EFFECTS OF COMPUTER-ASSISTED INSTRUCTION (CAI) ON STUDENTS' ACADEMIC ACHIEVEMENT IN CHEMISTRY AMONG BOYS AND GIRLS IN PUBLIC SECONDARY SCHOOLS IN ONDO STATE, NIGERIA

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ABSTRACT: *This study investigated the effects of Computer-Assisted Instruction (CAI) on students' achievement in Chemistry among boys and girls in public secondary schools in Ondo State. A quasi-experimental design was adopted for the study. The sample for the study consisted of 240 senior secondary school two (SSS II) intact class Chemistry students selected in stages using simple random sampling technique. Three schools were selected from three local government areas from the three senatorial districts in Ondo State. The students in the experimental groups were exposed to CAI while the control group was taught with the conventional teaching method. Chemistry Achievement Test (CAT) with a reliability coefficient of 0.81 was used to collect relevant data for the study. The experimental group was treated using CAI package while the control group was treated using the conventional classroom teaching. Analysis of Co-variance (ANCOVA) and t-test were used to test the research hypotheses at 0.05 level of significance. The result from the study showed that there was no significant difference between the achievement of male and female students in both the experimental and the control groups respectively. The results showed that when exposed to CAI, female students performed better than their counterparts. Based on the findings of the study, it could be concluded that the use of CAI has not shown any better effectiveness in the achievement of students. However, the method is a modern day of imparting knowledge. In another dimension, when both males and females are taught with the use of CAI, the method appeared to favour females than males. This suggests that the method us gender-biased. Based on the findings of the research, it is recommended that the potential of computer-assisted instruction should be utilised to enhance better achievement of the students in Chemistry, most especially among females while the male students also be encouraged to key into the use of the method for the flexibility of teaching and learning.*

KEYWORDS*: gender, computer-assisted instruction (CAI), students, chemistry.*

INTRODUCTION

The development of any nation is a measure of her development in the area of science and technology. Technological growth of a nation leads to its social and economic development. In the world today, science and technology has become dominant among the indicators of development. The technological advancement of the world today became feasible through the study of science.

Science can be seen as the branch of study in which facts are observed, classified and quantitative laws are formulated (Alio, 2004). Science is also known as an organised body of knowledge that ensures the ability to acquire skills. It is a well-known fact today that science has become an integral part of man's life. Science and technology influence major aspects of life including feeding, clothing, shelter, healthcare as well as leisure. It has become such an indispensable tool that no nation wishing to progress in the socio-economic sphere will afford to relegate its learning in schools. The role of science in this modern era of technology is wide and profound. In line with this reasoning, Ogunleye and Fasakin (2011) and Oredein and Awodunni (2013) emphasised the importance of scientific knowledge in boosting national prestige, military might, international rating of a country, among others.

New demands for qualitative science teaching and learning have emerged because of the global knowledge exposition, popularity of science discipline and the development of educational technology. Otor (2010) was of the opinion that the wealth of any nation depends on both human and material resources and that there is the need to harness these resources through the acquisition of appropriate skills. This behooves Nigeria to develop the young ones through appropriate knowledge of science and technology, as this is valuable in solving most of man's problems. Acquisition of the relevant experiences can contribute meaningfully to the attainment of the nation's desire for self-reliance and the quest for national development in science and technology. Observation of the typical Nigerian classroom situation reveals that teachers often disseminate knowledge and expect students to identify the facts of the knowledge presented. Not that alone, most teachers rely heavily on textbooks and most often, the information the teachers disseminate to students align with the view of the textbooks' writers. Furthermore, Baker (2011) pointed out that most classrooms encourage competitive learning among students and structurally discourage cooperation, this requires students to work in relative isolation on tasks that require low level thinking, rather than high order thinking. Students' independence though is devalued in most classrooms.

Observation shows that science education is receiving an ever increasing attention all over the world. The search for effectiveness in science teaching has been a focal point of educationally developed countries of the world. As a result of this, science teachers and educational agencies have been concerned with finding the best ways of encouraging the secondary school students to be more interested, motivated and excel in the discipline. Today, the emphasis of the Nigerian government is on the production of scientists and science teachers and this is reiterated by the Federal Government of Nigeria in its National Policy on Education (NPE) (2014). The policy emphasises that one of the aims of education should be, equipping students to live and be self-reliant in this modern age of science and technology.

Chemistry is one of the core science subjects in the 6-3-3-4 educational system as recommended in the NPE (2014). It has been a prerequisite subject for most science-oriented courses in tertiary institutions, and this calls for its effective teaching. It is rapidly expanding as it occupies a central position in the world of science, being a gateway to professions like Medicine, Pharmacy, and

many other science-related professions. Chemistry has contributed immensely to improving the quality of life in the area of health, teaching, agriculture among others. Thus, Chemistry education has practical aesthetic and intellectual values. These values can only be achieved through a sound knowledge of the subject. The importance of Chemistry in the national development underlines the need to produce people who possess the requisite expertise in Chemistry which is a positive effort towards nation building.

