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Effects of concept Mapping and Lecture Methods on the Academic Achievement of Senior Secondary Biology Students in Federal Capital Territory Abuja, Nigeria

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Abstract
The study was aimed at determining the effect of using concept mappings and lecture methods on the academic achievement of biology students in senior secondary schools in federal capital territory. The study was carried out with two objectives and two hypotheses tested at 0.05 alpha level of significance. The study adopted quasi experimental pre-test post-test control group design. The population of the study consisted of 6,208 SSII Biology students of the Federal Capital Territory, from which 128 were selected from two schools within Karshi zone of Abuja Municipal Area Council. Intact classes of 64 students of SSII^A students of Government Secondary School Nyanya were used for the experimental group which consisted of students taught Biology using concept maps and 64 SSII^A students of Government Day Secondary School Karu were used for the control group respectively. The major instruments used for data collection were Biology Achievement Test pre-test and post-test (BAT), Biology Achievement Retention Test (BART) used after 2 weeks of instruction. The items used for the pre-test, post-test and retention test were adopted from Educational Resource Centre (ERC) Abuja. The items were lifted based on the topics used for the study. The reliability of these instrument used was 0.65,0.65 and 0.64 respectively. The data collected was analysed using comparative mean and standard deviation for research questions and the t-test for the hypotheses. The findings of the study showed no significant difference between students taught using concept mapping and lecture method on their mean scores and retention of these concepts. Based on the findings, of no significant difference in the two methods used for the study the lecture method should be moved from a passive teacher oriented one by using relevant visual aids and involving the students through questioning, active participation and students' contribution to lessons.
Keywords: lecture method, concept mapping**,** academic achievement

Introduction

Biology is one of the vital science subjects studied in the Nigerian senior secondary schools. Biology as a key science subject refers to the study of plants and animals. The National policy on Education (2013) confirms the importance of biology in Nigeria when it listed biology as one of the core science subjects which are compulsory for all science secondary students in the senior classes. Biology occupies a unique position in the school

curriculum; this is because Biology is central to many sciences related professional courses such as Medicine, Pharmacy, Agriculture, Nursing, Biochemistry, Dentistry, Microbiology, Laboratory Technology and all other related courses. It therefore becomes binding on anyone wishing to offer any of the courses listed above or any related to such to offer Biology as one of the prerequisite subjects in the secondary school to gain admission into the University. though Biology is a prerequisite to these courses, poor achievement in Biology is alarming according to reports from Okebukola (1998), Ajaja (2002), Ahmed (2008) and also from my experience as a biology teacher with over fifteen years of teaching. I have experienced students' poor performance in biology internal and external examinations, the analysis of five years WAEC results of my school also attest to this. Below is this analysis.

Government Day Secondary School WAEC Results 2011-2106

Year	No who sat for the exam	No with credits	NO with passes	No failed %
2012	123	20	46	58
2013	127	35	54	38
2014	38	21	13	1
2015	50	13	26	11
2016	55	28	19	8

These consistent poor performances in Biology external examinations among Senior Secondary Schools students have given a lot of concern to educators, curriculum planners and students themselves Okoye (2004).

Teaching has been defined in many ways by different authors. Akudolu (1994) in Onuigbo (2011) defined teaching as a deliberate effort by a mature or experienced person to impart information, knowledge, skills and so on to an immature or less experienced person through a person that is morally and pedagogically acceptable. Fadare (2004) defined teaching as the action of someone who is trying to assist others to reach their fullest potentials in all aspects of development. Lyop and Mangut (2001), defines teaching as a process that facilitates learning. Owoso (2005) stated that the aim of teaching is to facilitate learning, stressing that there are many teaching methods and techniques used by teachers in teaching students. Various authors have listed many teaching methods used in teaching, but specifically, the Biology methods of National Open (2006) University has specified the lecture method, discovery, discussion methods, demonstration, project method, and field trip as conventional methods of teaching Biology.

For a teacher to communicate the knowledge in a topic to the pupils, the teacher needs to decide what teaching method or technique to use. Teaching method is defined as an overall plan for the orderly presentation of content or learning material, and usually a method is driven by a philosophy about how children learn. Lecture method according to Lyop and Mangut (2001) is characterized by a steady flow of information from teacher to the students, the teacher dispenses facts and opinions about procedures or contents, expressing his own ideas or citing an authority. Ogwa (2002), states that lecture method of instruction is the process of speaking to students, while they sit and listen to the teacher. Ogwa further emphasized that in lecturing method, the teacher acts as a conference organizer while the students listen as the audience. The lecture method is the most common of these traditional teaching methods.

