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EFFECT OF GUIDED-INQUIRY METHOD ON SENIOR SECONDARY SCHOOL CHEMISTRY STUDENTS' ACADEMIC ACHIEVEMENT IN ANAMBRA STATE, NIGERIA

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ABSTRACT

The study investigated the effect of guided-inquiry method (GIM) on senior secondary school chemistry students' academic achievement in Anambra state, Nigeria. Two research questions guided the study and two null hypotheses were posited and tested at 0.05 level of confidence. The study adopted a quasi-experimental, specifically, pretest posttest non-equivalent control group design. The population of the study consisted of 541 senior secondary two (SS 2) chemistry students in Awka South local government area of Anambra state. Using a simple random sampling technique with replacement, two intact classes of 87 SS 2 chemistry students formed the sample of the study. Chemical Reaction and Equilibrium Achievement Test (CREAT) was used as instruments for data collection. The reliability coefficient of 0.76 was established for CREAT using Kuder Richardson 20 (K-R 20). Mean and standard deviation was used to answer the research questions while Analysis of Covariance (ANCOVA) was used to test the null hypotheses at 0.05 level of significance. The findings revealed that guided-inquiry method is more effective in improving academic achievement of chemistry students than the Conventional lecture method. There was no significant difference in the academic achievement of chemistry students due to gender. In light of the findings from this study, it was recommended that chemistry and science teachers should adopt the use of GIM in teaching science students and as well structure lessons to provide hands-on activities, with a hope to enhance gender equality and to discourage gender stereotyping in teaching and learning of chemistry.

Key words: *Guided-inquiry method, academic achievement and senior secondary school.*

Introduction

Education is the bedrock of any nation's development and is central to all aspect of any nation's economy. It is the total process of human learning by which knowledge is impacted, faculties trained and skills developed. Education, according to Ugwu (2019) and Chukwuma and Aniekwe (2011) can be regarded as the process of imparting and acquiring general knowledge, instrument for effecting human learning, transformation and capacity development. Thus, it is a means through which man acquires learning and is molded to fit into the society. In the National Policy on Education, the Federal Government of Nigeria (FGN, 2014) had continued to update her educational system to meet up with various educational challenges. Senior secondary education in Nigeria, on its part, aims at equipping students to live effectively in our

modern age of science and technology, hence, the inclusion of science education in the secondary school curriculum in Nigeria. The Nigeria secondary school science education curriculum lay emphasizes on the teaching and learning of science subjects through hands-on activity based teaching methods.

Chemistry in particular as a science subject, takes up a very significant place in the senior secondary school science education curriculum because of its applications in everyday life and the role it plays in enabling students to develop intellectual capability. One of the objectives for teaching chemistry is to enable learners to use knowledge and skills acquired to solve problems in everyday life. However, most students in secondary schools in Nigeria find many chemistry concepts difficult to understand and this is evident in their inability to transfer or link their classroom experiences with real world problems. Hence, learning by memorization in chemistry classes is often common because the students are not actively involved in the classroom activities. It is also disappointing to note that the students' academic achievement in chemistry at both internal and external examination has remained considerably low despite the relative importance of chemistry (Erinosho, 2013 & Nja, Idiege and Obi , 2017). This is reflected in the steady decline in the academic achievement of chemistry students in West African Examination Council (WAEC). The WAEC Chief Examiner's report from 2011-2016 showed a percentage credit pass of 49.54%, 43.13%, 72.34%, 62.49%, 60.60% and 57.74% respectively.

The WAEC Chief Examiner's report (2016) stressed that the students' low achievement in chemistry could be as a result of students' shallow knowledge of the subject matter which may be due to lack of understanding of the demand of the problem (question), poor manipulative skills, poor teaching methods and strategies, students' negative attitude and lack of interest and over loaded chemistry curriculum. Researchers such as Ibrahim (2012), and Njoku and Ezenwa (2014) have attributed the causes of the low academic achievement in chemistry among others to be time constraint for conduction of practical, over-loaded chemistry syllabus, abstract and difficult nature of many chemistry concepts, lack of interest on the part of students, large class size, fear of the subject psychologically, attitude of students towards science, use of inappropriate method of instruction as most teachers use conventional (lecture) method of instruction that does not involve student active participation.

