Effects of Concept Mapping Instruction Approach on Students' Achievement in Basic Science

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Abstract
The study investigated the effects of concept mapping on students' achievement in basic science. The study was carried out in Ebonyi 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 122 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 basic science with concept mapping approach while the other was taught with conventional method. Three research questions and three null hypotheses guided the study. Mean, standard deviation and the Analysis of Co-Variance (ANCOVA) were used to analyze data. Results showed that concept mapping fosters students' achievement in basic science than conventional method. It boosts the achievement of both male female students in the subject. In addition there is no interaction between gender and teaching methods on students' achievement in basic science.
Keywords: Concept Mapping, Achievement, Basic Science, Conventional Method

Introduction
Basic science (formerly known as Integrated Science) is one of the core subjects listed in the National Policy on Education (2004) for Junior Secondary Schools in Nigeria. It is a basic subject that lays the foundation for the takeoff of the sciences (biology, chemistry and physics) in the Senior Secondary classes. Basic science as defined by UNESCO in Igwe (2003) is "an approach to science in which concepts and principles are presented so as to express the fundamental unity of scientific thought and avoid premature or undue stress on the distinctions between the various scientific fields". Science in its general view, according to Abonyi (2002) is the tool with which man learns about his environment, its resources and problems and how to control and utilize them both productively and sustainably.

Previous studies tend to show that students' achievement in basic science is very poor (Abonyi 2012). Onwiodukit (1996) attributed this to insufficient manpower, lack of equipment, poor attitude of students and poor understanding of the concepts involved in science. Others are poor method of teaching and nature of curriculum (Abonyi 2014). Abonyi argued that science instruction in Nigeria is particularistic and non learner centred. His argument is that a child creates a mental picture of nature from his immediate environment and interaction with his culture. This mental picture could be represented as concept map which could be most appropriately integrated in the instructional process to desired outcome in term of mastery and achievement.

One instructional strategy which probably has the potential to offer opportunities to address the problems of effective teaching and learning of basic science is the concept mapping advocated by Novak and Godwin in 1984. The use of concept maps as a teaching strategy was first developed by J.D. Novak of Cornell University in the early 1980's. It was derived from Ausubel's learning theory which places central emphasis on the influence of students' prior knowledge on subsequent meaningful learning. The concept map is a diagrammatic devise used to represent the conceptual structure of a subject discipline in a two dimensional form which is analogous to a road map. Novak (1990) further explained that concept maps are also visual diagrams constructed to represent the organization of concepts/ideas and outline the relationship among or between those concepts. Concept maps are representations of organized knowledge in diagrams which can be done in hierarchical and/or linear order with the most inclusive concept on top of the map and the most specific concept at the bottom (Novak 1991). Concept mapping deals with linking concepts. It can be likened to a spider chart, an organized chart or a flow diagram. Concept maps simply put are diagrammatic propositions. And propositions are two or more concept labels linked by words which provide information on relationships or describe connections between concepts. Concepts do not exist in isolation; each concept depends on its relationship to many others for meaning.

Ademzyk (1994) defined concept as the smallest unit of thought which can be totally abstract. He suggested that concept acquisition takes place in three stages namely:
1.   Stage I: Gaining concept which is continuous with learning.
2.   Stage II: Possessing a concept, that is knowing
3.   Stage III: Using and/or linking concepts, which is understanding
As such full concept acquisition takes place only when all these three stages have been accomplished. The full acquisition of the new concept enables the learner to apply the concept in new situations. Concept maps have the ability to take students through these stages in concept development Ademizyk asserted that concept

maps are suitable for classroom situation.

Although the potential gains of concept mapping approach to science instruction has been widely articulated in literature (Jonassen (1996; Igwe, 2003), its efficacy in basic science is still in doubt and demands an empirical investigation. In the same vein also, because concept categorization and structuring are sometimes influenced by gender and some cultural issues it may be logical to argue that male and female students may differ in their concepts maps and as such respond differently to preplanned instructional concept map. This may also generate some obvious doubts on likelihoods of interactions between methods and gender on students' achievements in situations where concepts maps form dominant instruction approach. This study therefore is a thorough exploration of the efficacy of the concept map approach vis-à-vis the moderator variables of gender.

Purpose of the Study
The purpose of this study is to investigate the effects of concept mapping on students' achievement in basic science. The study is designed to achieve the following purposes, to investigate:
1. Students' achievement in basic science.
2. Achievement of male and female students in basic science
3. Interaction effect of gender and instructional approach on students' achievement in basic science.

Research Questions
The following research questions guided the study:
1. What is the effect of concept mapping approach on students' mean achievement in basic science?
2. What is the effect of concept mapping on the mean achievement of male and female students in basic science?
3. What is the interaction effect of gender and instructional approach on students' mean achievement in basic science?