There are various strategies for the teaching and learning of Chemistry as a subject, these include: lecture method, discovery/inquiry method, fieldtrips, cooperative method, competitive method, individual or programmed instruction, project method, modern science teaching method, also known as innovative teaching method (concept mapping and computer assisted instruction). The choice of strategies to be used depends on some factors such: the concept to be taught, the targeted audience, availability of instructional materials, learning environment and learning objectives to be achieved (Jegede, 2010). Where appropriate teaching strategies are employed by the teacher, there is the possibility that students' interest and attitude will be enhanced which might eventually lend to enrolment increase. The most important thing is for a teacher to get used to teaching methods that will help students to achieve their learning objectives.

Observations have revealed that teachers are not mindful of the learning environment precisely the classroom interaction. They embark on teaching without taking into cognizance the strategy that is most appropriate at a particular point in time. Most teachers stick to the traditional chalk and talk method (conventional method of teaching) while few occasionally use the demonstration method. The teachers make themselves the all-in-all and carry out all the classroom activities by themselves only. This seems not to give room for students' contribution to classroom discussion, and makes students to conceal ideas to themselves.

One of the most effective ways to make teaching and learning interesting and effective is taking advantage of instructional technologies, especially the computers (Tareef, 2014). With the use of computers in education, a lot of terms have come into and gone out of use in education (Owusu, Monney, Appiah & Wilmot, 2010). Fogas and Prince (2001) was of the opinion that the professional development of teachers has been identified internationally as the primary factor in enabling effective information and communication technology by schools. Yusuf (2005) also revealed that educational opportunities are being missed because most teachers do not know how to operate computer nor can they teach students about the use of computers in the society. Some teachers still do not know how to use computers to promote educational efficiency.

Ikpe (2011) pointed out that factors such as teaching method adopted by the teachers may be due to the ways in which learning instructions are presented. Use of relevant instructional materials and teachers' proficiency, among others, seem influence the ease at which learning instructions are comprehended and internalised by students.

The instance of large population of students in classrooms and subsequent difficulty in providing sufficient teachers for sizeable students per class in school necessitated the use of computers and internet learning. This originated from the developed countries and in consequence the rapid development of the information and technology, where the use of computers in education has become inevitable. Today, because of globalisation, even developing countries like Nigeria tries to adopt certain things that worked in developed countries and hence, the adoption of computer-based instruction. Though this is still at elementary stage, there is the need to create awareness of the facilitative effects of its use. The introduction of Computer-Assisted Instruction into teaching and learning of Chemistry may have the potential of enhancing achievement in the subject, especially as computer has become a device that is exciting to majority of secondary school students.

Seweje and Jegede (2005) viewed Computer-Assisted Instruction (CAI) as a form of programmed instruction. Computers were originally programmed to act as adjunct in instruction because of the inadequacies of teaching machines, particularly their inability to adapt to the individual differences of the students. A very common use of CAI, with a wide range of sophistication has been the use of computers in mathematics, physics and chemistry classes and laboratories. This varies from simple use as a calculator to highly involved and complex computer programmes.

Liao (2007) found out that CAI had a positive effect on individuals by comparing 52 research studies carried out in Taiwan. In his meta-analysis study; the use of CAI enables learners to be active in the learning process to construct knowledge, develop problem solving skills and to discover alternative solutions. Baker (2011) noted that educational software can be a powerful tool when used by teachers who understand that technology is the vehicle, and not the message. The power of CAI to engage and challenge students in exactly the way science teachers need to is well documented in pockets of good practices. The presentation of teaching materials by means of the CAI seems to help students to process and develop information to find alternative solutions and develop their problem-solving skills.

Mahmood (2004) and Serin (2011) asserted that students using CAI learn better and faster than students receiving conventional instruction alone and also retain their learning longer. Students' scores on delayed tests indicated that the retention of content learned using CAI is superior to the one learned using traditional instruction alone. More so, Bybee, Poewll and Trowbridge (2008), Serin (2011) demonstrated that students attendance improved in computer assisted instruction classes as compared to the classes where conventional method was employed. Tareef (2014) found that CAI students had higher rates of time-on-task than traditionally instructed students and held that CAI incorporates adult learners' needs for self-directedness, readiness to learn, time perspective and utilisation of past experience. By using CAI, the learner may work independently without fear of embarrassment. Learning can occur at the learners own pace and time frame.

