test this hypothesis the posttest performance scores of students in various ability level in both experimental and

control group were computed using Two-Way Analysis of Variance (ANOVA). The result is presented in Table 2.

Table 2: Two-Way Analysis of Variance (ANOVA) of Students' Post-test Mean Performance Score in Algebra with respect to Ability Level and Group.

Source	SS	df	MS	F-value	P-value	Remark
Ability level	15311.022	2	7655.51	10.04	0.01	*
Group	20508.624	1	20508.62	26.90	0.00	*
Ability level X Group	4646.372	2	2323.19	3.05	0.00	*
Error	178383.742	234	762.32			
Total	197379.000	239				

* Significant at $P = 0.05$

The result in Table 2 showed significant differences: $P = 0.01 < 0.05$, $P = 0.00 < 0.05$ and $P = 0.00 < 0.05$ respectively. These imply that there are significant mean performance scores differences in algebra: among low, medium and high ability level students; between students in experimental and control group and in interaction between ability level and group. The null hypothesis H_0 is therefore rejected and the alternative hypothesis

which stated that there are significant differences in the mean performance score in algebra among low, medium and high ability level students exposed to concept mapping strategy and those exposed to lecture method upheld. However, the post hoc testing base on Scheffe's Test method was further used to analyze the collected data as presented in Table 3.

Table 3: Multiple Comparison of Post-test Mean Performance Scores of Low, Medium and High Ability Level Students in Experimental (E) and Control (C) Groups

(I) Ability levels	(J) Ability levels	Mean Difference (I-J)	Std. Error	P-value	Remark
High Ability E	High Ability C	7.3929*	1.22614	.001	*
	Medium Ability E	7.3690*	1.07540	.001	*
	Medium Ability C	14.4838*	1.13254	.022	*
	Low Ability E	17.0913*	1.00114	.001	*
High Ability C	Low Ability C	29.2329*	1.04042	.003	*
	High Ability E	-7.3929*	1.22614	.001	*
	Medium Ability E	-0.0238	1.12789	.381	**
	Medium Ability C	7.0909*	1.18250	.004	*
Medium Ability E	Low Ability E	9.6984*	1.05732	.001	*
	Low Ability C	21.8400*	1.09459	.002	*
	High Ability E	-7.3690*	1.0750	.001	*
	High Ability C	0.0238	1.12789	.095	**
Medium Ability C	Medium Ability C	7.1147*	1.02535	.001	*
	Low Ability E	9.7222*	0.87806	.031	*
	Low Ability C	21.8638*	0.92259	.002	*
	High Ability E	-14.4838*	1.13254	.001	*
High Ability C	High Ability C	-7.0909*	1.18250	.001	*

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Medium Ability C	Medium Ability E	-7.1147*	1.02535	.003	*
	Low Ability E	2.6075	0.94718	.186	**
	Low Ability C	14.7491*	0.98860	.001	*
	High Ability E	-17.0913*	1.00114	.001	*
	High Ability C	-9.6984*	1.05732	.023	*
Low Ability E	Medium Ability E	-9.7222*	0.87806	.001	*
	Medium Ability C	-2.6075	0.94718	.186	**
	Low Ability C	12.1416*	0.83485	.001	*
	High Ability E	-29.2329*	1.04042	.002	*
	High Ability C	-21.8400*	1.09459	.001	*
Low Ability C	Medium Ability E	-21.8638*	0.92259	.003	*
	Medium Ability C	-14.7491*	0.98860	.001	*
	Low Ability E	-12.1416*	0.83485	.004	*

* Significant at $P = 0.05$

** Not Significant at $P = 0.05$

The multiple comparisons in the Post Hoc analysis in Table 3 showed that significant differences in students mean performance scores do not exist in the following pairs: medium ability in experimental and high ability level in control group, low ability in experimental and medium ability level in control group. In each of these two pairs, the calculated P value is greater than 0.05 alpha levels. However, in each of all other pair of the multiple comparisons, the calculated P value is less than 0.05 alpha levels. This implies that there exists significant difference in students mean performance scores between each of the pair.