The persistent low academic achievement and limited understanding of chemistry concepts by secondary school chemistry students in Nigeria and also the search for more effective methods of teaching and learning chemistry has been an issue attracting the attention of researchers and science educators. For more than a decade now, the different instructional method and strategies employed in teaching chemistry have not help to improve students' understanding of the concepts, and their academic achievement in chemistry to an appreciable extent. Researchers such as Achimugu (2014) and Adam (2016) noted that most chemistry teachers use conventional (lecture) method that does not involve students' active participation in their teaching not minding the outcome of their teaching. This lecture method has been criticized for lack of effective interactive approach which caused low academic achievement in chemistry. Hence, this instructional method employed by most teachers in teaching chemistry more than a decade now has fail to improve the students' understanding of the concepts and their academic achievement to an appreciable extent.

Chemistry, being an activity-oriented science subject should be taught by way of discovery knowledge through effective student-centered and activity-based teaching method. It is therefore, pertinent at this critical time when high premium is placed on science education in general and chemistry in particular as the bedrock of national development to search for an approach for teaching chemistry, in order to

improve the students' learning outcome. Chemistry teachers therefore, need to use an approach that are students centered and activity-based teaching methods such as inquiry-based method as to enhance maximum learning outcome. Inquiry teaching method is a method of teaching where the learner is seeking to discover and create answers to recognize problems through procedure of making a diligent search, some time with minimum guidance from the teacher. It is defined by Yagger and Akcay (2010) as an active approach to learning in which students investigate a problem based on a model of scientific processes. This teaching approach encourages active participation of students and serves to develop critical thinking and also provide concrete learning experiences to substantiate the theoretical aspect that might have been taught. Hence, a deeper understanding of chemistry concepts can be achieved.

Researchers such as Alabi and Lasisi (2015) and Ndukwe (2021) have earlier carried out researches on the effects of innovative teaching methods such as guided inquiry and conventional teaching method on achievement of secondary school students in science subjects. According to Alabi and Lasisi (2015) and Ndukwe (2021), innovative teaching methods are an effective instructional strategy when compared with the conventional lecture method. Moreover, Jack and Suleiman (2017) stated that guided-inquiry laboratory experiments would be more effective for the student understanding of volumetric analysis and would not be gender stereotype. The problem is how can guided-inquiry method of teaching and learning help students gain better understanding of chemistry concepts and thus improve their academic achievement in chemistry.

Achievement in chemistry may also be influence by some learner's characteristics such gender. Gender is an important variable in educational research and it has continued to be an issue of concern to educators and researchers. Gender can be considered to be sexual classification into male and female. Gender issues in the context of education is referred to as the differences, both real and perceived between boys and girls and their relative achievements and opportunities (Mankumari & Ajay, 2017). Abungu, Okere and Wachanga (2014) findings indicated that male and female exposed to activity-based teaching approach show significant difference in chemistry achievement. Oribhabor (2019) and kisigot, Ogula and Munyua, (2021) in their respective studies found also a significant difference between male and female students' academic achievement in science subjects. Uwalake (2013) study revealed superiority in the academic achievement of females over males in chemistry.

On the other hand, the studies of Oludipe (2012) and Godpower-Echie and Ihenko (2017) reviewed a no significant influence in academic achievement of male and female students in basic science. Moreover, Ajayi and Ogbeba (2017), reported that there is no significant difference between male and female students taught stoichiometry using hands-on activities. The influence of gender on achievement and in science education is therefore still a controversial issue among science researcher. These contradictive evidences in academic achievement and lack of clear trend on gender influence in the study of science has resulted in the need to carry out a study with a view to determine the effect of guided inquiry on secondary school male and female students' academic achievement in chemistry.

In the light of the above problem, this research was designed to investigate the effects of guided inquiry method on senior secondary school students' academic achievement in chemistry in Anambra state of Nigeria.

Research Questions

The following research questions guided the study.

1. What are the mean gain achievement scores of chemistry students taught chemical reaction and equilibrium with guided inquiry method and those taught with conventional method using their pretest posttest scores?

2. What are the mean gain achievement scores of male and female chemistry students taught chemical reaction and equilibrium with guided inquiry method?

Hypotheses

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

1. There is no significant difference in the mean gain achievement scores of chemistry students taught chemical reaction and equilibrium with guided inquiry method and those taught with conventional method.
2. There is no significant difference in the mean gain achievement scores of male and female chemistry students taught chemical reaction and equilibrium with guided inquiry method.

