

CONCEPT MAPPING TEACHING STRATEGY AND STUDENTS' ACADEMIC ACHIEVEMENT IN CHEMISTRY IN CALABAR MUNICIPALITY CROSS RIVE STATE, NIGERIA

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Abstract

This study investigated the effect of concept mapping teaching strategy on the academic achievement of chemistry students in Calabar Municipality, Cross River – State – Nigeria. Three research questions and hypotheses were formulated to provide focus and to direct the study. The research design was a pretest-posttest, quasi- experimental factorial research design. The sampling technique was a simple random sampling technique. The sample comprised of eighty two secondary two (SSII) chemistry students. The instruments for data collection were a 30-item Chemistry Achievement Test (CAT). The experimental groups were taught using concept mapping strategy while the control group was taught using conventional method. The data obtained were analysed using analysis of covariance (ANCOVA) and Multiple Classification Analysis (MCA). The result revealed that students taught chemistry using concept mapping performed better than those taught using the conventional method. Gender was found not to have significant effect on students' academic achievement and the interaction effect treatment and gender on students' academic achievement was also found not to be significant. It was, therefore, recommended that chemistry teachers should adopt concept mapping teaching strategy for effective teaching and learning of chemistry concepts.

Introduction

Education is the bedrock of national development. Secondary school education in Nigeria is aimed at preparing the learner for a useful life within the society and for a higher educational attainment (Federal Republic of Nigeria, 2004). It is, therefore, important for Nigerian citizens to be well-prepared with the required knowledge that will enable them have a meaningful future. The role of science in technological and national development is acknowledged worldwide as science has contributed and is still contributing to different areas of human endeavour.

Chemistry is one of the basic ingredients of technology. The knowledge of chemistry is needed for students to successfully study professional courses including Medicine,

Nursing, Pharmacy, Engineering and others. It is, therefore, necessary that students studying chemistry should understand the subject so that they can apply the knowledge to their everyday lives (Oloyede, 2010). One of the most cited problems in implementing science curriculum has been the use of inappropriate approaches for the teaching of concepts (Fatokun & Eneiayeju, 2014; Ezeudu, 2013; Jack, 2013 & Oloyede, 2013). Much emphasis has been placed on this by the experimental science curriculum projects at both international and local levels. But despite the amount of efforts and emphasis, science teachers in Nigerian schools still revert to the use of expository or "chalk and talk" method for the teaching of science rather than interactive and investigative approaches (Ifeakor, 2006). It is clear that

when concepts are not meaningfully understood by students, they tend to shy away from questions set on them during the Senior Secondary Certificate Examination (SSCE). Invariably, this may lead to poor performance of students in these areas and the overall poor performance of students in chemistry at SSCE.

Teachers often believe that students understand a concept when they are able to perform certain operations, whereas the students only memorised the layout procedures. Consequently, the students' knowledge of chemistry lacks coherence; and, invariably, this leads to poor performance in examinations. Instead of having a well-integrated domain specific knowledge structures, students consider the different concepts as isolated elements of knowledge and this has resulted in continuous weakness in the understanding and knowledge of chemistry concepts and principles, with the attendant poor performance, especially in external examinations. It is, therefore, imperative for chemistry teachers to adopt methods that will make their lessons more effective, efficient and meaningful to promote insightful learning and long term retention of concepts. Chemistry teachers should create suitable learning environment in order to make their classrooms exciting, purposeful, participatory and interesting. Such teaching approaches that are interactive and activity-based can arouse the interest of students e.g. concept mapping.

Concept mapping is a constructivist based teaching/learning strategy that has its orientation in David Ausubel's Assimilation theory (1968) of cognitive learning that was designed to foster meaningful learning among learners. Concept mapping is a technique for representing the structure of concepts and the relationship between them (Cheema & Mirza, 2013). A concept map is a graphic tool for organising and representing knowledge in the form of organisational chart that provides networks of related ideas and concepts from which learners can gain an insight into the details of knowledge domain with ease (Obomanu & Ekenobi, 2014). Concept mapping strategy makes use of investigative approach; it is concise and interesting. It can be

used to organise knowledge or ideas into meaningful patterns; hence, it fosters creativity.

Studies have shown that concept mapping is very useful in helping students to have an in-depth knowledge of chemistry concepts (Oloyede, 2010; Cheema & Mirza, 2013; Ezeudu, 2013; Jack, 2013; Fatokun & Eniayeji, 2014). The available evidence from research studies in Nigeria indicated that little research effort has been directed at 'concept mapping in the teaching of chemistry in Calabar municipality. Research evidence also indicates that there exists gender disparity in science achievement and it varies among subjects. The differences in science achievement among boys and girls occur mostly as a result of social factors both from home and at school (Fatakum & Eniayeji, 2014; Nwagbo & Okonkwo, 2014). Based on this background, the study intends to find out if, by the application of concept mapping, students would have enhanced meaningful understanding of chemistry concepts and improved academic achievement in chemistry.

