EFFECTS OF COMPUTER ASSISTED INSTRUCTION (CAI) ON SECONDARY SCHOOL STUDENTS' PERFORMANCE IN BIOLOGY

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ABSTRACT
This study investigated the effects of computer assisted instruction (CAI) on secondary school students' performance in biology. Also, the influence of gender on the performance of students exposed to CAI in individualised or cooperative learning settings package was examined. The research was a quasi experimental involving a 3 x 2 factorial design. The sample for the study comprised 120 first year senior secondary school students (SSS I) sampled from three private secondary schools, in Oyo State, Nigeria. The students' pre-test and post test scores were subjected to Analysis of Covariance (ANCOVA). The findings of the study showed that the performance of students exposed to CAI either individually or cooperatively were better than their counterparts exposed to the conventional classroom instruction. However, no significant difference existed in the performance of male and female students exposed to CAI in either individual or cooperative settings. Based on the research findings recommendations were made on the need to develop relevant CAI packages for teaching biology in Nigerian secondary schools.

INTRODUCTION

Biology occupies a unique position in the school curriculum. Biology is central to many science related courses such as medicine, pharmacy, agriculture, nursing, biochemistry and so on. It is obvious that no student intending to study these disciplines can do without biology. These factors, among others, have drawn attention of researchers and curriculum planners towards biology as a subject in the school curriculum (Kareem, 2003). In spite of the importance and popularity of biology among Nigerian students, performance at senior secondary school level had been poor (Ahmed, 2008). The desire to know the causes of the poor performance in biology has been the focus of researchers for some time now. It has been observed that poor performance in the sciences is caused by the poor quality of science teachers, overcrowded classrooms, and lack of suitable and adequate science equipment, among others (Abdullahi, 1982; Bajah, 1979; Kareem, 2003; Ogunniyi, 1979). Students perform poorly in biology because the biology classes are usually too large and heterogeneous in terms of ability level. In addition, the laboratories are ill-equipped and the biology syllabus is over loaded (Ahmed, 2008; Ajayi, 1998).

The potential benefits of Computer Assisted Instruction (CAI) cannot be underestimated in the contemporary world. There is a plethora of established findings on the instructional value of computer, particularly in advanced countries. There are now several CAI packages on different subjects. It is obvious that the current trend in research all over the world is the use of computer facilities and resources to enhance students' learning. This may be the reason why Handelsman, Ebert-May, Beichner, Bruns, Chang, et al (2004) opined that "many exercises that depart from traditional method are now readily accessible on the web" (p. 521), even though teachers do not use these facilities. They further showed that the interactive approaches to lecturing significantly enhance learning.

In a review of empirical studies on CAI, Cotton (1997) concluded, among others, that the use of CAI as a supplement to conventional instruction produces higher achievement than the use of conventional instruction alone, research is inconclusive regarding the comparative effectiveness of conventional instruction alone and CAI alone, and that computer-based education (CAI and other computer applications) produce higher achievement than conventional instruction alone. In addition, students learn instructional contents faster with CAI than with conventional instruction alone, they retain what they have learned better with CAI than with conventional instruction alone, and CAI activities appear to be at least as cost effective as and sometimes more

cost-effective than other instructional methods, such as teacher-directed instruction and tutoring. Furthermore, computer assisted instruction has been found to enhance students' performance than the conventional instructional method in counselor education (Karper, Robinson, & Casado-Kehoe, 2005). However, Mill (2001) findings revealed that CAI was found to be as effective as classroom for fact based learning, but not as effective for topics requiring critical thinking or mathematical problem solving. In addition, the time required for by learners to use CAI was higher overall than conventional classroom instruction. Students taught using traditional instruction combined with the use of computer performed significantly better than students taught using traditional instruction in a college setting (Akour, 2006). Similarly, college students taught statistics using lecture-plus-CAI obtained higher averages on midterm and final exams than students taught using lecture method only (Basturk, 2005). Based on a review of several studies and shortcoming on studies comparing CAI with conventional instruction, CAI can be considered as effective as traditional instruction. Furthermore, how CAI is delivered can affect its effectiveness, and that new studies are needed to clarify the effect of CAI in contemporary student environment (Jenk & Springer, 2002). Thus, empirical findings on the use of CAI have been mixed.