Research Method

Research design

A quasi experimental research design was adopted for this study. Specifically, a pretest-posttest non-equivalent control group design was used. A quasi experimental study is a type of experimental study that determines the effect of treatment paradigm in a non – randomized sample. This design was used because the research involved intact classes. The classes were assigned into experimental and control group by a toss of a coin. The design is schematically represented as follows:

Group	pre – test	Treatment	post – test
E	O_1	X_1	O_2
C	O_1	X_2	O_2

Where:
E = Experimental group
C = Control group
O_1 = Pretest for E and C
O_2 = Posttest for E and C
X_1 = Experimental treatment (Guided inquiry method)
X_2 = Control treatment (conventional method of instruction)

Area of the study: The study was carried out in Awka South L.G.A in Anambra state.

Population of the study: The population of the study consisted of all the senior secondary school two (SS 2) chemistry students from the 18 public secondary schools in Awka South L.G.A. There were 541 chemistry students made up of 204 males and 337 females, as at the time of the study, (Source, Post Primary School Service Commission, Awka Anambra State academic record).

Sample and sampling technique: Intact classes comprising of a total of 87 SS2 chemistry students from two (2) schools out of the 18 public secondary schools in Awka South L.G.A. formed the sample of the study. Purposive sampling technique was first used to select eight schools from the 15 co-educational secondary schools in Awka South L.G.A. According to Nworgu (2015), purposive sampling involves the selection of a sample that possesses particular characteristic relevant to achieving the purpose of the study. A Simple random sampling technique with replacement was used to draw two co-educational senior secondary schools out of the eight co-educational schools in which one school was used as experimental group, the other school as control group. The experimental sample (N = 35) consisted of 14 males and 21 females while the control sample (N = 52) consisted of 33 males and 19 females.

Instrument for data collection: The data for this study were collected via an instrument, Chemical Reaction and Equilibrium Achievement Test (CREAT). This was developed by the researchers and it was used to measure how much the students have gained from the topics taught after their exposure to the learning experiences. CREAT consisted of 50 multiple choice objective test items with four options per item that is A-D. Each item was 2 marks making 100% for the 50 items. The students were required to answer all the questions and the instrument was used for both pre-test and post-test.

Validation of the instrument: To ensure both face and content validity of the instrument, the test was given to three experts, two Science Education lecturers and one Measurement and Evaluation specialist in Nnamdi Azikiwe University, Awka Anambra State. The content validity was accomplished by ensuring that the CREAT reflected the specifications of the test blue print. Face validity was established by requesting the validators to assess the instruments including their items in terms of clarity, proper wording of items, appropriateness and adequacy of the items in addressing the purpose of the study and to make corrections and suggestions where necessary. All corrections and suggestions were taken into consideration in producing the final copy of the instruments.

Reliability of the instrument: The reliability of the internal consistency of CREAT was established using Kuder Richardson formula 20 (K-R 20). This is because the items are dichotomously scored and they are not of equal difficulties. An equivalent sample of 45 SS II chemistry students outside the research area was used. They were administered with CREAT and the scores obtained were used to calculate the reliability coefficient of the instruments. The reliability coefficient of the instruments was found to be 0.76 for CREAT and at this stage the instruments was ascertain to be reliable for this study.

Method of data collection: The instrument was used to generate data on two different times during the study, namely pretest and posttest. Participants of the experimental and the control groups were given pretest before treatment and posttest after treatment. The results of the test formed part of the data of this study.

Experimental procedure: Pretest was administered to the students before the commencement of the experiment. In the treatment administration, the students for both the experimental and control groups received the same lesson contents using the same length of time but different lesson plan was used. In the experimental group, guided inquiry method was used while in the control group, the conventional method was used to teach the contents. The study lasted for six weeks, five weeks was used for teaching the students, and then on the sixth week the posttest was administered to the same students but this time, the test items was reshuffled starting with even number item from the bottom. The research assistants of the groups who were the class teachers of the students administered the test (CREAT) on the students. After the posttest administration, the researchers collected the scripts, and the scripts of both groups were scored, their scores dully recorded and were used for analysis.

Method of data analysis: The data collected were subjected to both descriptive and inferential statistics. Mean scores was the statistical tool for answering the research questions and 2 × 2 analysis of covariance (ANCOVA) was used to test all the hypotheses. This was used to take care of the initial differences in the two groups and to control selection bias. $P \leq 0.05$ level of significance was set for rejecting or not rejecting the null hypotheses.

Presentation of Results

Research Question 1: What are the mean gain achievement scores of chemistry students taught chemical reaction and equilibrium with guided inquiry method and those taught with conventional method using their pretest posttest scores?

