Effects of Concept Mapping Instruction Approach on Students' Achievement in Biology

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Abstract

The study investigated the effects of concept mapping on students' achievement in biology. The study was carried out in Rivers State of Nigeria. The study employed a quasi experimental design. Specifically the pretest posttest non-equivalent control group research design was used. The sample was 83 students selected from two secondary schools drawn from the population through a simple random sampling. One school was used for treatment and the other for control. The treatment group was taught biology with concept mapping approach while the other was taught with conventional method. Two research questions and two null hypotheses guided the study. Mean, standard deviation and the Analysis of Covariance (ANCOVA) were used to analyze data. Results showed that concept mapping fosters students' achievement in biology than conventional method. It boosts the achievement of both male female students in the subject.

Keywords: Concept Mapping, Achievement, Biology, Conventional Method

Introduction

The desire to improve science achievement through more effective instructional strategies and increasing awareness in recent years of the importance of learner-centeredness in the teaching learning situation has directed a lot of attention to understand how learners learn and how to help them learn concepts. Science is the pursuit and application of knowledge and understanding of the natural and social world following a systematic methodology based on evidence (Science Council, 2009). In Nigeria, the sciences are taught in subjects such as Physics, Chemistry and Biology. As a biology teacher of many years, experience has shown that even though a large populace of students show interest in offering

biology as a subject and think it to be the simplest of the sciences, there have been a consistent poor achievement in both internal and external examinations. On the order hand even though biology lessons are supposed to be taught with practical lessons it has been observed over the years that most biology teachers do not teach their lessons with praticals. The National Curriculum for Senior Secondary Schools Volume Three (3) Science in (Ajaja 2019) stated the specific objectives to be achieved by each subject (curriculum). The cardinal objectives for biology include: Adequate laboratory and field skills in Biology; Meaningful and relevant knowledge in Biology; Ability to apply scientific knowledge to everyday life in matters of personal and community health and agriculture; and Reasonable and functional scientific attitudes. (Ajaja, 2019) 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.

According to Ogunleye and Babajide, (2014), Nigeria has witnessed persistent poor students' performance in biology at the Senior School Certificate level. This has been linked to the adoption of instructional strategies which did not give enough consideration to learners' previous knowledge and how they reasoned in order for learners to construct their knowledge based on these. In order to improve students' academic achievement, researches into science teaching and learning methods such as problem solving ,inquiry method, demonstration method, lecture method, concept mapping and many others have been developed with the aim of making learning more meaningful and less complex.

Using strategies such as problem solving, concept mapping of teaching to motivate students' prior knowledge were considered equivalent to preparing for a learning experience. The use of activating strategies have produced significant gains in learning potential by recognized prior knowledge as the basis for familiarity with concepts, and have provided students with a context that argues strongly for new learning to occur. Studies have clearly shown that meaningful learning is more efficient and lasting (Novak & Gowin, 1984; Novak, 1991) because of the

integration and linkages made. In contrast to rote learning, the outcome of meaningful learning is that the new information is transferred into long term memory in a relevant linkage with prior knowledge. This study therefore employed the use of students' prior knowledge to aid in the construction of concept maps.

Abimbola & Danmole (2018) asserted that to reduce the difficulty students' face in learning concepts, teacher must analyze concepts meant for learning and specifying its level of complexity, abstractness and sophistication. This analysis would enable teachers to lead students to know the relationships between concepts. They maintained that concept mapping techniques is useful in that it helps teachers in knowing what to teach, how to teach it and how to evaluate students.

In considering knowledge based problems encounter by pre-service teachers, one of the approaches that have been found helpful in facilitating and identifying individual needs is the use of concept mapping. White & Gunstone, (2019) believe that the effective strategy designed to promote efficient and meaningful learning rely upon connecting prior knowledge to new concepts.

Ausubel,(1963)and Novak,(1990) assert that the mental ability of students to enhance their credible standard and good performance relies on the understanding, proper application of an acquired skill and successfully relating them with new ones. The extents to which the students interrelate concepts can be assessed using concept mapping technique.

Mintze, Wandersee, & Novak (2019) defined concept maps as tools used for organizing and representing knowledge. Pellegrinno, Chudowsky & Glasser (2015) identified concept mapping as a method of arranging conceptual nodes, and labels of nodes and links to show relationship among multiple concepts in a domain. Concept maps are therefore tools that help organize knowledge for meaningful learning. The linking words that are used to connect concepts provide meaning for the preposition and the domain of the knowledge. When concept maps are used to represent scientific concepts, they help to resolve ambiguities,

inconsistencies and rigors of representing scientific knowledge (Kharatmal & Nagarjuna 2014).