Gender issues too have been linked with performance of students in academic tasks in several studies but without any definite conclusion. But there is a general conclusion that general imbalance exist in computer use, access, career and attitude. That is why Davies, Klawe, Ng, Nyhus, and Sullivan, (n.d.) based on their review suggested that current gender imbalance in technology and the role that technology will play in the future should be a concern for men and women, practitioners, policy makers and parents. Some studies revealed that male students perform better than the females in physics, chemistry, and biology (Danmole, 1998; Novak & Mosunda, 1991; Okeke & Ochuba, 1986) while others revealed that female students are better off than males (Kelly, 1978: Wonzencreaft, 1963). Some studies such as those of Bello (1990) did not find any form of influence being exerted by gender on students' academic performance in the sciences. Gender factor on the use of CAI has also been of interest to researchers. Collazos, Guerrero, Llana, and Oetzel, (n.d.) examined gender influence on collaborative use of computer based communication. They found that group with minority women had low index of collaboration compared to homogenous group and group with majority women.

Spence (2004) found no significant influence of gender on the achievement of college students in mathematics when they were exposed to mathematics courseware in online and traditional learning environment. However, female online learners were significantly less likely to complete the course compared to their traditional female counterpart or male online counterparts. In a review of studies on access, use, attitude, and achievement with computer, Kirkpatrick and Cuban (1998) concluded that when female and male students at all levels of education had the same amount and types of experiences on computers, female achievement scores and attitudes are similar in computer classes and classes using computer.

Learning setting in either cooperative or individualized setting may be a significant factor in students' learning. Cooperative learning is meant to enhance students' learning and develop their social skills like decision-making, conflict management, and communication (Bonwell & Eison, 1991). Through cooperative learning methods students share ideas together so that they can learn to work together and to learn that they are responsible for one another's learning as well as their own learning (Slavin, 1991). Cooperative learning tends to be more carefully structured and delineated than most other forms of small-group learning (Newberry, nd). Four key elements of cooperative learning are: positive interdependence, individual accountability, group rewards, and group training (Johnson & Johnson, 1987; Slavin, 1995). The close affinity and links between technology and technology had been noted by Millis and Cottell (1998) in their assertion that cooperative learning and technology are natural partners. This is because use of technology involves human dimensions of caring, community, and commitment. Furthermore, using technology in ways that promote sequenced learning within groups can lead to more in-depth processing of course content and, hence, more retention of information (Newberry, nd).

However, little is known about the use of computer assisted instructional package in the Nigerian education system particularly in cooperative learning setting. In addition, very few empirical studies exist in Nigeria regarding the use of CAI in biology. Thus, much remain to be empirically studied on the effect of CAI in biology education, in Nigeria.

PURPOSE OF THE STUDY

The study investigated the effect of computer-assisted instruction on the performance of secondary school students in biology. Specifically, the study examined:

(1) The difference in performance in biology, if any, of secondary school students exposed to individualized computer assisted instruction, cooperative computer assisted instruction, and those exposed to conventional instruction.
(2) The influence of students' gender on their performance in biology, when they are exposed to individualized computer assisted instruction, or cooperative computer assisted instruction.

Research Questions

1. Will there be any difference in the performance of biology students exposed to individualized computer assisted instruction, cooperative computer assisted instruction, and those taught using conventional method?
2. Does gender influence the performance of biology students exposed to individualized computer assisted instruction?
3. Does gender influence the performance of biology students exposed to cooperative computer assisted instruction?

Research Hypotheses

The following research hypotheses were tested in the study.

Ho1 There is no significant difference in the performance of students in biology when they are exposed to (i) individualized computer assisted instruction, (ii) cooperative computer assisted instruction, and (iii) conventional instruction.

Ho2 There is no significant difference between the performance of male and female students in biology when they are exposed to individualized computer assisted instruction.

Ho3 There is no significant difference between the performance of male and female students in biology when they are exposed to cooperative computer assisted instruction.

