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ABSTRACT

This study investigated the effect of models on senior secondary school students' achievement in organic chemistry. Three research questions and three hypotheses guided the study. The study adopted a quasi-experimental design. The sample for the study consisted of 70 SSII chemistry students drawn through simple random sampling technique from two co-educational schools in Nsukka Local Government Area of Enugu State Nigeria. The instrument for data collection was Organic Chemistry Achievement Test (OCAT) adopted from past WAEC question papers and therefore did not require further validation. A reliability coefficient of 0.79 was obtained using Kuder Richardson formula-20. The data obtained were analysed using mean and analysis of covariance (ANCOVA). The results showed that students taught organic chemistry using models achieved significantly higher than those taught with lecture method. Gender had no significant effect on students' achievement in organic chemistry. There was no significant interaction effect between model and genders on students' mean achievement scores in organic chemistry. Based on the findings it was recommended among other things that there should be workshops and seminars for chemistry teachers on how to use models to teach organic chemistry.

Keywords: Models, Achievement, Gender, Chemistry.

INTRODUCTION

The role of science and technology in the development of a nation is never in dispute. According to Jegede (2012) [1], the current development in science and technology has greatly affected human beings and to be ignorant of these developments is to live in an empty, meaningless and probably unreal life. The technological development of any nation lies on its emphasis on sciences. This is evidenced in the admission ratio of 60:40 of the...
science and science-related courses to the Arts and Humanities into Nigerian federal and state universities (Federal Ministry of Education, 2013) [2]. In an effort to achieve nation’s developmental goal, the federal government of Nigeria made special provisions and incentives through the provision of instructional materials, laboratory equipments, training and retraining of teachers, provision of research grants and adoption of information and communication technology (ICT) in schools [2].

In addition to these provisions, the federal government of Nigeria through the education trust fund (ETF) intervention project supplied labless science equipments and instructional materials to about six hundred and thirty-three secondary schools all over the country [2]. The aim was to reduce or eradicate the problems encountered by teachers in teaching as a result of the absence or dearth of laboratory equipment and instructional materials in schools. However, inspite of these efforts by the federal government, students' performance is still poor in the sciences particularly Chemistry.

Chemistry is a branch of science which deals with how substances are made up, how atoms of elements combine or break up and how atoms and compounds react under different conditions. Pure chemistry is more concerned with academic development of chemistry extending the frontiers of chemical knowledge through laboratory research, developing improved methods of imparting chemical knowledge and experimenting on alternative methods of producing desired results.

Organic chemistry which is an aspect of chemistry is a component of the chemistry curriculum. The curriculum content which was prepared by the Comparative Education Study and Adaptation Centre (CESAC) and presented to a national critique workshop organized by the Federal Ministry of Education Science and Technology (FMEST) in 1984 was aimed at satisfying the chemistry requirement of the senior secondary school
programme in the new National Policy on Education (NPE). The objectives of the chemistry curriculum are to:

- develop interest in the subject chemistry,
- acquire basic theoretical and practical knowledge and skills,
- develop interest in science, technology and mathematics,
- acquire basic STM knowledge and skills,
- develop reasonable knowledge of competence in ICT application that will engender entrepreneurial skills,
- apply skills to meet societal needs of creating employment and wealth,
- be positioned to take advantage of the numerous career opportunities offered by Chemistry,
- be adequately prepared for further studies in Chemistry.

This is in addition to the former objectives which are to:

i. Facilitate a transition in the use of scientific concepts and techniques acquired in integrated science with chemistry,

ii. Provide the students with basic knowledge in chemical concepts and principles through efficient selection of content and sequencing,

iii. Show chemistry in its inter-relationship with other subjects,

iv. Show chemistry and its link with industry everyday life, benefits and hazards,

v. Provide a course which is complete for pupils not proceeding to higher education while it is at the same time a reasonably adequate foundation for a Post-secondary Chemistry Course [3].
The fundamental principles of chemistry covered in this curriculum include: particulate nature of matter, periodicity, chemical combination, quantitative aspects of chemical reaction, rates of reaction, equilibrium, carbon chemistry and industrial application of chemistry. A review of students' achievement in Senior Secondary Certificate (SSC) examination in chemistry showed a pathetic trend of performance compared to other sciences [3]. Students' poor performance in chemistry has been attributed to many factors such as mathematical aspects of chemistry, poor teaching methods, lack of instructional materials and lack of interest are among others [4],[5],[3]. The West African Examinations Council Chief Examiners (2012)[6] reported that candidates concentrated mainly on familiar questions that demanded recall of facts and were unable to apply their knowledge of scientific principles to answer other questions. Other areas of weakness according to the chief examiners report include poor mathematical skills, inability to write chemical formula correctly, poor spelling and poor understanding of the structures and properties of organic compounds.