Yang (2010) observed that gender contributes to poor achievement of students in Chemistry and science subjects generally. Gonzuk and Chargok (2001) revealed that the number of females who

study chemistry in secondary and tertiary institutions is small compared to the number of males. This has created a gender disparity in the academic achievement of students in Chemistry and science subjects as a whole. Many reasons have been advanced for low participation of girls in science. Olasehinde and Olatoye (2014) pointed out that females are deficient in science because they lack analytical and visual-spatial skills that are needed for abstract reasoning in science. However, this argument has been proved wrong because emerging evidence shows that ability is not a determining factor in whether or not females would participate in science. Girls and boys are found to perform equally well if instructional context is fair and conducive (Erinosho, 2008).

Many studies have been conducted to determine the factors that influence students' academic achievement. Baker and Maclyntyre (2003), Kissau (2006) and Bosede (2010) asserted that sex and location of school influence students achievement in some subject areas. The results of these studies differ with some favouring males and urban locations and others favouring females and rural locations. In another study, Okereke and Onwukwe (2011) showed that male students achieved better than female students. Uduosoro (2011) asserted that the gender of students whether male or female does not affect the academic performance of the students.

Busari, Ernest and Ugwuanyi (2016) also revealed in their study that CAI engages learners, make them active participants in class as well as motivate the students. Samuel and Okonkwo (2020) also found out that low academic self-concept in Chemistry is overcome when many difficult concepts are made clearer through appropriate teaching techniques such as CAI. More so, abstract concepts which pose difficulties are easily understood when given e-visual explanations. Igboegwu and Okonkwo (2012) found that there is no significant gender difference in the performance of students in Chemistry while Ezeudu and Obi (2013) found that there was a significant difference in the academic achievement of male and female students in WAEC results in Chemistry. The male students had higher mean score than the female students. This is in line with the earlier submissions of Achor, Kurumeh and Orokpo (2012), Okereke and Onwukwe (2011) and Ukozor (2011). However, it contradicts the findings of Jegede (2007), Nbina and Wagbara (2012) and Julius (2018) who found females achieving better than the males.

Some researches (Ifeakor, 2006; Ukozor, 2011; Ezeudu & Obi, 2013) found out that gender dichotomy exists in students' performance in science and itemised some reasons for the disparity in performance. These include: teacher-student relationship, nature of the subject, the rigour attached to science activities and hazards attributed to scientific activities. To eliminate gender influence on students' performance in science, there might be the need to put individual differences into consideration during classroom interaction. Appropriate use of teaching strategies might solve the problem and give both sexes equal privileges.

The study of gender differences among senior secondary school students is inconclusive. Therefore, this study sought to compare boys and girls in the senior secondary schools students' achievement in Chemistry.

Purpose of the Study
The study investigated the effect of Computer-Assisted Instruction (CAI) on gender achievement in Chemistry.

Research Questions
The following research questions were raised to guide this research:
1.   Is there any difference in the Chemistry mean achievement scores of male and female students exposed to CAI and the group not exposed?
2.   Is there any difference in the Chemistry mean achievement scores of male and female students that were exposed to CAI?

Research Hypotheses
To guide this study, the following research hypotheses were generated for empirical verification:
1.   There is no significant difference in the Chemistry mean achievement scores of male and female students that were exposed to CAI and the group not so exposed.
2.   There is no significant difference in the Chemistry mean achievement scores of male and female students that were exposed to CAI.

RESEARCH METHOD

A quasi experimental design was used for the study. The population consisted of all the Senior Secondary class II Chemistry students from public secondary schools in Ondo State. This consists of 11,560 Senior Secondary School Two (SSS II) students offering Chemistry. A sample of 240 SSS II Chemistry students found in the intact classes of three selected from three secondary schools from the three senatorial districts in Ondo State using simple random sampling technique. An instrument was used to collect the relevant data for this study which was tagged 'Chemistry Achievement Test (CAT)'. The CAT was a 40-item, four optioned multiple choice questions drawn from the topics taught during the treatment (i.e. chemical bonding and the periodic table). Respondents were asked to choose the most appropriate option for the item. Items on the CAT instrument were selected from senior secondary school examination past questions. Each correct option for each item of the instrument was scored one (1) mark while each incorrect response was scored zero (0) mark. Thus the maximum score obtainable is 40 marks.

The research material used for this study was the Computer-Assisted Instruction software which was developed by the researcher with the aid of program developer. The software is titled 'Computer Interactive Device (CID) which was designed in a branched form and responded to instruction. The software was developed using the Rapid Application Development (RAD) model of James Martins approach of 1980. The model consisted of four operational stages of:

i.   The requirement planning
ii.   User design phase

iii.   Construction phase
iv.   Cut over or the implementation phase

Text material in the Senior Secondary School Chemistry curriculum used for the study was transformed into CAI software. This software is an interactive and user friendly programme and is composed of CAI tutorials which are presented in one or more windows. The CID (software) was installed in the computer laboratory of the experimental schools for the students to be exposed to while the control group is left to the conventional teaching method.