According to Marzano & Kendall, (2017), concept maps are made towards enriching conceptual understanding of different instructional contents regarding topics, identifying prior understanding, bridging gaps in knowledge, removing misconception, and can be designed to detect changing in understanding thereby enhancing the performance of the students. Marzano & Kendall (2017) also maintained that good concept maps that move from teacher-generated to student-generated help students imagine new gaps in knowledge, and also help refine their thinking to pure unadulterated facts of their lives into real creativity. Concept mapping helps meaningful learning in several other ways. For example, concept mapping is an activity that provides the student with an opportunity to organize, summarize, analyze and evaluate many different ideas and also promotes the development of critical thinking skills, which can then be used to enhancing meaningful learning (Novak & Canas 2014). Furthermore, because the concept mapping process externalizes the concepts in the student's existing knowledge structure, it is possible to identify misconceptions, incongruities and weaknesses in that existing knowledge structure. Therefore, this study used concept mapping strategy with a view to finding how it can enhance students' academic achievement in biology.

Literature review

Oloyede (2019) in his research work examined the effect of guided discovery and concept mapping teaching strategies on SSS students' biology achievement. The result showed that there was a significant difference in the retention of the two groups 45 used for the research in favour of the group taught using concept mapping. This finding according to Oloyede is in agreement with those of Okebukola (2018) and Udeani (2019).

Altin (2017) in his work on the study of computer assisted experimental method and concept mapping method with regards to some cognitive processes and level of Retention observed that the use of concept mapping in teaching biology courses had positive and significant effect on the level of retention of students.

Studies on the influence of concept maps on students‟ achievement has shown that students taught using concept map achieved significantly higher than taught using lecture method. (Boujaound & Altieh, 2018). Studies from Okoye and Okechukwu (2016) shows that when incorporated into teaching, it helps to improve students' performance.

Lawal (2014), in a study on the effects of The effect of Concept Mapping Strategy on Cognitive Preference and Academic Achievement in Genetics of 95 undergraduate students in genetics, it showed that there was a statistical difference in cognitive preference grouping of the subjects (students) after the treatment in concept mapping technique. It also discovered that there was a correlation between the achievement scores in genetics and concept map grades of the subjects. In a study conducted by Aishana, (2017) on concept mapping instructional strategy and expository method in a mathematics class, the study was conducted on 300 Junior Secondary school students (JSS 2) from five (5) schools in the Federal Capital Territory used t-test and concluded there was no significant difference between students that were exposed to concept mapping those exposed to expository method. However, there was significant difference in performance between boys and girls; the boys performed better than the girls, but concluded that concept mapping is effective in concept acquisition and capable of stimulating students resulting from their interactions and discussions of the topics. Hsu and Chang (2015) examined forty students in the Design Department at a Technical University to analyze whether computer-based concept mapping and applications improved students' video production and creative performance. The instrument used for the collection of the data was a questionnaire, descriptive statistics and correlation analysis were used for the data analysis, and the results showed that:

(1) The application of computer-based concept mapping received approval from students.
(2) Students' concept mapping performance is directly related to academic performance.
(3) Students' concept mapping performance can effectively predict their creative performance.

The study also examined whether concept mapping helps students create digital films and it concluded that computer-based concept mapping benefits students' creative and thinking abilities.

Carroll, (2012) investigated the influence concept mapping and inquiry methods in creativity on 60 secondary schools students in biology and confirmed that giving students hands-on experiences and opportunities to construct their own meaning through inquiry achieve much in both cognitive and creativity. The results of the study also revealed that the student creativity traits of fluency, flexibility, originality and motivation were better enhanced through inquiry than in concept mapping.

Statement of the Problem

The inability of biology students to see the real world application of concepts and principles coupled with the traditional method of teaching have been attributed as the major cause of poor performance in the junior secondary school examination (WAEC) and internal examinations. (WAEC, Annual Reports from 2008-2012).Among the several factors enumerated to account for this poor performance, poor teaching methods seems to be a major contributory factor.

Research Questions

The following research questions guided the study:

- What is the effect of concept mapping strategy and lecture method on biology achievement test?
- What is the effect of concept mapping strategy on biology Achievement Test of male and female students?

Hypotheses

The following null hypotheses were tested at 0.05 level of significance:

- There is no significant difference in the mean scores of students taught using concept mapping strategy and those taught using lecture methods.
- There is no significant difference in the mean scores of male and female students taught using the concept mapping strategy.

Methodology

This study adopted the quasi-experimental design. The specific design the researchers used for this study is a pre-test post-test non-equivalent control group design. The study was carried out in Rivers State of Nigeria. A total of eighty three junior secondary school students drawn from two intact classes of SS II were involved in the study. Two secondary schools were drawn from the secondary schools in Rivers State through a simple random sampling. Because most of the schools in the area are coeducational, the researcher used only co-educational schools. Out of the two secondary schools that were used for the study, one was assigned to the treatment group while the other was assigned to the control group through a simple toss of coin. In all, 45 students were used for treatment group and 38 students were used for control group. The instrument the researcher used for data collection is Biology Achievement Test (BAT). The instrument is a 30 item multiple choice test developed by the researcher from the content that was covered in the study. The items were drawn using a table of specification. The instrument covered the three main topics in the lesson note plan: the living components of the environment, grouping of living things and classification of living things. The instrument was subjected to both face and content validation. The Kuder Richardson coefficient of internal consistency for the instrument is 0.97.