Bligh (1993) observed that originally, lecturing was the only way that knowledge stored in the books could be transmitted to a large number of students. The word lecture is derived from the Latin legere meaning to read. Bligh states that many centuries after the invention of movable type and other significant advances in technology, learning continues to be the primary mode of instruction in secondary schools as well as in higher education. According to the author, reasons for lecture method are because lectures are cheap since teachers can lecture in auditorium full of students. Lectures are easily changed and updated and they are efficient in covering material quickly.

Lyop and Mangut (2001) points out the inherent setbacks of lecturing method. They affirm that it does not promote meaningful learning as it appeals only to the sense of hearing. According to them more effective learning goes on only when many senses are involved. They opined that schools consist of many ability groups in each class, the abilities of student they believed vary considerably and therefore conclude that the lecture method cannot meet the different needs of the students. They believe that some students learn better through the manipulation of objects while others will learn easily through hearing and seeing objects and events. Lecture method they opined encourages rote learning and regurgitation of information without necessarily aiding understanding. The lecture method they stated is unsuitable for teaching science in secondary school and is better suited for teaching in higher institutions of learning.

A survey carried out at Dorset House school of occupational Therapy, Oxford into the perceived effectiveness of different teaching methods used within the lecture format in the human biology course of year 1 & 2 by Butler (1992) showed that the traditional didactic lecture method was perceived by students as the least effective method used, yet by involving the students actively within the lecture time, the format was enhanced and was regarded as a

more effective teaching and learning tool. Experimental tasks and learning package used within the lecture format were also perceived by students as effective.

Effective lecturing is characterized by enthusiasm and expressiveness, clarity, and interaction (Murray in Perry & Smart, 1997). Scientists and science educators have however come to a conclusive agreement as many researches have been on going on how to involve students in the learning process and science educators have come up with concept maps as one of such teaching learning techniques. Okoye and Okechukwu (2006), Kinechin (2000a, b), Markow and Lenning (1998). According to Novak and Canas (2006) concept maps are graphical tools for organizing and representing knowledge. They include concepts, usually enclosed in circles or boxes of some type and relationships between concepts are indicated by a connecting line linking two concepts. Words on the line, referred to as linking words or linking phrases specify the relationship between two concepts. Wikipedia.com (2011) defined concept map as a diagram that depicts suggested relationships between concepts. It is a graphical tool that designers, engineers, technical writers and others use to organize and structure knowledge. Giving an overview, the Wikipedia encyclopaedia describes concept map as a way of representing relationship between ideas, images or words in the same way that a sentence diagram represents the grammar of a sentence, a road map represents the locations of highways and towns and a circuit diagram represents the workings of an electrical appliance. In concept map, each word or phrase connects to another, and links back to the original idea, word or phrase. Concept maps are means of developing logical thinking and study skills by revealing connections and helping students see how individual ideas form a larger whole.

The technique of concept mapping according to Wikipedia encyclopaedia was developed by Joseph D. Novak as a means of representing the emerging science of knowledge of student by his research team at Cornell University in the 1970s s. It has subsequently been used as a tool to increase meaningful learning in the sciences and other subjects as well as to represent the expert knowledge of individuals and teams in education, government and business. Concept maps have their origin in the learning movement called constructivism. In particular, constructivists hold that learners should actively construct knowledge. Concept maps are graphical tools for organizing and representing knowledge, they include concepts usually enclosed in circles or boxes of some types, and relationships between concepts indicated by a connecting line linking two concepts. Words on the line, referred to as linking words or phrases and these specify the relationships between the two concepts. Novak and Canas (2006); they defined a concept as a perceived regularity in events or objects, or record of events or objects designated by a label. Concept maps are represented in a hierarchical fashion with the most inclusive, most general concepts at the top of the map and the more specific, less general concepts arranged hierarchically below. Concept maps were developed to enhance meaningful learning in sciences. They serve to clarify links

between old and new knowledge and force the learner to externalize those links. Concept maps are useful tools to help students learn about their knowledge structure and the process of knowledge construction (Meta knowledge). In this way, concept maps also help students to learn how to learn (Meta learning).

