

**EFFECT OF DIFFERENTIATED SCIENCE INQUIRY ON ACADEMIC ACHIEVEMENT  
AND CREATIVE THINKING SKILLS OF CHEMISTRY STUDENTS IN ANAMBRA  
STATE, NIGERIA**

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**Abstract**

*This study investigated the effect of differentiated science inquiry (DSI) on academic achievement and creative thinking skills of chemistry students in Anambra State. To achieve the purpose of the study, two research questions were drawn and three hypotheses formulated and tested at 0.05 level of significance. The study adopted quasi experimental design. The population of the study was all the SS3 chemistry students in Aguata education zone totaling 2,278 students from 60 public schools in the zone. Multi-stage sampling procedure was used to obtain 72 (SS3) senior secondary III chemistry students. Two intact classes made up the sample. By a throw of coin, one intact class of 37 was used as control group while the other of 35 was used as the experimental group. The experimental group was taught using DSI while the control group was taught using lecture method of instruction. Chemistry Achievement Test (CAT) and Creative Thinking Skill Test (CTST) were used to collect the data for the study. The instruments were validated by experts and their reliability was established at 0.89 and 0.97 respectively. The data obtained for the study were analyzed using mean and standard deviation to answer the research questions and analysis of covariance (ANCOVA) was used to test the hypotheses at 0.05 level of significance. The findings revealed that differentiated science inquiry teaching method was more effective in enhancing students' academic achievement and creative thinking skills in chemistry than lecture method of instruction. There was significant difference in the creative thinking skill of the male and female students taught chemistry using differentiated science inquiry. There was improvement in the creative thinking skill for the male students than that of the female students taught chemistry using differentiated science inquiry. The study also revealed that there was no significant interaction effect of gender and teaching method on students' creative thinking skill. Based on the findings, recommendations were made among which are chemistry teachers should adopt the use of differentiated science inquiry in their classroom instruction in order to enhance students' academic achievement and creative thinking skill in the subject.*

**Keywords:** Differentiated Science Inquiry, Science Inquiry, Creative Thinking, Creative Thinking Skills, Academic Achievement.

## Introduction

Science has permeated the life and daily activities of man to the extent that man's life can hardly be sustained without it. Everybody in the society today feels the impact of science and technology. The advancement of science and technology is greatly governed by its application to societal needs and aspirations. The role of science and technology encompasses political, social, medical, economic, education and so on. Science and technology provide new and fast routes to economic growth. They are used in establishing the global position of a nation. Thus, the superpowers, the developing and underdeveloped nations are classified based on their levels of scientific and technological advancement. This is with respect to their military might, economical power, industrial development and level of agricultural mechanization. The aforementioned indices of scientific and technological advancement require chemistry as a core discipline. This may be among the reasons why the federal government of Nigeria in the NPE (2013, revised) included chemistry as one of the science subjects students offered in the senior secondary school. Also, chemistry is a critical determinant of the post-secondary education and career options available to young people in the sciences (Ezeliora, 2009; Nnaka, 2010).

Chemistry according to Peter Atkins (2013) is defined as a science that deals with the structure and properties of substances and with the changes that they go through. Chemistry is the scientific study of interaction of chemical substances that constitute atoms or the subatomic particles; protons, electrons and neutrons (Gabriel, 2012). Chemistry is therefore defined as the study of the composition, properties, structures, interactions and transformation of aggregates of matter either in isolation or in combination. It is an integral part of the science curriculum both at the senior secondary school as well as higher institutions. At this level, it is often called "general chemistry" which is an introduction to a wide variety of fundamental concepts that enables students to acquire tools and basic skills useful at the advanced level. Chemistry contributes enormously to all aspects of human endeavor. All activities carried out by man, through man and in man, have to do with chemical activities. Chemical reactions occur when you breathe, eat or just sit at a place reading. Nations of the world recognize the importance of chemistry and build their national capacity on chemical related disciplines for sustainability. Nigerian is not let out, for she is focusing on improving her economy through industrialization. In view of this, Nigeria has in the national policy on education made chemistry a compulsory science subject at secondary school level and a compulsory subject requirement for all science related disciplines in university admission (FRN, 2014).