Purpose of the study

The purpose of the study, therefore, is to find out if the use of concept mapping in teaching would bring about better understanding of chemistry concepts and increased academic achievement among students. Specifically, the study seeks to determine if there is any significant:

- (i) Main effect of treatment on students' academic achievement in chemistry
- (ii) Main effect of gender on students' academic achievement in chemistry.
- (iii) Interaction effect of treatment and gender on students' academic achievement in chemistry.

As a guide to the study, three research questions and three hypotheses were formulated and tested at 0.05 level of significance. In the course of the study, the research questions were converted to hypotheses to allow for testing.

Research question

1. What is the main effect of treatment on students' academic achievement in chemistry?
2. What is the main effect of gender on students' academic achievement in chemistry?
3. What is the interaction effect of treatment and gender on students' academic achievement in chemistry?

Statement of hypotheses

1. There is no significant main effect of treatment on students' academic achievement in chemistry.
2. There is no significant main effect of gender on students' academic achievement in chemistry.
3. There is no significant interaction effect of treatment and gender on students' academic achievement in chemistry.

Literature review

A teaching method comprises the principles and methods used by teachers to enhance students' learning (Wikipedia, 2017). Alberta Education (2002) defined instructional strategy as techniques teachers use to help students become independent and strategic learners.

The use of concept mapping as an instructional strategy has attracted the interest of many scholars. Agboola & Oloyede (2013) compared the effectiveness of concept mapping and peer tutoring instructional strategies in improving students' performance in chemistry and found that students in concepts mapping group performed better than those in peer tutoring group. Ezeudu (2013) studied the influence of concept mapping on secondary school students in organic chemistry in Nsukka Local Government Area. She found that students taught using concept mapping performed better than those taught using lecture method and recommended that chemistry teachers should adopt the use of concept mapping in teaching and learning of chemistry. In corroboration, Oloyede & Adeoye (2009) found, in their study, that students taught using concept mapping

performed better than their counterparts taught using guided discovery. Other research works have also ascertained the superiority of concept mapping compared to other teaching methods. Patrick (2011); Jack (2013); Otor (2013) found, in their studies, that concept mapping led to increased academic achievement compared to other teaching methods.

However, the studies carried out by Adloan (2012) and Adbulkarim & Hassan,(2013) revealed that there is no significant difference in the academic achievement of students taught using concept mapping strategy and the traditional method of teaching.

Academic achievement and gender:

Oludipe (2012) opined that there are no longer distinguishing differences in the cognitive, affective and psychomotor skills in the achievements of students in respect to gender. Studies carried out by Oloyede (2010); Ezeudu (2013); and Chawla (2015) have ascertained this claim as they found that there is no significant difference in the academic achievement of male and female students when taught using concept mapping teaching strategy.

Ezeudu further found out that there exists a significant interaction effect of teaching method and gender on students' achievement. That finding was corroborated by that of Mbia (2009) who also found that teaching method and gender interact to affect students' academic achievement. However, Nja and Neji (2013) and Christian (2014) revealed a non-significant interaction effect between teaching method and the gender of students.

Research methodology

The study adopted a 2x2x2 quasi-experimental factorial design. The design is the pretest-posttest, control group with two treatment variables as independent variable and one moderator variable. The control group involved students exposed to conventional method and experimental groups involved students exposed to conventional method. The experimental group involved students exposed

to concept mapping. Both groups were pretested and post tested.

Sampling technique and sample

The researcher adopted a simple random sampling technique to select two schools out of 16 government-owned co-educational schools in the local government area.

The studies were randomly assigned to experimental and control groups in each of the two schools using replacement withdrawal methods of balloting. The sample comprised 82 senior secondary school II chemistry students from two schools out of 16 schools in Calabar Municipality. The experimental group had 40 subjects taught using concept mapping while the control group had 42 subjects taught using the conventional methods of teaching.

Instrumentation

The instrument used for this study was a researcher-made Chemistry Achievement Test (CAT). The lesson notes and concept maps were based on selected chemistry topics from the SS2 syllabus for the third term in 2017/2018 academic session. The concept maps and lesson notes were on the topics: thermochemistry; energy and forms of energy, heat content and heat of reaction, exothermic and endothermic reactions.