Research question 1: What is the effect of concept mapping strategy and lecture method on biology achievement test?

Table 1: Mean and Standard Deviation Showing the Effect of Concept Mapping Strategy and Lecture Method on Biology Achievement Test

Teaching Methods	N	Mean	Std.dev
Concept mapping	45	46.84	2.57
Lecture	38	39.34	3.78

From table 1, it can be observed that the adjusted mean achievement score for the experimental group is 46.84 and the adjusted mean achievement score for control group is 39.34. The two mean scores from the table tend to suggest that the students in the experimental group performed better academically than the students in the control group. This further suggested that concept mapping approach has positive effects on the students' academic achievement in biology.

Research question 2: What is the effect of concept mapping strategy on biology Achievement Test of male and female students?

Table 2: Mean and Standard Deviation Showing the Effect of Concept Mapping Strategy on male and female students' Biology Achievement Test

Teaching Methods	N	Mean	Std.dev
Male	25	47.00	2.67
Female	20	46.65	2.49

From table 2 above, it can be seen that the adjusted mean achievement score of male students (47.00) is slightly greater than that of the female students (46.65). This shows that concept mapping had a slight effect on the achievement of male and female students in Biology in the favour of male students.

HO1: There is no significant difference in the mean scores of students taught using concept mapping strategy and those taught using lecture methods.

Table 3: Analysis of Covariance (ANCOVA) of the significant difference in the mean performance scores of students taught biology using concept mapping strategy and those taught using traditional method

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	1272.130[a]	4	318.033	34.942	.000
Intercept	5699.907	1	5699.907	626.238	.000
Pretest	110.140	1	110.140	12.101	.001
Gender	.001	1	.001	.000	.994
Teaching method	1050.924	1	1050.924	115.463	.000
Gender * TM	3.101	1	3.101	.341	.561
Error	709.942	78	9.102		
Total	158387.000	83			
Corrected Total	1982.072	82			

a. R Squared = .642 (Adjusted R Squared = .623)

For hypothesis 1, result in table 3 shows that the calculated F-ratio (F-cal) is 1154.463 while the critical value (F-critical) at alpha level of 0.05 is 3.84. The decision rule is to reject the null hypothesis if the calculated value is greater than the critical value at a given probability level. The null hypothesis was therefore rejected. The researcher therefore concludes that there is significant difference in the mean achievement scores of students' taught Biology using concept mapping approach and those taught with the conventional approach.

HO2: There is no significant difference in the mean scores of male and female students taught using the concept mapping strategy.

Table 4: Analysis of Covariance (ANCOVA) of the significant difference in the mean performance scores of male and female students taught biology using concept mapping strategy

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	66.916[a]	2	33.458	6.246	.004
Intercept	4237.316	1	4237.316	790.983	.000
Pretest	65.555	1	65.555	12.237	.001
Gender	1.845	1	1.845	.344	.560
Error	224.995	42	5.357		
Total	99040.000	45			
Corrected Total	291.911	44			

a. R Squared = .229 (Adjusted R Squared = .193)

For hypothesis 2, table 4 indicates that F-calculated is 0.344 while the critical value is 3.89 at an alpha level of 0.05. Since the calculated value is less than the critical value at a given probability level, the null hypothesis is upheld. The researcher therefore concludes that there is no significant difference in the mean achievement scores of male and female students' taught Biology using the concept mapping approach.

Conclusion

This study further strengthens that concept mapping is one way to make instructional concepts arranged from known to unknown in a more organized manner and also to acknowledge that knowledge is hierarchical. The study also showed that teaching physics by inquiry develops the learners' ability to observe, ask questions, presume and verify assumptions and to make critical analysis of data. These skills enhance creativity and the role of the teacher as organizer and facilitator of learning is very important.

From the findings of this study the following conclusions are drawn:

(i). Innovative teaching strategies enhances students' academic achievement and creativity;

(ii) Engage students with more pragmatic activity based practical approaches to science instructions without altering the concepts;

(iii). Teachings innovations such as Concept Mapping and Inquiry Strategies are student centered, when properly utilized, they can enhance both creative thinking abilities and knowledge acquisition.

Recommendations

On the basis of the finding emanating from the study, the following recommendations are made:

(i) Teachers should be trained in the use of learner centered and activity based instructional strategies such as Concept Mapping Strategy of instruction;

(ii) Teachers should pay attention to the training of their students in the development of Concept Mapping instructional strategy towards enhancing their academic achievement

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