Interestingly, as important as chemistry is, students' achievement in the subject at secondary school level has not been encouraging. Record of students' performance at Senior School Certificate Examination (SSCE) in chemistry conducted by West African Examination Council (WAEC) shows that between 2010 and 2019 (except in 2010, 2011 and 2012), less than 50% of the students who enrolled for chemistry obtained credit level pass and above to secure admission into the university in order to pursue courses that require chemistry. The records stressed that there was improved achievement in 2010, 2011 and 2012 (50.2%, 62.6% and 67.2%) but the failure rate continued in 2013, 2014, 2015 and 2018 (46%,



47.83%, 38.68% and 48.15%) with an improved achievement in 2016, 2017 and 2019 (52.97%, 59.22% and 64.18%), In general, this cannot be considered an acceptable achievement.

The students' poor achievement in chemistry in particular and sciences in general has been attributed to many factors. These include school factors, students' factors and teacher's methods of teaching such as conventional methods and mostly inquiry method, a constructivist approach among others (Gabriel, 2012; Uzoamaka, 2013; Oguama, Ugwoke & Ugwuanyi, 2020). Research findings revealed that chemistry teachers in particular and science teachers in general in Nigeria education system has remain stock to the conventional approach (talk-chalk method) of instruction. This is teacher-centered method of chemistry instruction whereby the teacher present verbally the facts and their own knowledge about the subject and the students passively listen and jot down notes. There is therefore the need to shift from the didactic method of chemistry instruction to constructivist (activity-oriented) approach which would induce creative thinking skills in the learners to enhance achievement outcome.

One of the skills students are predominantly trained in to achieve the objectives of education in the 21<sup>st</sup> century is creative thinking skills (Moon, 2008). Creative thinking skills according to Boden as cited in Fuad, Mahana, Suarsini and Zubaidah (2017) is the ability to bring new ideas that are surprising and valuable in many ways. Creative thinking is related to novelty, to the ability to do, create something, to implement new forms, to generate a lot of imaginative skills or to make something that already exists into something new (Greenstein, 2012). Abraham (2016) defined creative thinking as a form of expressing oneself in a unique way. Creative thinking therefore is the intentional gaining of new insights and different ideas through existing experience or information. Students' creative thinking skills which are different from one another require learning condition involving learning experience so that the potential of creative thinking can develop (Yusaeni, Corebima, Susilo & Zubaidah, 2017). Creative thinking skills according to Hadzigeorgion (2012) are the foundation of science. These skills thus need to be trained through learning. Hence chemistry in particular and science learning in general should put more emphasis on students' activities through inquiry (Harris & Rooks, 2010; Ozdemir & Isik, 2015) and provide opportunities for students to develop their creative thinking skills. Johnson as cited in Fuad et al (2017) noted that inquiry learning is considered to be basic and widely used for encouraging creative thinking skills in chemistry and science learning. Previous studies (Michalopoulon, 2014; Nurhadi, Lukman, Abas, Erni, Yuliana & Hamrina, 2016) revealed that inquiry learning can train students' creative thinking skills. This study is set to find out the effect of differentiated science inquiry learning models on the creative thinking skills of students in chemistry.