Table 2: Pretest and Posttest Means Achievement and Standard Deviation Scores of the Experimental and Control Groups on Chemical Reaction and Equilibrium Achievement Test (CREAT).

		Pretest		Posttest		
Groups	**N**	**$\bar{X}$**	**SD**	**$\bar{X}$**	**SD**	**Mean Gain**
Control	52	25.77	13.69	47.38	9.87	21.61
Experimental	35	31.26	14.29	78.34	6.27	47.08

Data presented in Table 2 show that the control group had a pretest mean and posttest mean achievement scores of 25.77 and 47.38 while those of the experimental group were 31.26 and 78.34 respectively. The pretest standard deviation for control (13.69) and experimental (14.29) groups indicate that the individual scores are widely spread apart from each other. On the other hand, their posttest standard deviation 9.87 and 6.27 respectively indicate that their scores are not too far from the mean and from each other. The table also reveals that the mean gain achievement score of the experimental group was 47.08 and is remarkably higher than that of the control group which was 21.61. This means that experimental group taught with guided inquiry method achieved more than control group taught with conventional method.

Research Question 2: What are the mean gain achievement scores of male and female chemistry students taught chemical reaction and equilibrium with guided inquiry method?

Table 3: Pretest and Posttest Mean Achievement and Standard Deviation Scores of Male and Female Chemistry Students in Experimental Group on CREAT.

		Pretest		Posttest		
Groups	**N**	**$\bar{X}$**	**SD**	**$\bar{X}$**	**SD**	**Mean Gain**
Male	14	30.71	16.85	76.14	8.65	45.43
Female	21	31.63	12.74	80.29	7.78	48.66

Table 3 reveals that, the male and female students in the experiment group had a pretest mean achievement scores 30.71 and 31.62 respectively while their posttest mean achievement scores were 76.41 and 80.29 respectively. The pretest standard deviation for male (16.85) and female (12.74) indicates that their responses were far from the mean and from each other. On the other hand, their posttest standard deviation 8.65 and 7.78 respectively indicates that their responses were not too far from the mean and from each other. The mean gain achievement score of female (48.66) was slightly higher than the mean gain achievement score of the male students (45.43). This shows that both male and female students maintain unequal intellectual level even when they were exposed to the same learning environment and structure.

Testing the null hypotheses

Null hypothesis 1: There is no significant difference in the mean gain achievement scores of chemistry students taught chemical reaction and equilibrium with guided inquiry method and those taught with conventional method.

Table 4: ANCOVA on the mean achievement scores of chemistry students taught with guided inquiry and those taught with conventional method.

Source of variation	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	21114.907[a]	2	10557.454	66.573	.000
Intercept	59212.675	1	59212.678	373.384	.000
PRETEST	5.531	1	5.531	.035	.852
GROUP	20147.007	1	20147.007	127.043	.000
Error	13321.047	84	158.584		
Total	340952.000	87			
Corrected Total	34435.954	86			

R Squared = .613 (Adjusted R Squared = .604)[a]

The result of the 2-ways analysis of covariance from Table 4 shows that the F-value was 127.043 and the P-value was 0.000. Since the P-value was less than 0.05 level of significance at df of 1 and 84, it shows that there is a significant difference between the mean achievement scores of the control and experimental groups in favour of the experimental group with higher mean score. The null hypothesis is therefore rejected.

Null hypothesis 2: There is no significant difference in the mean gain achievement scores of male and female chemistry students taught chemical reaction and equilibrium with guided inquiry method.

Table 5: ANCOVA on the mean achievement scores of male and female chemistry students taught with guided inquiry method.

Source of variation	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	146.716[a]	2	73.358	.970	.390
Intercept	35485.713	1	35485.713	469.338	.000
PRETEST	2.544	1	2.544	.034	.856
GENDER	142.827	1	142.827	1.889	.179
Error	2419.456	32	75.608		
Total	218952.000	35			
Corrected Total	2566.171	34			

a. R Squared = .057 (Adjusted R Squared = -.002)

The result of the 2-ways analysis of covariance from Table 5 indicates that the F-value was 1.889 and the P-value was 0.179. Since the P-value was greater than 0.05 level of significance at df of 1 and 32, it shows that there is no significant difference between the mean achievement scores of male and female chemistry students who were taught with guided inquiry method. The null hypothesis is therefore upheld.