DISCUSSIONS

The pretest results from the present study showed that the mean score of the students in the experimental group was not significantly different from that of the students in the control group. This indicated that the two groups used in the study exhibited comparable characteristics. Hence, they both entered the instruction/experiment on equal strength. This goes to show that the two groups were suitable for the study when comparing the impacts of concept mapping strategy with the conventional lecture teaching method

on performance in algebra. Again, this is a confirmations that if any observable significant difference is seen in the the posttest mean scores of the two groups, then such difference would not be attributed to chance but the impact of the intervention which is the concept mapping strategy.

The post test mean performance score difference in algebra among low, medium and high ability level students that used concept mapping strategy and those exposed to lecture method resulting from analysis using two-way analysis of variance (ANOVA) in Table 1 were significant, indicating that concept mapping strategy prove to be more effective than the lecture method in improving performance in algebra. However, multiple comparisons using Scheffe test as shown in Table 3 further reveal the following results: High ability in experimental performed significantly higher than the Medium ability in experimental group. Other results in the same manner occurred between High ability in experimental and Low ability in experimental group, medium ability in experimental and Low ability in experimental group. These results supports the finding of Kehinde and Emmanuel (2011) which claimed that significant



difference exists in performance among various ability levels of students taught with concept mapping strategy. It could be deduce from this finding that concept mapping is not sensitive to ability level amendment. The implication is that concept mapping treatment has no capability to bridge the already existing ability level gap in performance among high, medium and low ability level subjects.

Furthermore, the significant difference in performance in algebra established between subjects in: High ability in experimental and High ability in control group in favour of experimental High ability level, Medium ability in experimental and Medium ability control group in favour of experimental Medium ability level, Low ability in experimental and Low ability control group in favour of experimental Low ability level, signifies the effectiveness of concept mapping strategy in improving the performance of secondary school students in algebra. Subjects in each ability level in experimental group performed significantly higher than their counterparts in the control group. This indicates that the use of concept mapping strategy in teaching algebra is potentially viable in promoting students performance in the algebra. This result is consistent with the findings of previous study like Okebukola (2005), which provided evidence that concept mapping is an effective tool for learning and promoting academic performance. This can be attributed to active participation and group interaction involved in concept mapping strategy which made the students in ability levels in the treatment group to excel significantly higher than their counterparts in the control group.

However, the no significant mean performance score difference in algebra between subjects in: Medium ability in experimental and High ability level in control group, Low ability in experimental and Medium ability level in control group

indicate that concept mapping strategy has a considerable impact in bridging the ability level gap in algebraic performance between students in experimental and control group to the extent that subjects in medium ability level in experimental group perform better than the high ability level ones in control group. The concept mapping treatment given to subjects in experimental group had made them to excel better in performance in algebra than those in control group. This finding contradicted the study of Lamiotte and Dansereau (2001) but corroborates similar result such as (Esiobu & Soyibo, 2006). The opportunity for active participation by the learner provided by concept mapping strategy which was lacked in the use of lecture method boost the performance of students in the lower ability levels.

CONCLUSIONS

The results of this study have indicated that Subjects in experimental group involved in concept mapping in algebra performed significantly higher than those in control group such that:

1. Subjects in each ability level in experimental group performed significantly higher than their counterparts in control group.
2. Medium ability level students in experimental group perform better than the high ability level students in control group.
3. Concept mapping strategy has a considerable impact in bridging the ability level gap in performance in algebra between students in low ability level in experimental group and those in medium ability level in control group as the difference between their mean score was not significant.



RECOMMENDATIONS

Based on the findings from the study, the following recommendations are made:

1. The use of concept mapping strategy for teaching mathematics should be encouraged by government in our secondary schools to improve high, medium and low ability level students' performance in the study of algebra.
2. Teacher training institutions such as Universities and Colleges of education that train secondary school mathematics teachers should incorporate the use of concept mapping strategy part of their mathematics teacher education curriculum to produce mathematics teachers who will promote the teaching of algebra through the use of concept mapping strategy.
3. The authors of secondary school mathematics textbooks should make concept mapping activities an integral part of their write up.

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