Inquiry-based learning is a form of active learning that starts by posing questions, problems or scenarios to the students and the students are allowed to proffer solutions to the problems. Abugu (2010) defined inquiry method of instruction as a constructivist approach whereby the learners construct and reconstruct problems based on their past experience with a view to

proffering solution to the problems. There are five levels or models of inquiry according to Llwellyn (2013) with each model being differentiated by the amount of teacher's intervention towards the students or on the amount of guidance given by the teachers to their students. In classroom, the implementation of one model or level of inquiry sometimes poses problem to the accomplishment of stated classroom objectives because of the students' differences in their academic interest, readiness, learning styles and speed of receiving and processing information. In view of this, implementing one type of model of inquiry in a class has disadvantage which is not accommodating students' development in achievement outcome. For instance, if a teacher selects and applies inquiry model 4 to a class, students having low ability would find it difficult to follow the lesson and hence would not do well in their academic achievement. Conversely, if the teacher selects and applies inquiry level 1, students with high ability would quickly get bored because it would be easy for them. Therefore an inquiry learning model such as differentiated science instruction (DSI) that accommodates such diversity is very necessary. Liewllyn (2011) stated that differentiated science inquiry is evidence-based teaching practices such as knowing who students are as learners, choosing multiple instruction strategies, using ongoing classroom assessment and organizing flexible groupings. Differentiated science inquiry can take any form like, confirmation, structural, guided, coupled and open inquires, which can help teachers select learning resources, plan instruction and assess student learning for better academic achievement output.

Academic achievement is a very important factor in education. It is the extent to which a student, teacher or institution has achieved their educational goals (Sepehrian, 2013). Kpolovie, Joe and Okoto (2014), defined academic achievement as the ability of a student to study and remember facts and being able to communicate his knowledge orally or in written form even in an examination condition. The authors also opined that academic achievement is a measurable index that depicts a student's cognitive, affective and psychomotor domains in educational settings. The researchers are of the opinion that students will achieve more academically when various science inquiry has been adopted in learning sciences which may highly contribute to improving creative thinking skills of the students. They believe that differentiated science inquiry may facilitate students in managing and understanding information effectively and systematically.

Irrespective of the importance of chemistry to everyday life and requirement for many science disciplines, student still dread the subject and poor achievements as recorded by the secondary school external examinations (WAEC, 2018; NECO 2018). The chief examiners report has consistently showed that the percentage of credit pass in chemistry never got up to 50% for the past six years (WAEC 2020). The poor performance in chemistry is not acceptable since this will affect the nation in future, not only in secondary school level but in the universities and all science disciplines and by implication Nigerian security, economy and manpower development.

Ample evidence abounds to show that student's achievement and creative thinking skill in chemistry is still poor. Various factors have been attributed to be responsible for the poor performance which is generally clustered into teacher related, some student related and subject nature related. One of the major factors is ineffective teaching methods, thus the call

for other teaching methods that are constructive in nature which should involve learner's active participation and promote skill acquisition, like differentiated science inquiry which have received very little attention if any, in the literature of Aguata Education zone which will seek to answer the problems students are facing in increasing their achievement level and creative thinking skills.

### **Purpose of the study**

The study sought to determine;

1. difference in mean achievement scores of students taught Chemistry using differentiated science inquiry and those taught using traditional mode of instruction.
2. difference in mean creative thinking skill scores of male and female students taught Chemistry using differentiated science inquiry.
3. interaction effect of gender and teaching method on students' creative thinking skill.

### **Research Questions**

The following research questions guided the study;

1. What is the difference in mean achievement scores of students taught Chemistry using differentiated science inquiry and those taught using traditional mode of instruction?
2. What is the difference in mean creative thinking skill scores of male and female students taught chemistry using differentiated science inquiry?

### **Hypotheses**

The null hypothesis was tested at 0.05% alpha level of significance.

1. There is no significant difference in mean achievement scores of students taught Chemistry using differentiated science inquiry and those taught with lecture method of instruction.
2. There is no significant difference in mean creative thinking skill scores of male and female students taught Chemistry using differentiated science inquiry.
3. There is no Interaction effect of gender and teaching method on students' creative thinking skill.