Furthermore Ajaja (2011) stated that the development of concept mapping as an instructional tool can be traced to the early work of Ausubel and others in the 1970s. Continuing, Ajaja noted that since its introduction, concept mapping has become a very useful tool in teaching and learning and particularly in science education. Literature on concept mapping indicates that it has been used for instruction, assessment and learning (Johnson & Raven, 1998; Novak &Musonda, 1991; Power & Wright in Ajaja 2011, 1992; Trowbridge &Bybee, 1996; Trowbridge, Bybee& Powell, 2000). Some studies on the effects of concept mapping when used as an instructional tool for teaching and learning, indicated its relevance in improving the cognitive and affective aspects of learning. A study conducted by Ajaja (2011) determined the effects of concept mapping as a study skill on student's achievement in Biology. The major findings of this study indicated a significant and consistent improvement in Biology achievement as the period of experience with the use of the method increased. Also, students who used concept mapping as a study skill retained biological knowledge longer than those who used other methods. All the students interviewed in the concept mapping classroom agreed that concept maps helped them not only in the determination of the relationships among the concepts but also shaped their understanding of the concepts and increased their critical thinking. The findings of Hall, Dansereau, and Skaggs (1992), and Kinchin (2000a & 2000b) were similar to these research findings. Kinchin (2000a) found a significant impact of concept mapping on achievement when used for instructing secondary school biology students. Kinchin (2000b) in a study comparing the effect of the use of concept mapping as a study skill on students' achievement, found a positive effect on students who used concept maps to revise and summarize the materials given.

Apart from studies which solely determined the effects of concept mapping on students' achievement, mapping has been used along with other instructional strategies and their combined effects on students' achievement determined. Whereas some studies showed significant improvement on students' achievement when concept mapping was combined with other instructional strategies, others found no significant differences. For example, Okebukola (1989) investigated whether concept mapping alone as an instructional strategy in Biology would enhance meaningful learning when compared with concept mapping in cooperative learning groups. The study found a significantly higher achievement scores in Biology among students in the concept mapping group than those in class, taught with concept mapping and cooperative learning group.

The major limitation of concept mapping is that it taps high cognitive ability and a very good mastery of the subject area. Low ability teachers and learners may not be able to draw and use concept maps for teaching and learning. Bennett (2003) identified two major limitations of the use of concept mapping in instruction. First, concept mapping is not easy to construct, and respondents require training and practice in producing maps. Second, there are difficulties with the interpretation of concept maps in particular with devising appropriate ways of scoring to enable valid comparisons to be made. Thus, limitations are found to frustrate low achievers in mastering the techniques required for the use.

The literature review suggests that the use of concept mapping instructional strategy significantly improve science students' achievement and retention, the students taught with lecture method performed significantly less well than students taught with concept mapping strategies. This development indicates a significant breakthrough in science education research in the identification and creation of alternative learning environments to lecture environment. However, a question may be asked as to whether the lecture method if improved upon as indicated in the literature reviewed will produce varying effects on students' achievement when used to teach specific school science subjects. This is a gap in the literature review which needs to be filled to enable researchers and science teachers to fully appreciate the roles and effects of these two instructional strategies in the teaching and learning of science.

To guide this study, the following objectives, research questions and hypotheses were raised and answered.

Research Objectives

This study sought to achieve the following objectives:

1. Compare the mean performance of students taught biology using concept map and lecture method.
2. Determine the level of retention of biology knowledge between students taught using concept maps and lecture method.

Research Questions

1. What is the difference in the mean scores of students taught biology using concept maps lecture method?
2. What are the mean scores of students taught using concept maps and lecture method in the retention of biology concepts used for the study?

Null Hypotheses Testing

$H0_1$: There is no significant difference in the mean scores of students taught biology using concept maps and those taught using lecture method.

$H0_2$: There is no significant difference in the mean scores of students taught using concept maps and those taught using lecture method in the test of retention of biology concepts.

Methodology

The study was conducted using the quasi- experimental design, specifically the pre-test and post-test; non- equivalent control group design was used. This implies that, intact classes (non-randomized groups) were used for the study.

Quasi-experimental research design was adopted because it was not possible for the researcher to randomly sample the subject and assign them to groups without disrupting the academic programme and the time table of the secondary schools involved in the study. Hence the design is considered quite suitable for conducting the study.

The population for the study comprised of the 6208 SSII biology students of FCT Abuja from which 1116 were drawn from Karshi Zone of Abuja Municipal Area Council FCT. There are six (6) public senior secondary schools in the Karshi zone of Abuja Municipal Area Council of the Federal Capital Territory. Two co-educational senior secondary schools were purposely sampled for the study. The schools sampled include Government Secondary School (GSS) Nyanya and Government Day Secondary School (GDSS) karu in the federal capital territory Abuja. Two arms of SS 2 classes were randomly sampled and used for the study. $SSII^A$ of Government Secondary School GSS (Nyanya) was used as the experimental class (concept mapping). $SSII^A$of Government Day Secondary School, Karu was used as the control class (lecture method). One hundred and twenty-eight (128) SS 2 students were purposely used for the study, (of which 64 constituted students for concept map) and sixty-four (64) SS two students constituted the students in the control group. The sample size chosen above agrees with the view of Eboh (2009) who states that a common quasi-experimental design uses two or more groups which have not been randomly selected or allocated and the number in each group should be manageable. His view is in support of the small sample size.