Validity and reliability of the instrument

A table of specification for a 30-item tests in chemistry was prepared to guide the selection and to ensure adequate coverage of the content and the taxonomy of educational objectives. The instrument was also validated by two experts at the University of Calabar and two experienced chemistry teachers from two schools in Calabar. Adjustments were made as appropriate.

To ascertain the reliability of the study instrument, a trial test was carried out using thirty SS2 students offering chemistry in two schools outside the sampled schools with test re-test method. The data collected from tests were analysed using Pearson Product Moment Correlation (r) and Kuder Richardson formula KR-20 method of estimating reliability. This

was used to determine the internal constituency of the test items. The correlation analysis of the scores derived from the first and second testing gave reliability estimate of 0.88. The reliability coefficient obtained from CAT using KR-20 was 0.77.

Procedure for data collection and data analysis

The researcher sought permission to carry out the study from the school authority in each of the schools used for the study. Chemistry teachers from the two schools were trained on the use of the teaching methods, the contents, objectives and the activities of the students as well as the research conditions were discussed in the course of the training. To ensure uniformity common instructions were given to the teachers; then the two teachers from the two schools took turns to do a trial teaching while the researcher watched and gave necessary corrections. The first meeting with the experimental groups was used to introduce the concept mapping teaching strategy where the teacher highlighted the meaning, aims and instructional procedures of concept mapping teaching strategy.

Before the commencement of the teaching, a pretest was administered to both groups to determine the entry behaviour of the students. The result of the pretest using independent t-test analysis indicated that there is no statistically significant difference between the experimental and control groups in their pretest scores. Thus, the two groups were equivalent before the administration of treatment.

The two groups were taught by their regular class teachers who were trained as instructors using their respective teaching methods. The teaching period lasted for four weeks and took place simultaneously in the schools used for the study. The classes were held twice a week and each lesson lasted for 80 minutes. At the end of the treatment, the instructional effectiveness of the methods was tested by administering a post test on the students.

The result obtained from the pre-test t-scores were used as the covariate to remove

extraneous variations from the dependent variables thereby increasing the precision of the measurement.

Table 1
Summary of result of independent t-test analysis on the pre-test scores

Group	N	\bar{X}	SD	t	p-value
Control group	42	12.53	7.29		
Experimental group	40	11.48	8.48	1.236	8.189

p.05, df=80

Results and discussion

Analysis of covariance (ANCOVA), mean and standard deviation were used to analyse data. Results of the descriptive data analysis are presented in Table 2. The results showed that students in the concept mapping group (the experimental group had a higher mean score of 29.04 in the post test, while the control group had 23.50 with achievement gains score of 14.66 and 10.50 respectively. Therefore, students in the experimental groups achieved better than the control group. Also, female students had a slightly higher mean score of 26.67 than male students who had a mean score of 26.43 in the post test.

Hypothesis one

There is no significant main effect of treatment on students' academic achievement in chemistry.

Table 2

Summary of analysis of covariance on post-test scores according to treatment and gender groups

Source of variance	Sum of squares	df	Mean square	F-ratio	p-level
Intercept	5656.380	1	5656.380	6175.810	.000
Pretest	7.131	1	7.131	12.378	.238
<u>Main effect</u>					
Treatment	609.629	1	304.815	332.806	.000
Gender	.091	1	.091	.099	.753
<u>2-way interaction</u>					
Treatment*Gender	.908	2	.454	.496	.610
Model	742.941	12	61.912	67.597	.000
Residual	101.664	111	.916		
Total	844.605	123			

Model Goodness of fit R = .891; R Squared = .793

To test this hypothesis, analysis of covariance was applied to the data. The result is presented in Table 2. Table 2 shows that there is significant main effect of treatment ($F_{2, 123} = 332.806, p < .05$) on achievement. This result indicates that the experimental and control groups differ significantly from each other in academic achievement. On the basis of this result, therefore, hypothesis 1 is rejected.

Hypothesis two

There is no significant main effect of gender on students' academic achievement in chemistry.

Table 3

Summary of MCA on post-test scores according to treatment and gender groups

Variables	Groups	N	Unadjusted mean	Adjusted mean	Eta	Beta
Treatment	Expt. Gp1	40	27.15	27.14	.635	.889
	Control	42	23.50	23.50		
Gender	Male	41	35.45	35.18	.447	.012
	Female	41	26.95	27.22		

Model Goodness of fit R = .891; R Squared = .793

To test this hypothesis, analysis of covariance was applied to the data. The result is presented in Table 2. Table 2 shows that there is no significant effect of gender ($F_{1, 123} = .099, p > .05$) on achievement. This result indicates that male and female students do not differ significantly from one another in academic achievement. Multiple classification analysis, MCA, was also applied to the data. The result (see table 3) indicates that the adjusted mean scores for male and female groups are 26.58 and 26.52, respectively. The result also showed that a beta value of .012 for main treatment

effect was obtained, suggesting that treatment accounted for only 1.2 percent of variance of scores on post-test measure. Hypothesis two is therefore upheld.