### **Methods**

The research design adopted for this study is a quasi-experimental which involves the pretest, posttest experimental and control group design (Nworgu, 2018). The design was adopted because the two groups have common variable (achievement, creative thinking skills and gender). In this study, there are two levels of independent variables (two treatments) and two levels of gender (male and female). Pretest and posttest were given to both the experimental and control groups. Experimental group are subjected to treatment using differentiated



science inquiry while the control group was also subjected to treatment using traditional mode of instruction. The independent variables in this study are the differentiated science inquiry and traditional mode of instruction while the dependent variables are the creative thinking skills and achievement scores. Gender is a moderating variable.

### **Sample and Sampling technique**

The sample of this study consists of 72 (37 males and 35 females) SS3 students offering chemistry, drawn from two schools out of the 60 government owned secondary schools in Aguata Education zone. The subjects were sampled using multistage sampling procedure. Firstly, simple random sampling technique was used to choose one Local Government (Orumba South Local Government Area) out of the three local government Area in Aguata Education zone. This method ensured that each local government area (LGA) was given an equal and independent chance of being selected. Secondly, using purposive sampling technique, two schools were sampled out of the 14 government schools in the selected local government area (Orumba South Local Government Area), the reason for purposive sampling was to get schools with teachers who have BSc in chemistry and have taught for more than 5 years and also to obtain schools with more than 20 chemistry students in SS3. Lastly, toss of coin was used to assign the two schools to experimental group and control group. After the sampling, the experimental class consisted of 35 students (18 males and 17 Females), while the control group consisted of 37 students (19 males and 18 females).

### **Validation of the Instrument**

Two research instruments (CAT and CTST) were subjected to face validation by three experts, one from Measurement and Evaluation and one from Science Education, all from faculty of Education, Nnamdi Azikiwe University, Awka and one experienced chemistry teacher from secondary school, who have taught chemistry for over 10 years. The instrument was validated in terms of clarity of instructions; correct wording of items and appropriateness and adequacy of the items in addressing the purpose and problems of the study. The reliability coefficients of the instruments were established at 0.89 and 0.97 respectively. On the basis of the index, the instruments were considered reliable and suitable for conducting the research.

### **Experimental procedure**

The study involved two groups which were experimental and control groups. On the first day of the experiment, the CAT was administered by their regular chemistry teachers as pretest to the groups in their intact classes. Thirty minutes was allowed for the pretest. The teachers invigilate their students in both the experimental and control groups. At the end of the test the question papers and answers was collected from the students by their teachers. The reason for the retriever of the question papers was to ensure that the students did not reserve the same content for the posttest. The pretest achievement paper was marked; scores was collected and handed over to the researcher. The initial administration was aimed at establishing the same level of content knowledge for the experimental and control groups. The CTST was also

administered by their regular chemistry teachers as pretest to the groups in their intact classes to measure the students' creative thinking skills immediately after the CAT.

Teaching commence on the next chemistry period by their regular teachers for 5 weeks of teaching, posttest was administered to the subjects by the chemistry teachers. Thirty minutes was allowed for the test, after which the CTST was also administered for ten minutes. The test was marked by the teachers. Scores was collated, collected by the teachers and handed over to the researcher. The aim of the posttest was to find out if there was any gain in knowledge that might have arisen from the treatment.

### Method of Data Analysis

The data obtained from each group using the creative thinking skills test (CTST) and chemistry achievement test (CAT) were analyzed using mean, standard deviation and Analysis of Covariance (ANCOVA) statistics. Mean and standard deviation was used to answer the research questions and ANCOVA was used to test the hypotheses. Four hypotheses were tested. One of the reasons of choice of ANCOVA for testing the research hypotheses was based on its ability to control the effect of pretest. All the hypotheses were tested at 0.05 level of significance.

### Results

Results were presented in tables according to the two research questions and three hypotheses.

**Research Question One:** What is the difference in mean achievement scores of students taught Chemistry using differentiated science inquiry and those taught using lecture method of instruction?