RESEARCH METHODOLOGY

Research Design

This study was a quasi-experimental type, of the pre-test, post-test, non-equivalents, non- randomized, control group design. The design is a 3x2 factorial design. This paradigm represents three levels of treatment: the individualized Computer Assisted Instruction (experimental group 1), Cooperative Computer Assisted Instruction (experimental group 2) and the Conventional Instruction (control group); and two levels of gender (Male and female).

Sample

The target population of this research was the first year senior secondary biology students in Oyo town and Ibadan city, Nigeria. The nature of the study, however, required that the research sample was purposively selected. This is because a research on CAI must necessarily be conducted in schools where computers are available for students' use and where the students are computer literate. This was why the NESTO College, Oyo, and Ise Oluwa Montessori Secondary School, Ibadan were purposely sampled for the study. These two schools were selected as the experimental groups. A third school, St. Francis Catholic College, Oyo was also sampled as the control group, as the school is believed to be more or less equivalent in standard to the schools used for the experimental group.

The sample for Experimental Group 1 is made up of 40 students. This comprises of 20 males and 20 females. The Experimental Group II also has 40 students made up of 19 males and 21 females, while the control group was made up of 19 males and 21 female students.

Research Instruments

The instruments for this research were the treatment instrument "Computer Assisted Instructional Package (CAIP)" and the test instrument, "Biology Performance Test (BIOPET)". The treatment instrument, Computer Assisted Instructional Package (CAIP) on Biology, was a self-instructional, interactive package that lasted for $2^1/_2$ hour for an average student. It contained five lessons structured into modules. The topics covered in the package are food chain, food web, energy flow, nutrient, movement, and pyramid of numbers, all from the ecology aspect of the Nigerian senior secondary biology curriculum. It was developed by the researchers, with the assistance of a professional programme developer using Dream weaver and flash that is, written in Hypertext Markup Language (HTML) with illustrations converted to Graphic Interchange Format (GIF). Intrinsic

programming sequence in which single alternative frame exist to reinforce concepts that appear difficult to some students was adopted. At a consistent portion of each frame, navigation buttons were included.

In the development of the package four methodological phases were strictly followed: analysis, design, implementation and validation. In analysis stage, students' cognitive skills to be improved were considered as a baseline for the development of components of the software, and evaluation instruments were also analyzed and developed at this stage. At the design stage, storyboards, scripts, frameworks and other aspects of the software were defined. At the implementation stage, the software development was based on user-centered design, where the opinion, interests, needs, emotions, thoughts, and so on of users became key factors in the software's development. Validation involved the evaluation by biology experts for the appearance, operation and logic of hyperlink, spelling, grammar, readability, and clarity from the viewpoint of persons unfamiliar with the content. In addition, end users' usability evaluation was done through a pilot study on a sample, similar to the final sample used in the study. The results obtained in the usability experience were used for improvement of the package.

The test instrument, Biology Performance Test (BIOPET), was a 30 item multiple-choice objective test with five options each which were drawn from the past West African Examination Council (WAEC) Senior Secondary Certificate Examination biology paper II questions. The test content was based on a table of specification covering the six levels of cognitive domain of learning.

Procedure for Data Collection

All the groups (experimental and control groups) were subjected to the BIOPET as pre-test. Then, the students in the first experimental (individualised) group were exposed to CAIP which had been installed on desktop computers using a web browser (Explorer or Firefox), while the second experimental group were exposed to the same content with four students working on a desktop computers. Other applications such as Internet access, CAI packages, games, and so on were disabled or removed. The students in the experimental groups were introduced to the CAI format under teacher's supervision long enough for them to be familiar with the navigation buttons and use the package independently. In addition, they were encouraged to take enough notes that could be useful for them in the post test.

The control group students were exposed to the conventional teaching method on the same content used for experimental groups. They were taught using conventional classroom format. The classroom contained a chalkboard, overhead projector, and charts which were used for the instruction. The treatment for all the groups lasted for five weeks. After the treatment the three groups were exposed to the BIOPET which had been rearranged as post test.