The Chief Examiners reported that candidates answered organic chemistry questions poorly. Even those who answered the questions failed to draw correct structures and give correct International Union of Pure and Applied Chemistry (IUPAC) names to the organic compounds. The Chief Examiners recommended that the candidates could perform better if appropriate instructional materials are used in teaching them. The instructional materials are the ones whose production and usage are activity oriented, pupil-centred, interesting, intellectually stimulating and innovative and are capable of creating interest and ultimately affecting learners' behavior. Instructional materials for teaching-learning process are many and varied and such materials include: models, mock-ups, diorama, simulations, graphs etc.
Nachmias (1992) [7], described a model as a likeness of something, a representation of reality. Nwoji (2012) [8], defined a model as a three-dimensional instructional material which the teacher can use in place of the real things which may be too heavy, too complex, too expensive or too dangerous for teaching and learning. Model according to Okwo (2001)[9] is a recognizable representation of a real thing. It is the closed alternative to the real things and often more suitable for teaching purposes. Models can be constructed to represent an enlarged, reduced or the exact size of the real thing. Thus the globe is a reduced model of the earth, the atom may be represented by an enlarged model. Research shows that different kinds of models exist namely: scale models, mathematical models, molecular models etc. Okwo, (2001) [9], carried out a study on the effect of scale models on students’ achievement in Geography. The study revealed that the use of scale models had significant effect on the achievement of students in Geography. Similar research was carried out in Mathematics by Okwo, (2001) [9], using mathematical models. The findings of the study revealed that the use of mathematical models enhance students’ achievement in mathematics. There is no record of a study carried out on the effects of molecular models on students’ achievement in chemistry known to the researchers and that is the why of this study.

**PURPOSE OF THE STUDY**

The general purpose of the study is to determine the effect of models on senior secondary school students’ achievement in organic chemistry.

Specifically, it seeks to

(1). Determine the relative mean achievement scores of students taught organic chemistry using models and those taught with the conventional lecture method.
(2). Find out the difference in the mean achievement scores of male and female students taught using models.

(3). Determine the interaction effect of model and gender on students mean achievement scores in organic chemistry.

RESEARCH QUESTIONS

The following research questions guided this study

(a). What are the mean achievement scores of students taught organic chemistry using models and those taught using conventional lecture method?

(b). What is the difference in the mean achievement scores of male and female students taught organic chemistry using models?

(c). What is the interaction effect of media and gender on students' mean achievement scores in organic chemistry?

HYPOTHESES

Three null hypotheses were formulated and were tested at 0.05 level of significance.

(1). There is no significant difference in the mean achievement scores of students taught organic chemistry using models and those taught using the lecture method.

(2). There is no significant difference between the mean achievement scores of male and female students taught organic chemistry using models.

(3). There is no significant interaction effect of model and gender on students' mean achievement scores in organic chemistry.

METHODOLOGY

The study adopted the quasi-experimental design. This design is considered appropriate for this study as intact classes were used. The study made use of the pre-test and post-test control group design which is represented thus

\[ E: O_1 X_M O_2 \]
\[ C: O_1 X_I O_2 \]

Where, \( E \) = Experimental group  
\( C \) = Control group  
\( O_1 \) = Pre-test  
\( X_M \) = Model  
\( X_I \) = Lecture method  
\( O_2 \) = Post-test

The study was carried out in Nsukka Local Government Area of Enugu State. Nsukka Local Government Area was chosen because it has many co-educational Schools. It was also chosen because all the secondary schools in the local government prepare students for chemistry examination at the Senior School Certificate Examination (SSCE) conducted by WAEC, NECO and NABTEB. The population of the study was all the SSII students in state-owned co-educational secondary schools in Nsukka Local Government Area. Statistics from the Post Primary Schools Management Board Nsukka Zone for the 2012/2013 session show that there were 718 chemistry students in SSII in seventeen co-educational secondary schools in the local government area. SSII was used because it is at that level that carbon compounds appear glaringly in the chemistry scheme of work. The class was chosen again because they have acquired enough knowledge in chemistry and are not preparing for any external examination.

The sample for the study consisted of 70 SSII students from two co-educational schools in the local government area drawn through the simple random sampling technique. SSII students in an intact class of 36 in one co-educational school was assigned
to the experimental group while the other 34 in another intact class in another co-
educational school was assigned to control group through balloting. The instrument used for data collection was the Organic Chemistry Achievement Test (OCAT). The OCAT was made up of 25 items multiple choice objective questions with options (A-D) designed to measure students understanding of the content chosen for the study. The instrument (OCAT) was standardized questions adopted from past WAEC question papers and therefore did not require further validation. The instrument was trial-tested using twenty students from another local government different from the area of the study. The reliability coefficient was calculated using Kuder Richardson’s formula (K – R 20). The reliability co-efficient was 0.79.