Hypotheses
The following null hypotheses were formulated and tested at an alpha level of 0.05.
HO_1:There is no significant difference in the mean achievement scores of students taught Basic Science with concept mapping approach and those taught Basic Science with conventional approach.
HO_2: There is no significant difference in the mean achievement scores of male and female basic science students taught with concept mapping approach.
HO_3:There is no significant interaction between gender and instructional approach on students' mean achievement in Basic Science.

Research Method
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 Ebonyi State of Nigeria.
A total of one hundred and twenty two junior secondary school students drawn from two intact classes of JSS I were involved in the study. Two secondary schools were drawn from the secondary schools in Ebonyi State through a simple random sampling. Because most of the schools in the area are coeducational, the researcher used only coeducational 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, 70 students were used for treatment group and 52 students were used for control group
The Instrument the researcher used for data collection is Basic Science Achievement Test (BSAT). 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.

Experimental Procedure
To control for possible pre-existing differences in overall ability between the treatment and control groups a pre-test was administered to both groups before the commencement of the experiment in the respective schools. The treatment group was taught with concept mapping approach while the control group was taught with conventional approach using the same content outline for four weeks.

Method of Data Analysis
 Researc h questions were answered using mean and standard deviation while the hypotheses were tested at 95% confidence level using analysis of Co-variance (ANCOVA.).

Results
Research Questions
Research Question 1
What is the effect of concept mapping on students' mean achievement in basic science?
For this research question both pretest and posttest data obtained with the Basic Science Achievement Test for the treatment and control groups were used to answer the research question. Mean for pre and post test were adjusted statistical in the analysis to take care of the initial equivalence of the research subjects. Summary of result is shown in table 1.

Table 1: *Mean Basic Science achievement scores of students taught Basic Science using the Concept Mapping and those taught with the conventional method*

Groups	N	Mean	Std Dev.
Treatment Group (Group Taught with concept mapping Approach)	70	47.07	11.43
Control Group (Group taught with conventional method).	52	37.00	9.42

From table 1, it can be observed that the adjusted mean achievement score for the experimental group is 47.72 and the adjusted mean achievement score for control group is 37.0000. 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 basic science.

Research Question Two
What is the effect of concept mapping on the mean achievement of male and female students in basic science?
For this research question both pretest and posttest data obtained with the Basic Science Achievement Test for only the treatment group was used to answer the research question. Summary of result is shown in table 2.

Table 2: *Mean Basic Science scores of males and females taught Basic Science using the concept mapping Approach*.

Gender Categories	N	Mean	SD
Male Students	30	45.30	12.81
Female Students	40	48.40	10.24

From table 2 above, it can be seen that the adjusted mean achievement score of female students (48.40) is greater than that of the male students (45.30). This shows that concept mapping had a slight effect on the achievement of male and female students in Basic Science in the favour of female students.

Research Question 3
What is the interaction effect of gender and instructional approach on students mean achievement in basic science?
The scores of males and females that were subjected to the concept mapping approach and those subjected to the conventional approach were used to assess the interaction. Summary of result is presented in table 3.

Table 3: *Summary of interaction of gender and teaching method on students' mean achievement scores in Basic Science*.

GENDER GROUPS	Treatment Group	Adjusted Mean for Conventional Method
Males	45.30	35.90
Females	48.40	38.50

As shown in Table 3 the adjusted mean scores of males and females in the treatment group is higher than those of male and females in the conventional group. This is to say that at all levels of gender, the treatment group is superior to the control group implying that there is no interaction between method and gender on achievement in basic science.

Hypotheses
HO₁: *There is no significant difference in the mean achievement scores of students taught Basic Science with concept mapping approach and those taught Basic Science with conventional approach*.
HO₃: *There is no significant interaction between gender and instructional approach on students' mean achievement in Basic Science*.

Both hypotheses 1 and 3 were tested using Analysis of Co-Variance. Summary of the analysis for these two null hypotheses is shown in table 7.

Table 7: *Analysis of Co Variance for Students Overall Basic Science Achievement scores by teaching methods and by gender with interaction effect*

Sources of variation	Sum of squares	Df	Mean Squares	F	F_{cv}
Covariates	**3802.715**	**1**	**3802.715**	**44.251**	
Main Effects	**2677.913**	**2**	**1338.957**	**15.581**	
Teaching Methods	**2173.051**	**1**	**2173.051**	**25.287**	**3.84**
Gender	**238.508**	**1**	**238.508**	**2.775**	
2 – Way Interaction	**28.048**	**1**	**28.048**	**.326**	**3.84**
Teaching Methods & Gender					
Explained	**6508.676**	**4**	**1627.169**	**18.935**	
Residual	**10054.349**	**117**	**85.935**		
Total	**16563**	**121**	**136.885**		

For hypothesis 1, result in table 7 shows that the calculated F-ratio (F-cal) is 25.287 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 Basic Science using concept mapping approach and those taught with the conventional approach.