Discussion of Findings

The result from testing hypothesis 1 of this study revealed that the students from experimental group who were exposed to guided-inquiry method performed significantly better than their counterparts in the control group who were taught the same chemistry concepts using conventional method of teaching. This is confirmed by the test of the hypothesis which revealed that there is a significant difference between the mean achievement scores of experimental group and control group in favour of experimental group (table 4).

This finding of this study is in agreement with the findings of Alabi and Lasisi (2015), and Ndukwe (2021). They separately reported that guided inquiry method is most effective in enhancing learning of science subjects than the conventional method. Jack and Sileiman (2017) research findings on effectiveness of guided-

inquiry laboratory experiments on secondary schools students' academic achievement in volumetric analysis were also in line with the findings of this study by indicating that guided-inquiry laboratory experiments had much more effect on students' academic achievement than the traditional teaching method. The effectiveness of this guided inquiry method as a means of enhancing students' academic achievement in chemistry may be attributed by the nature of the instruction. It is more learner-centered and thus it provided a lot of activities for the students to control their own action in the learning process. The result of this study therefore indicated that guided inquiry method is better than conventional method in enhancing students' academic achievement in chemistry.

The result of testing hypothesis two of this study revealed that gender did not influence students' academic achievement in chemistry significantly when taught with guided inquiry method. The null hypothesis which states that there is no significant difference in the mean achievement scores of male and female chemistry students who were taught with guided inquiry method is therefore not rejected. The result of this study is in conformity with the findings of Oludipe (2012) study on influence of gender on junior secondary school students' academic achievement in basic science using cooperative learning teaching strategy. Findings of Oludipe's study revealed that there was no significant difference in academic achievement of male and female students at the pretest, poattest and delayed posttest levels respectively. Similarly, Godpower-Echie and Ihenko (2017) study on influence of gender on interest and academic achievement of students in integrated science reviewed that, there is no significant influence in academic achievement of students in basic science due to gender. The findings of this study also supported the work by Ajayi and Ogbeba (20170, which showed that hands-on activities teaching strategy has an equal effect on both male and female chemistry students when taught stoichiometry.

The finding of this study however is in disagreement with the findings of Uwalake (2013); Mankumari & Ajay (2017); Oribhabor (2019) and kisigot, Ogula and Munyua, (2021). Their work indicates significant gender differences in the academic achievement of students in science subjects. In the study of Mankumari & Ajay (2017) on gender differences in the academic performance of students showed that the female students outperformed their male counterparts. Moreover, the findings of Uwalake (2013) also revealed superiority in the academic achievement of females over males in chemistry. On the other hand, Oribhabor (2019) and kisigot, Ogula and Munyua, (2021) studies on the influence of gender on mathematics achievement of secondary school students and effect of gender on students' academic achievement in public secondary schools respectively. They reported separately that male students performed significantly better than their female counterpart on students' academic achievement in science subjects.

The differences in their academic achievement can be attributed to gender stereotyping which encourage male and female students to show interest in subjects relevant and related to the role expected of them in the society. The equivalent performance of both male and female students reported in this study might have been induced by the fact that the participant of experimental group was able to discuss freely with one another within the group and even the whole class.

Conclusion

The study indicated that guided inquiry teaching method yielded a more viable result on academic achievement among secondary school chemistry students irrespective of their gender. This experimental group taught chemistry with guided inquiry method, had higher mean achievement scores than their counterpart taught with conventional teaching methods. Also a non significant gender influence on academic achievement was indicated. Therefore, it was concluded that the use of guided inquiry instructional method enhances the secondary school chemistry students' academic

achievement, better than the use of conventional method.

Recommendations

Based on the findings of this study, and their implications, the following recommendations were made:

1. Chemistry teachers and other science teachers should be encouraged to teach their students using Inquiry teaching method and discourage the use of only conventional method that are not activity-oriented teaching method alone as the former technique enhance better academic achievement of the students, therefore it is highly recommended that the use of inquiry teaching method should be encouraged in all secondary schools in Anambra state and other states in Nigeria.
2. Guided inquiry teaching method should be used by the chemistry and other science teachers at large to enhance gender equality and to discourage gender stereotyping in teaching and learning of science subjects.
3. Government should sponsor teachers to attend workshops and seminars on the appropriate and effective use of the Inquiry teaching method in the realization of chemistry and other science subjects' better performance among senior secondary school students.
4. The teacher training institute should train their products on the appropriate use of inquiry-based teaching method so as to keep them abreast with the current development in methodology of teaching.

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