The Biology Achievement Test (BAT) was used in the study. The dependent variable in this study is the students' Biology achievement. Two tests were used to measure achievement, one a pre -test which was used to test students' pre-requisite knowledge in topics related to the ones covered during the study. The post-test measured students' achievement at the conclusion of the study. The Biology Achievement test comprised of 25 test items of multiple choice questions. These questions were drawn from questions developed by Educational Resource Centre (ERC) for promotion examinations for 2009, 2010, 2011 and 2012. Each question had four options A – D, the multiple-choice items. The questions used in the pre-test were re-numbered for the post-test and the question relating to

the two topics taught in the first two weeks was used for the retention test. The students' Pre, Post and Retention test questions were scored. Each correct answer carried one mark and each wrong answer carried no mark. Students who scored twelve (12) marks were seen has having performed well. The following instruments were used for data collection:

- Biology Achievement Test (BAT) for Pre-test and Post-test.
- Biology Achievement Test for Retention (BATR)

The BAT achievement tests were past questions developed by Educational Resource Centre (ERC) 2009 – 2012. Only the items on the syllabus were lifted. A pre- test on the two topics on concept map meant for the treatment group (experimental group) was administered on a class of 65 students at Government Secondary School Karu in Abuja,after which they were taught the two topics using concept map, class was taught using a double period of 80mins each. After the lesson a post test was given on the topics taughtand a retention test was administered two weeks after the treatment. The reliability co-efficient of the instruments used for the study was determined using the Kuder-Richardson Formula 21 which determined the suitability of the instruments for the study and they yielded a co-efficient value of 0.65,0.65and0.64 respectively Brown (1983) has indicated that reliability co-efficient of 0.5 or more is considered reliable.

Data Analysis

Research Question 1: What is the difference in the mean scores of students taught Biology using concept maps and lecture method?

The performances of the students exposed to the two methods of teaching the subject were compared here. Table1 shows the mean scores along with the standard deviation and standard errors.

Table 1: Mean achievement scores of students exposed to the use of concept mapping, experiments and lecture method

Methods of teaching	N	Pre-test scores			Post test scores		
		Mean	Std. Dev.	Std. Error	Mean	Std. Dev	Std. Error
Concept mapping	64	8.78	2.86	0.358	13.53	3.57	0.466
Lecture method	64	8.33	1.95	0.244	14.29	4.70	0.570

The mean scores were generally low before the students were exposed to the two methods but after the test, there was a general increase in the achievement scores with performance of students taught using concept maps increasing from mean of 8.78 and standard deviation of 2.864 to mean of 13.53 and standard deviation of 3.578 while Performance among students

taught using lecture method increased from mean of 8.33 and standard deviation of 1.952 to mean of 14.29 and standard deviation of 4.70. In order of magnitude, the students taught with the lecture method could be said to have the highest score followed by students were taught with concept maps.

Research Question 2: What are the mean scores of students taught using concept mapping and lecture method in the retention of Biology concepts?

The mean retention scores of the students exposed to the two methods of teaching Biology involved in the test are presented in Table 2 along with their standard deviations and standard errors.

Table 2: Mean retention level of the students exposed to the two methods of teaching the subject

Method of teaching Biology	N	Pre-test Scores			Post Test Scores		
		Mean	Std. Dev.	Std. Error	Mean	Std. Dev.	Std. Error
Concept mapping	64	4.0625	1.39016	.17377	4.0625	1.39016	.17377
Lecture	64	3.7344	1.21161	.15145	3.7463	1.19777	.14633

The exposure did not increase the retention abilities of the students to any considerable level as indicated in the table. But within each of the groups, retention level before and after were relatively equal. This would imply that the use of the two methods did not really have much impact on the retention abilities of the students.

$H0_1$: There is no significant difference in the mean scores of students taught biology using concept maps and those taught using lecture method.

Table 3: Two sample t-test on performance of students exposed to concept mapping and lecture method in the teaching of Biology

Variables	N	Mean	Std. Deviation	Std. Error	t-value	DF	P
Concept mapping	64	13.53	3.578	0.466	5.366	126	0.808
Lecture method	64	13.52	3.576	0.464			

(t-critical = 1.96)

The result reveals that students who were taught Biology with the two methods did not show any significant differences in their performances. This is indicated by the observed mean score of 13.52 for those taught with the use of lecture compared with 13.53 for students who were taught Biology with the use of Concept maps. The observed level of significance

for the test is 0.808 (P>0.05). With these observations, there is enough evidence to accept the null hypothesis that there is no significant difference in the mean scores of students taught Biology using concept maps and those taught using lecture.