For hypothesis 3, the ANCOVA table (Table 7) reveals that for the two-way interaction, the F-calculated is .326 while the critical value is 3.89 at alpha value of 0.05. Based on the decision rule, the researcher upholds the null hypothesis and concludes that there is no significant interaction between gender and method on students' achievement in Basic Science.

HO₂: *There is no significant difference in the mean achievement scores of male and female basic science students taught with concept mapping approach*

Scores of male and females in the treatment group only were used to test this hypothesis. Summary of result is shown in Table 8

Table 8: *Analysis of Co Variance for Students Overall Basic Science achievement scores by teaching methods and by gender*

Sources of variation	Sum of squares	Df	Mean Squares	F	F_{cv}
Covariates	**2298.366**	**1**	**2298.366**	**23.235**	
Main Effects	**88.758**	**1**	**88.758**	**.897**	**3.89**
Gender	**88.758**	**1**	**88.758**	**.897**	**3.89**
Explained	**2387.124**	**2**	**1193.562**	**12.066**	
Residual	**6627.519**	**67**	**98.918**		
Total	**9014.643**	**69**	**130.647**		

For hypothesis 2, table 8 indicates that F-calculated is .897 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 Basic Science using the concept mapping approach.

Summary of Results

The results of data analysis presented in chapter four reveal that:

(1). the concept mapping approach is superior to the conventional approach in fostering both achievement and retention in basic science.

(2). there is no significant difference in the mean achievement and mean retention scores of both male and female students taught basic science using the concept mapping approach.

(3). there is no interaction between method and gender on both achievement and retention in basic science

Discussion of Results

The results of this study revealed that the students taught basic science with concept mapping performed significantly better than the students taught with conventional method. In other words, the difference between the adjusted mean achievement of the experimental group was significant in favour of the experimental group. This implies that concept mapping method has a positive effect on the students' achievement in basic science.

This finding is in agreement with the works of Ademzyk (1994), Achimagu (1995) and Ibiene (2009), which revealed that instructional method helps in imparting knowledge, skills, abilities and attitudes expertly to facilitate students achievement. This is also in line with the result of Brodie (1991), who in conclusion said that the process of drawing a concept map by students makes the task of revision more effective and simply and significantly makes learning more meaningful and consequently facilitates students' achievement in the subject.

This result is equally in line with the result of Jonassen (1996), which revealed that concept mapping produced significant students' achievement in sciences. Moreso, Ryder (2004), observed that concept mapping attracts students' attention, motivate them, reduce anxiety and facilitates recall of information and hence, enhances their achievement. Novak *1991), in his work also noted that the use of concept mapping in teaching – learning process provides concrete basis of conceptual thinking, offer a variety of experience, reduce meaningless word responses and makes learning more permanent and consequently, enhance students achievement.

From the results obtained and tested based on research question 2 and hypothesis 2, it is evident that the mean achievement of male and female students in basic science is not significant. This means that the difference between the achievement of male and females in basic science is not significant. This further shows that concept mapping produced the same effect on the mean achievement of the male and female students. The result of this study is contrary to the work of Olatoye and Afuwaye (2004), which revealed that there is gender difference in the achievement of students in science subjects. This study that provides gender disparity is against other studies which showed that concept mapping is not gender biased. This is due to the fact that concept mapping presents topics/concepts bit by bit, from known to unknown, shows meaningful relationships between concepts and promotes creative thinking in both male and female students. Concept mapping takes care of individual differences in the students and as well reduce to the barest minimum the bore on the students when taught with conventional method.

The finding of this study agrees with the findings of Onwioduokit and Akinyemi (2005), Ibiene (2009), Nsofor (2001), Yoloye (2004), and Agummuoh and Nzewi (2003). They observed that both males and females could do well in science if exposed to similar learning conditions.

The result of data analysis revealed no interaction between method and gender on students' achievement in basic science.

The result is supported by the work of Danmole and Adeoye (2004), which yelded a similar result. Furthermore, the result is in line with the work of Ibiene 92009), assertion that there was no significant difference when interaction effect of gender and instructional method was explored, showing that the males and females were affected positively by the method. However, the instructional method (concept mapping) seemed to have provided an environment free from stress and boredom in which male and female students have achieved some level of equilibrium in basic science. Concept mapping therefore, should be used for teaching both male and female students in basic science.

Conclusion
The major results obtained from this study based on data analysis reveal that Concept mapping method of teaching is more effective than the conventional method in fostering achievement of students in basic science. The difference between the mean achievement of students in the concept mapping group and conventional group is statistically significant, and in favour of the concept mapping group. The study further reveals that concept mapping has no differential impact on the achievement of male and female students in basic science. In the same vein also there is no significant interaction between gender and instructional method on students' achievement in basic science

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