**EXPERIMENTAL PROCEDURE**

Before the commencement of the experiment, subjects in both the experimental and control groups were pre-tested. The test was marked and the scores sorted according to the variables of model and gender. The units on hydrocarbons and organic compounds were taught to the two groups. The regular chemistry teacher in the experimental group taught the students with models while those in the control group were taught by their chemistry teacher without models. Each lesson lasted for forty minutes. The experiment lasted for six weeks. The same units were taught to the two groups. At the end of the treatment, a common post-test was administered to the two groups. The questions in the post-test were the same with that in the pre-test but for the re-arrangement of the question numbers and answer options. At the end of the post-test, the scripts were collected, marked and scores recorded. The data was analyzed based on these scores. The data for analysis were scores obtained from both the pre-test and post-test. The research questions were answered using mean scores. Any group that had a mean score higher than the other was deemed to have
performed better than the other in the test, however, the significance of the difference in the scores of the group was determined in the test of hypothesis. The hypotheses were tested using the analysis of co-variance (ANCOVA) at 0.05 level of significance. The null hypotheses were rejected if the calculated F value was greater than the critical value of F, otherwise the null hypotheses were accepted.

RESULTS

The presentation of the results is in line with the research questions and hypotheses that guided the study.

RESEARCH QUESTION 1

What are the relative mean achievement scores of the students taught organic chemistry using models and those taught using the conventional lecture method?

Table 1: Pre-test/post-test mean scores of the experimental and control groups in organic chemistry

<table>
<thead>
<tr>
<th>Group</th>
<th>Pre-test</th>
<th>Post-test</th>
<th>Mean Gain</th>
</tr>
</thead>
<tbody>
<tr>
<td>Experimental (Model)</td>
<td>29.43</td>
<td>47.54</td>
<td>18.11</td>
</tr>
<tr>
<td>Control (Lecture)</td>
<td>27.55</td>
<td>30.48</td>
<td>2.93</td>
</tr>
</tbody>
</table>

Results from Table 1 shows that students taught with models had a pre-test mean score of 29.43, post-test mean score of 47.54 and a mean gain of 18.11. On the other hand, students taught with the conventional lecture method had a pre-test mean score of 27.55, post-test mean score of 30.48 and a mean gain of 2.93. The result reveals that the experimental group (those taught with models) performed better than the control group those taught with the conventional lecture method in organic chemistry.

RESEARCH QUESTION 2
What is the difference in the mean achievement scores of male and female students taught organic chemistry using models?

**Table 2: Pre-test and Post-test Scores of Male and Female Students in Organic Chemistry Using Models**

<table>
<thead>
<tr>
<th>Group</th>
<th>Pre-test</th>
<th>Post-test</th>
<th>Mean Gain</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>27.80</td>
<td>37.11</td>
<td>9.31</td>
</tr>
<tr>
<td>Female</td>
<td>29.61</td>
<td>42.64</td>
<td>13.03</td>
</tr>
</tbody>
</table>

It can be observed from Table 2 that male students taught with models had pre-test scores of 27.80, post-test score of 37.11 and a mean gain of 9.31. Female students who were taught using models alongside with the male had a pre-test score of 29.61, post-test score of 42.64 and a mean gain of 13.03. This shows that female students performed better than the male students in organic chemistry.

**RESEARCH QUESTION 3**

What is the interaction effect of models and gender on students mean achievement scores in organic chemistry?

**Table 3: Interaction effects of models and gender on students mean achievement in organic chemistry**

<table>
<thead>
<tr>
<th>Group</th>
<th>Gender</th>
<th>Overall Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model</td>
<td>Male</td>
<td>Female</td>
</tr>
<tr>
<td></td>
<td>46.23</td>
<td>48.38</td>
</tr>
<tr>
<td>Lecture</td>
<td>30.42</td>
<td>30.44</td>
</tr>
</tbody>
</table>

Table 3 presents the results on the interaction effect of models and gender on students mean achievement scores in organic chemistry. The table shows that the males in the experimental group (models) had a higher mean of 46.23 as against the mean score of 30.42 recorded by their counterparts in the control group. Similarly, the females in the experimental group had a mean score of 48.38 ahead of their counterparts in the control
group. The result therefore reveals that the males in the experimental group achieved higher than the males in the control group, while the females in the experimental group achieved higher than the females in the control group. The superiority of the scores of the males and females in the experimental group over the males and females in the control group appears to have resulted from the effect of treatment alone and not from the interaction effect of model and gender. Therefore, there is no observed interaction effect of model and gender on students mean achievement in organic chemistry.

HYPOTHESIS 1

There is no significance difference in the mean achievement scores of students taught organic chemistry using models and those taught conventionally.

Table 4: Summary of analysis of covariance (ANCOVA) of students’ post achievement scores in organic chemistry by model and gender.