**Table 1: Mean(x) and Standard Deviation (SD) of achievement scores of students**

Mode of Instruction	N	Mean X	Standard Deviation (SD)
Control	37	13.08	3.233
Experiment	35	18.36	3.582
Total	72	15.74	4.347

Table 1 show that the two groups had improvement as observed in their posttest. For instance, those taught chemistry using differentiated science inquiry had a mean of 18.36 after treatment with a standard deviation of 3.582, while those taught using traditional mode of instruction had a mean score of 13.08 with standard deviation at 3.233. This shows that group taught chemistry with differentiated science inquiry had more variation in the spread.

**Research Question Two:** What is the difference in mean creative thinking skill scores of male and female students taught chemistry using differentiated science inquiry?

**Table 2: Mean(x) and Standard Deviation (SD) of creative thinking skill scores of male and female students.**

Gender	N	Mean X	Standard Deviation (SD)
Male	18	57.22	15.511
Female	17	54.42	10.886
Total	35	55.83	13.443

From table 2, male students have a mean creative thinking of 57.22 while female students have a mean creative thinking skill of 54.42. The mean showed that a creative thinking skill of male students was improved more by differentiated science inquiry than their female counterpart.

**Hypothesis 1:** There is no significant difference in mean achievement scores of students taught Chemistry using differentiated science inquiry (DSI) and those taught with traditional mode of instruction (TMI).

**Table 3: Analysis of Covariance (ANCOVA) Test of significant Difference Between the mean achievement scores of students taught chemistry using DSIMM and those taught using lecture method**

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	1386.188 <sup>a</sup>	2	693.094	73.702	.000	.509
Intercept	2355.349	1	2355.349	25	.000	.638
Pre_Test_CAT	333.162	1	333.162	35.428	.000	.200
Method_of_Instruction	1030.622	1	1030.622	109.594	.000	.436
Error	1335.371	69	9.404			
Total	38667.000	72				
Corrected Total	2721.559	71				

a. R Squared = .509 (Adjusted R Squared = .502)

Table 3 shows that there is significant difference between the mean achievement scores of students taught chemistry using DSI and those taught using TMI with  $F=109.594$ ,  $P=0.000 < \alpha=0.05$ . The null hypothesis that there is no significant difference between the mean achievement scores of students taught chemistry using DSI and those taught using TMI is rejected. There is significant difference between mean achievement scores of the students which favours DSI group.



**Hypothesis 2:** There is no significant difference in mean creative thinking skill scores of male and female students taught Chemistry using differentiated science inquiry.

**Table 4: Analysis of Covariance of the influence of Gender on Students' Creative Thinking Skills in Chemistry.**

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	6962.867 <sup>a</sup>	2	3481.433	25.934	.000	.268
Intercept	15728.665	1	15728.665	117.166	.000	.452
Pre_CTST	6678.209	1	6678.209	49.747	.000	.259
Gender	2.223	1	2.223	.017	<b>.898</b>	.000
Error	19062.485	32	134.243			
Total	478173.000	35				
Corrected Total	26025.352	34				

a. R Squared = .268 (Adjusted R Squared = .257)

Table 4 reveals the result of the hypothesis 2. The  $F=0.017$  was not significant when  $P=0.898$  ( $P>0.05$ ). This shows that there was no significant difference in the mean creative thinking scores of male and female students taught using differentiated science inquiry. Thus, the null hypothesis was not rejected. There was no significant difference between the mean creative thinking skill scores of male and female students taught chemistry using differentiated science inquiry.

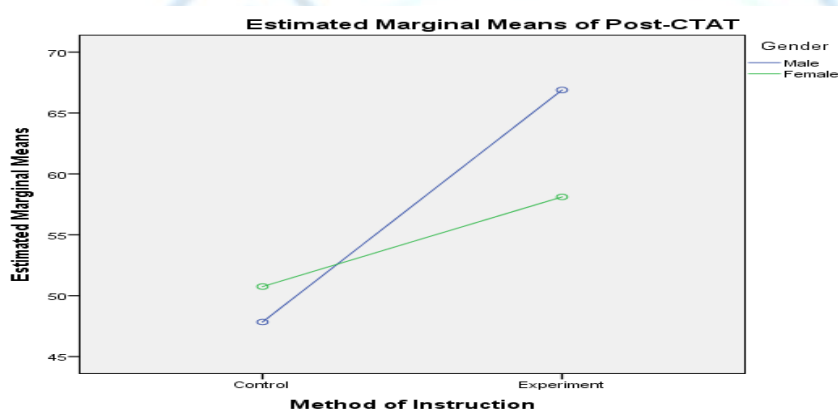
**Hypothesis 3:** There is no Interaction effect of gender and teaching method on students' creative thinking ability.