Hypothesis three

There is no significant interaction effect of treatment and gender on students' academic achievement in chemistry. Analysis of covariance was applied to the post test scores. The result is presented in Table 2. The result shows that there is no significant interaction effect of treatment and gender ($F_{2, 123} = .496, p > .05$) on achievement.

123 = .496, $p > .05$) on achievement. On the basis of this result, hypothesis 3 is upheld.

Discussion of findings

Hypothesis one

Effect of teaching methods on students' achievement in chemistry. The result of data analysis of hypothesis one indicates that SSII chemistry students taught chemistry using concept mapping strategy performed significantly better than their counterparts in the control group taught using conventional method. This finding is suggestive of the fact that concept mapping provides an expanded student-oriented activity which can help to create effective learning and acquisition of necessary scientific literacy and higher originality of learning among the experimental group. The result of this study is consistent with Oloyede and Adeoye (2009); Patrick (2011); Agboola and Oloyede (2013); Ezeudu (2013); Jack (2013) and Otor (2013) as they found in their studies that concept mapping led to increased academic achievement compared to other teaching methods.

The finding, however, disagrees with that of Barchok (2014) whose study revealed that collaborative concept mapping has no effect on the learning outcomes of students.

Hypothesis two

Effect of gender on the academic achievement in chemistry. The result of this hypothesis indicates that male and female students do not differ significantly from each other in academic achievement. Both girls and boys were exposed to the same learning strategy which are interactive and activity-based performed well as their confidence in doing science was boosted irrespective of their gender. This result confirms the assertion of Julius and Wachanga (2013); Ezendu (2013) and Chawla (2015) that concept mapping strategy eliminates gender disparity in achievement as they found in their separate studies that gender does not affect students' chemistry achievement when they are taught using concept mapping.

In corroboration, Agboola and Oloyede (2009) and Oloyede (2010) found that the

gender of students has no effect on chemistry students' academic achievement when taught using concept mapping teaching strategy. On the contrary, Nwagbo & Okonkwo (2014) and Yusuf (2014) found that male students performed better than their female counterpart.

Hypothesis three

Interaction effect of treatment and gender on students' academic achievement in chemistry.

The analysis of hypothesis three indicates that the interaction effect of treatment and gender on students' academic achievement is not significant. This means that method of teaching and gender do not significantly interact to contribute to the variance in achievement in chemistry. This is because being a male or a female has little or no effect on a child's academic achievement; because if lessons are presented in a way that learners' participation is encouraged where learners try out things and arrive at solutions to problems on their own, each learner will have meaningful understanding of concepts presented irrespective of their gender. This finding synchronised with those of Nja and Neji (2013) and Christiana (2014) whose studies revealed that gender and treatment do not interact to affect the academic achievement of students in chemistry. The finding, however, deviates from Ezeudu (2013) and Mbia (2009) whose analysis of data revealed that there is a significant interaction effect of treatment and gender on students' academic achievement.

Conclusion

Based on the findings of the study, the following conclusions were reached: concept mapping is a very effective learning strategy as it enhanced insightful learning of chemistry concepts leading to high academic achievement. It should, therefore, be employed in chemistry teaching in secondary schools in Calabar municipality. The conventional method should be complementary to other teaching methods as it is not an effective method of teaching. Gender was found to have no significant influence on students' academic

achievement and does not interact with teaching methods to affect academic achievement.

This study has, therefore, added fresh evidence to the body of knowledge on the effect of concept mapping on chemistry students' academic achievement in relation to gender of students.

Recommendations

In view of the findings of this study, the following recommendations are hereby put forward:

1. Concept mapping should be adopted for the teaching of chemistry in secondary schools.
2. Examination bodies and curriculum designers should prescribe concept mapping in their syllabuses for the teaching of chemistry.
3. Gender should not be seen as a limiting factor on students' academic achievement as both male and female students have the ability to perform well when exposed to appropriate teaching methods
4. The state Ministry of Education and school administrators should organise retraining programmes to educate chemistry teachers on the use of concept mapping strategy for effective teaching and learning of chemistry.

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