$H0_2$: There is no significant difference in the mean scores of students taught using concept maps and those taught using lecture method in the test of retention of biology concepts.

Table 4: Two sample t-tests on retention level by students exposed to concept mapping and use of experiments in the teaching of Biology

Variables	N	Mean	Std. Deviation	Std. Error	t-value	DF	P
Concept mapping	64	4.0615	1.37928	.17108	6.679	126	0.708
Lecture method	64	4.0587	1.36976	.17095			

(t-critical = 1.96)

The test as indicated in the table revealed that students who were taught the subject with the use of lecture method did not perform significantly higher than those taught with Concept maps (P > 0.05). By this observation, the null hypothesis that there is no significant difference in the mean scores of students taught using concept mapping and those taught using experiments in the test of retention is therefore retained.

Findings

The major findings from the data analysis and test of the hypotheses are summarized as follows:

1. The use of concept mapping though enhances performance of students is not significantly better than the lecture method when the lecture method is enhanced with visual aids, questioning and students' participation.
2. There is no significant difference in the retention level of students taught Biology with lecture method and concept mapping.

Discussion of Results

In answering the research question one, mean scores between the lecture and concept mapping methods, showed no significant difference. The result here is contradictory to the reports of Udeani and Okafor (2006), Okoye and Okechukwu (2006) and Ajaja (2011) where it was established that the group taught by the concept mapping instructional strategy performed significantly ($p < 0.05$) better than their control group. The results are however in agreement with the work of Stensvold and Wilson (1992) who investigated on the effect of students' construction of concept mapping on high school chemistry laboratories on their comprehension of chemical concepts. They found no differences between the experimental and control groups. In addition, Boujaound and Attieh (2008) in their study on concept maps

as study tools on achievement in chemistry also noted that results from the mean scores of chemistry achievement post-test for the experimental and control groups showed insignificant difference.

On the insignificant difference in the retention levels of students taught with concept maps and lecture methods in research question two, Stevenson and Wilson (1992) and Boujaound and Attieh (2008) suggested that concept maps can be of disadvantage to high ability students who may have their own successful strategy which are not applied when concept maps where used. Furthermore Ajaja (2011) on the study concept mapping as a study skill: effects on students' achievement" suggested that when students do not have much experience with a method, it puts them on the same level with students who have had several years of experience with the method of study the study is in agreement with Ajaja (1998) while discussing (Egelston and Lahnston :1973) findings on the effect of experience and task difficulty in achievement. They noted that task difficulty emanating from in lack of enough experience will result in a familiar method being superior on an immediate test of retention. Also, in another study by Ajaja (2013) on which "strategy best suits Biology teaching: lecturing, concept mapping, cooperative learning or learning cycle" he observed that lower retention of biological knowledge was found in students taught with lecture method and concept mapping than those taught with 5E learning cycle which comprised of Engagement, Exploration, Explanation, Elaboration and Evaluation and cooperative learning the problem Ajaja opined that the problem may not be unconnected with an earlier identified limitations associated with the two methods. These problems are difficulties in construction of concept map and their interpretation, and as pointed out by Bennet (2003) may have frustrated particularly the low ability students in the effective learning and retention of the concepts they were exposed to. Bennet advocated for efficient acquisition of the skills necessary for use both by the Biology teachers and students to reduce the limitations associated with the method and also advocated that lecture method should still be used to teach very abstract topics to enable students easily acquire knowledge, new information and explanation of events or things as this will reduce the frustration students will experience with the other methods when dealing with very novel concepts.

Conclusions

The use of lecture method if taught using pictorial charts, asking students and involving them in the lesson thus moving them from passivity to been active in the class can help to improve students' academic performance.

The efficient acquisition of the skills necessary for its use both by the Biology teachers and students will reduce the limitations associated with the method. Lecture method could still be used to teach very abstract topics to enable students easily acquire knowledge, new information, and explanation of events or things. It will reduce the frustration students will experience with the other methods when dealing with very novel concepts.

Recommendations

Based on the finding of the study the following were recommended

1. A better alternative to the lecture method that teachers should use is the concept mapping
2. Both the teachers and students should be well trained to acquire the skills necessary for its the use of concept mapping techniques
3. principals of secondary schools should encourage biology teachers in the use of innovative strategy such as concept mapping in instructional delivery.
4. Biology teacher should adoption concept mapping as an appropriate instructional strategy,

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