RESULTS

The scores of students in the three groups were analysed using ANCOVA. The analysis was done using the three research hypotheses stated for the study. The results of the analyses and discussions are as stated below.

Hypothesis One: There is no significant difference in the performance of students in biology when they are exposed to (i) Individualized Computer Assisted Instruction (ICAI), (ii) Cooperative Computer Assisted Instruction (CCAI), and (iii) Conventional Instruction (CI).

To determine the relative effectiveness of the three instructional treatment (ICAI, CCAI and CI), the students scores were analysed using ANCOVA and the result is as shown in Table 1.

Table 1: Analysis of Covariance of Mean Score of students Exposed to ICAI, CCAI, and, CCI

Source of Variation	Sum of Squares	df	Mean square	F	Significance of F
Covariates (Pre-test)	981.571	1	981.571	433.589	.000
Main effect (treatment)	167.160	2	83.580	36.920	.000
Explained	1148.731	3	382.910		
Residual	262.604	116	2.264		
Total	197.465	119	11.8599		

* denotes F is significant at 0.05 alpha level.

An examination of Table 1 reveals that an F (2, 117) = 36.920, $\alpha = 0.000$ for the main effect (treatment) was significant. This is because the significance of F = 0.000 is less than the 0.05 alpha level. This result shows that different CAI modes (ICAI and CCAI) as well as the conventional method of instruction (CCI) produced significant difference on the post test performance of students when the covariate effect (pre-test) was

statistically controlled. Hypothesis one was therefore rejected. A follow up Scheffe test was conducted to locate where the significant difference existed among the three treatments' mean scores of the three treatment groups as indicated in Table 2.

Table 2: Scheffe Test of Significance on the Mean Scores of Students Exposed to ICAI, CCAI and CCI

Groups	Mean Scores	Group 1 (CAI)	Group II (CCAI)	Group III (CCI)
Group I (ICAI)	17.8750		*0.014	*0.000
Group II (CCAI)	20.0500	* 0.014		*0.000
Group III (CCI)	14.0500	*0.000	*0.000	

* The mean difference is significant at the 0.05 level.

The data in Table 2 indicate that there was significant difference in the post test mean scores of students exposed to ICAI (X=17.8750) and those exposed to CCAI (X =20.0500) in favour of experimental group II, that is those exposed to cooperative computer assisted instruction. It also indicates that significant difference exists in the post test scores of students exposed to CCAI (X = 20.0500) and those exposed to CCI (X = 14.0500) in favour of students exposed to CCAI. Significant difference was established in the post-test scores of students exposed to ICAI (X=17.8750) and those exposed to CCI (X=14.0500) in favour of ICAI group.

Hypothesis Two*:* There is no significant difference between the performance of male and female students in biology when they are exposed to individualized computer assisted instruction (ICAI).

Analysis of covariance (ANCOVA) was used to find out the effect of the main treatment (ICAI) on the performance of the male and female student. The result is presented in Table 3.

Table 3: Analysis of Covariance of Mean Scores of Male and Female Students Exposed to CAI

Source of variation	Sum of squares	df	Mean squares	F	Significance of F
Covariates (Pre-test)	213.621	1	213.621	85.793	*0.000
Main Effect Gender	1.074	1	1.074	.431	** .515
Explained	214.695	2	107.348		
Residual	92.129	37	2.490		
Total	306.824	39	7.8672		

** denotes F is not significant at 0.05 alpha level.

An examination of Table 3 shows that an F (1, 37) = 0.431, $\alpha = 0.515$ for the main effect (treatment) was not significant at 0.05 alpha level. This result shows that the male students' performance did not differ significantly from that of their female counterparts when both were taught using Individualized Computer Assisted Instruction (ICAI) when the covariate (pre-test) was statistically controlled.

Hypothesis Three: There is no significant difference between the performances of male and female students in biology when they are taught using Cooperative Computer Assisted Instruction (CCAI).

Analysis of Covariance (ANCOVA) was used to find out the effect of CCAI (the main treatment) on the performance of female and female students. The result is presented in Table 4.

Table 4: Analysis of Covariance on Mean Scores of Male and Female Students Exposed to CCAI.