<table>
<thead>
<tr>
<th>Source</th>
<th>Type III Sum of Square</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
<th>Significance</th>
<th>Decision</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corrected</td>
<td>30300.88</td>
<td>8</td>
<td>3787.611</td>
<td>36.489</td>
<td>.000</td>
<td></td>
</tr>
<tr>
<td>Model</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intercept</td>
<td>11814.738</td>
<td>1</td>
<td>11814.738</td>
<td>113.815</td>
<td>.000</td>
<td></td>
</tr>
<tr>
<td>Pre-test</td>
<td>7973.869</td>
<td>1</td>
<td>7973.869</td>
<td>76.815</td>
<td>.000</td>
<td></td>
</tr>
<tr>
<td>Model</td>
<td>14673.779</td>
<td>1</td>
<td>14673.779</td>
<td>141.357</td>
<td>.000</td>
<td></td>
</tr>
<tr>
<td>*S Gender</td>
<td>49.047</td>
<td>1</td>
<td>49.047</td>
<td>.472</td>
<td>.492</td>
<td></td>
</tr>
<tr>
<td>*NS Method/Gender</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gender</td>
<td>108.908</td>
<td>1</td>
<td>109.809</td>
<td>1.058</td>
<td>0.305</td>
<td></td>
</tr>
<tr>
<td>NS Error</td>
<td>27301.167</td>
<td>263</td>
<td>103.807</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>486505.000</td>
<td>272</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Corrected Total</td>
<td>57602.055271</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table 4 shows that treatment as a main factor has a significant effect on students’ achievement in organic chemistry. This is because the F value of 141.357 in respect of treatment is shown to be significant at .000 level. This means that at 0.05 level, the F value of 141.357 is significant. The result indicates that the use of models significantly improved students’ achievement in organic chemistry. Therefore, the null hypothesis of no significant difference between the mean achievement scores of students taught organic chemistry using models and those taught using the conventional lecture method is rejected.

**HYPOTHESIS 2**

There is no significant difference between the mean achievement scores of male and female students taught organic chemistry using models.

Results presented in table 4 reveals that there is no significant difference between the mean achievement scores of male and female students in organic chemistry. This is because the F value of 0.472 in respect of gender as a main factor is shown to be significant at 0.492 level and therefore not significant at 0.05 level. Therefore, the null hypothesis of no significant difference between the mean achievement scores of male and female students in organic chemistry is upheld.

**HYPOTHESIS 3**

There is no significant interaction effect of model and gender on students mean achievement scores in organic chemistry.

The interaction effect of model and gender as shown in Table 4 is not significant. This is because the F value of 1.058 in respect of interaction between media and gender is shown to be significant at 0.05 level. Therefore, the null hypothesis of no significant interaction effect of model and gender on students mean achievement scores in organic chemistry is accepted.

**DISCUSSION OF THE RESULTS**

Results of the study indicate that students in the experimental group obtained a higher post-test mean score than those in the control group. Similarly, students in the experimental group had a higher mean gain score than those in the control group. The difference between the mean scores was statistically significant as shown by the results presented in Table 4. The gain score of 18.11 recorded by the experimental group is superior to the gain score of 2.93 recorded by the control group as shown in Table 1.

The result of this study reveals that though organic chemistry is a difficult area of chemistry according to WAEC Chief Examiners Report (2012) and Ajah (2013), much can be achieved in it with the use of models. It also goes to show that the lecture method may not be able to produce the right results.

Similarly, the findings of this study regarding the achievement of male and female students in organic chemistry shows that the females were ahead of the males but this was not found to be statistically significant in the test of the hypothesis. The lack of significant difference in the achievement of males and females in organic chemistry arises probably from the fact that the use of models is not gender biased. Rather, with the effective use of the models, good results can be achieved by the males and the females.

**CONCLUSIONS**
The following conclusions are drawn based on the findings of this study.

First, students taught organic chemistry using models achieved significantly higher than those taught using the conventional lecture method.

Secondly, gender has no significant effect on students’ achievement in organic chemistry. Though, the female students had a mean score higher than the male students, the difference in the mean scores was not statistically significant.

Thirdly, there is no interaction effect of model and gender on students' achievement in organic chemistry. The use of models was consistent in producing superior results across gender.

**RECOMMENDATIONS**

Based on the findings, the following recommendations are made:

- Teachers of chemistry in secondary schools should make use of models in teaching organic chemistry.
- Seminars, workshops and conferences should be organized to sensitize and train the chemistry teachers on the use of models for teaching organic chemistry.
- More studies should be carried out to explore other media that can be used to teach organic chemistry.
- Curriculum planners should incorporate the use of models in teaching organic chemistry in the next review of the curriculum.
- Teachers of chemistry should provide equal opportunities for male and female students to learn as both can achieve similar results with the appropriate media.

**REFERENCES**