**Table 5: Analysis of Covariance (ANCOVA) Test of Interaction Effect of Gender and teaching method on students' creative thinking ability in chemistry.**

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	7882.464 <sup>a</sup>	3	2627.488	20.420	.000	.303
Intercept	452984.396	1	452984.396	3520.432	.000	.961
Method_of_Instruction	6321.131	1	6321.131	49.126	.000	.258
Gender	311.755	1	311.755	2.423	.122	.017
Method_of_Instruction * Gender	1238.259	1	1238.259	9.623	<b>.003</b>	.064
Error	18142.888	69	128.673			
Total	478173.000	72				
Corrected Total	26025.352	71				

a. R Squared = .303 (Adjusted R Squared = .288)

Table 5 shows the interaction between gender and teaching method on students' creative thinking ability in chemistry. It can be deduced that there exist significant interaction effect between method and gender on the creative thinking ability of the students, thus,  $F=9.623$ .  $P=0.003 < \alpha = 0.05$ . By implication the method of teaching and the gender of the students had its effect on the creative thinking ability of the students, thus, the null hypotheses that there is no Interaction effect of gender and teaching method on students' creative thinking ability was rejected.



**Figure 2:** profile plot of interaction effect of teaching approach and gender on the creative thinking ability of students in chemistry.

## Discussion

The result of this study had shown that students taught using differentiated science inquiry performed better than those taught using traditional mode of instruction. The findings of the study revealed that the students taught chemistry with Differentiated science inquiry had more variation in their spread as seen in research questions one. The findings of the study as shown in hypothesis 2 revealed that there was significant difference in the creative thinking skill of the male and female students taught chemistry using differentiated science inquiry. There was improvement in the creative thinking skill for the male students than that of the female students taught chemistry using differentiated science inquiry as revealed in table 2 showing standard deviation of male and female students to be 15.512 and 10.887 respectively, showing a wide variation spread. This revealed that gender had significant effect on creative thinking skill in favour of males. This agreed with the opinion of Gok (2014), who indicated that males have a better problem-solving ability than female; problem solving ability is closely related to creative thinking skills.

It is also revealed that there was significant interaction effect of gender and teaching method on students' creative thinking skill. The male students scored higher creative skill than the female students with the difference in the mean scores which were not significant at 0.05 level of confidence.

## Conclusion

On the basis of the findings of this study, the following conclusions were made. The use of differentiated science inquiry significantly enhances students' academic achievement in chemistry when compared with those taught with traditional mode of instruction. Secondly, differentiated science inquiry promotes creative thinking skill among chemistry students. However, male students creative thinking skills is significantly higher than female students when taught chemistry with differentiated science inquiry.

## Recommendations

The following recommendations were made based on the findings of the study.

1. Chemistry teachers should adopt the use of differentiated science inquiry for chemistry instructions, in order to enhance students' general understanding of contents of the subject. This will help to improve their creative thinking skills.
2. Government should regularly organise and monitor workshops, seminars, conferences and in-service training for teachers on the use of differentiated science inquiry, in order to enhance teachers' expertise. It is expected that if Chemistry teachers' professional know-how is improved upon, it will impact positively on students' academic achievement.
3. Teacher educators and institutions should become mentors of Chemistry teachers on how to effectively apply the differentiated science inquiry, not only during the course of a teachers' training program, but on a continuous basis with follow-ups.

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