Treatment procedure: The research procedure was in three stages, namely: pre-treatment, treatment and the post-treatment.

The pre-treatment stage involved taking permission from the principals and Head of Science Department and also the SSS II Chemistry teachers involved in the study. It also involved giving orientation to the research assistants. Having done this, the researcher then administered the pretest to the two groups in order to ascertain the homogeneity. The treatment stage involved exposing the experimental group to the treatment using the computer interactive device (CID) to learn the concepts chosen for the study. During the same period, the control group was also taught the same concepts but through the conventional methods. This stage lasted for four weeks. The post-treatment stage involved re-arranging and re-administering the CAT on the students after four weeks of treatment which is known as post-test.

Testing of Hypotheses
The research hypotheses were tested using Analysis of Co-variance and t-test at 0.05 level of significance.

Hypothesis 1: There is no significant difference in the Chemistry mean achievement scores of male and female students that were exposed to CAI and the group not exposed
Table 1: Summary of ANCOVA of gender and treatment on students' achievement in Chemistry

Source	*SS*	*df*	*MS*	*F_{cal}*	*F_{table}*
Corrected Model	3016.221	4	754.055	26.555	2.37
Covariate	1046.877	1	1046.877	36.868	3.84
Sex	6.617	1	6.617	.233	3.84
Group	1718.329	1	1718.329	60.514	3.84
Sex * Group	49.414	1	49.414	1.740	3.84
Error	6672.963	235	28.396		
Corrected Total	9689.183	239			
Total	135456.000	240			

$P < 0.05$

Table 1 shows that F_{cal} (1.740) is lesser than F_{table} (3.84) at 0.05 level of significance. The null hypothesis is not rejected. This implies that there is no significant difference in the Chemistry

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mean achievement scores of male and female students that were exposed to CAI and the group not exposed. Similarly, the main effect of gender on students' achievement in Chemistry is not significant (F1,235=0.233, P>0.05). However, treatment had significant effect on students' achievement in Chemistry (F1.235=60.514, P<0.05).

Hypothesis 2: There is no significant difference in the mean achievement scores of male and female students that were exposed to CAI

In order to test the hypothesis, scores on the mean achievement scores of male and female students that were exposed to CAI were obtained and subjected to statistical analysis involving t-test at 0.05 level of significance. The result is presented in table 2.

Table 2: t-test showing the mean achievement scores of students exposed to CAI by gender

Group	*N*	*Mean*	*SD*	*df*	t_{cal}	t_{tab}
Male	51	22.63	3.81			
Female	63	24.51	4.76	112	2.292*	1.980

P<0.05

Table 8 reveals that tcal(2.292) is greater than ttable(1.980). The null hypothesis is rejected. This implies that there is significant difference in the mean achievement scores of male and female students that were exposed to CAI. The female students performed better than their male counterparts when exposed to CAI.

DISCUSSION

The findings of this study revealed that there was no significant difference between the achievement of male and female students in both the experimental and the control groups respectively. This is in line with the findings of Uduosoro (2011) who found out that gender does not affect the academic achievement of students whether male or female and also the findings of Igboegwu and Okonkwo (2012), Busari et al (2016), and Samuel and Okonkwo (2020) who revealed that there was no significant gender difference in the performance of students in Chemistry. Findings also revealed that female students performed better than their male counterparts in the experimental group (that is, when they are both taught with CAI). This is in agreement with the submission of Jegede (2007), Nbina and Wagbara (2012), and Julius (2018) who found females achieving better than males. But this is contrary to Okereke and Onwukwe (2011), Ezeudu and Obi (2013), Achor, Kurumeh and Orokpo (2012) and Ukozor (2011) who found out that the male students performed better than their female counterparts.

CONCLUSION

Based on the findings of this study, it could be concluded that as good as the use of CAI in teaching, it does not show any difference in the achievement of those taught with CAI and those taught with the conventional method. In addition, the use of Computer-Assisted Instruction in teaching

Chemistry enhances better achievement of female students in Chemistry than their male counterparts. This implies that the method is gender biased.

Recommendation

Based on the findings in this study, it is recommended that the potential of computer-assisted instruction should be utilised to enhance better achievement of students in Chemistry. Besides, teachers should encourage the use of CAI among male students in order to improve their performance.

Chemistry teachers should strive as much as possible to inculcate the use of stimulatory innovative teaching strategies of the 21st century in ensuring that both male and female students have better achievement in Chemistry. The individualisation, self-pacing and interactive nature as well as the incorporation of questions and feedback in the computer-assisted instruction process made it to impart better on students' learning of, and achievement in Chemistry.

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