Source of variation	Sum of squares	df	Mean squares	F	Significance of F
Covariates (Pre-test)	487.626	1	487.626	225.108	0.000
Main effect (Gender)	. 249	1	.249	.115	**.737
Explained	487.875	2	243.938		
Residual	80.149	37	2.166		
Total	568.024	39	14.565		

** denotes not significant at 0.05 level.

An examination of the results in Table 4 shows that an F (1, 37) = 0.115 $\alpha = 0.737$ for the main effect (treatment) was not significant at 0.05 alpha level. The result shows that the mean scores of the male and female students did not differ significantly when they were taught using Cooperative Computer Assisted Instruction (CCAI), when the covariate (pre-test) was statistically controlled.

DISCUSSION OF FINDINGS

The result of the analysis of covariance on the performance of students taught biology using computer assisted instructional packages in cooperative and individualised learning settings and those taught with conventional classroom instruction indicated a significant difference in favour of the students in the experimental groups. Scheffe test used as post hoc to locate the observed significant difference indicated that there was significant difference between the performances of students exposed to ICAI and CCAI (the two experimental groups). It is to be noted that students exposed to CCAI did better than those exposed to ICAI, as reflected in higher group mean. Furthermore, between the two experimental groups and the control group (conventional group) significant differences were established in favour of the two experimental groups.

These findings agree with earlier findings of Phillips and Moss (1993) and the findings of Jegede, Okebukola and Ajewole (1992) which are directly on biology. Similarly, the findings agree with the studies of Ajelabi (1998) on social studies, Egunjobi, (2002) in geography, (Udousoro, 2000) in mathematics, and Okoro, and Etukudo, (2001) in chemistry, conducted in Nigeria which confirmed that CAI has been effective in enhancing students' performance in other subjects than the conventional classroom instruction. The finding is also supported by the findings of Karper, Robinson, and Casado-Kehoe (2005) on counselling education. It, however, contradicts the conclusion of Mill (2001). It is possible to infer that the significant difference observed may be accounted for by the novel nature of the CAI settings, in the Nigerian school setting.

The influence of gender on the academic performance of students in biology when taught with CAI package in individualised or cooperative learning settings was examined using hypotheses two and three. The result of the analysis of covariance (ANCOVA) showed no significant gender difference for learners exposed to CAI package in the two settings. These findings showed that gender had no influence on the performance of students in biology whether they were taught with CAI in individualised or cooperative setting. These findings on gender agree with the earlier findings of Bello (1990) on gender and performance in biology. It also agreed with the conclusions of Kirkpatrick and Cuban (1998) based on their review of studies on computer and gender, and also the findings of Spence (2004). Thus, it can be deduced that the use of computer assisted instruction enhanced the performance of both male and female students.

Limitations of the Study

The following limitations can be observed regarding this study. First, the study was designed to focus on learning of biology by senior secondary students drawn from three private Nigerian secondary schools. Thus, the findings may not be generalisable to other public institutions and other private institutions. Second, the study did not examine other alternative means like Internet for delivering the course content. Third, the curriculum content was limited to six ecology topics of the entire biology curriculum. Fourth, computer use was limited to the presentation of curriculum contents only, as the three groups were exposed to pre-test and post-test using paper and pencil approach. Despite these limitations the findings are significant, particularly in the use of CAI in the Nigerian school system.

RECOMMENDATIONS

Based on the findings of this study, the following recommendations are made.

1. Necessary attention should be accorded computer literacy and operation in the secondary schools and relevant computer assisted instructional packages should be developed for use within the Nigerian school systems. In addition, Nigerian public schools should be equipped with necessary ICT facilities to leverage the potentials of ICT in Nigerian schools.
2. Since the findings of this study showed that students who worked on the computer cooperatively performed better than those who work on the computer singly, students should be encourage to develop social interaction in the use of computer. In addition, the finding implies that the number of computers to be procured for the schools does not have to be on individual students' basis. A class of 40 would not need more than eight computers systems for instructional needs.
3. Further empirical studies should be carried out on the use of computer for instructional purposes, on different subjects and at different levels to provide sound basis for the integration of computer in Nigerian schools.

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