Relative Effectiveness of Computer-Assisted Instructional Strategy on Students' Learning Outcomes in Mathematics

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Abstract

This study investigated the relative effectiveness of computer- assisted instructional strategy on senior secondary school students' learning outcomes in mathematics. Also, the influence of gender on the performance of students exposed to computer- assisted instructional strategy was examined. The researcher used a quasi-experimental pre-test, post-test, control group design to carry out the study. The treatments were computer- assisted instruction and conventional teaching method. Two hundred and forty (240) second year senior secondary school students (SSSII) from six (6) public secondary schools in Ondo West Local Government Area of Ondo State were randomly assigned to the experimental and the control groups. The students' pre- and post-test scores were subjected to Analysis of Covariance (ANCOVA) and Chi-Square .The findings of the study showed that the performance of students exposed to computer- assisted instruction(experimental group) was better than their counterpart (control group) exposed to the conventional classroom instruction. However, no significant difference existed in the performance of male and female students exposed to computer -assisted instruction. Based on the research findings, recommendations were made on the need to develop relevant computer-assisted instructional packages for teaching mathematics in Nigerian secondary schools.

Introduction

Mathematics occupies a unique position in the school curriculum and it is central to science-related courses. Kolawole and Oluwatayo (2004) maintained that in order to produce future scientists and technologists in quality and quantity, the knowledge of mathematics is inevitable. There exists a symbiotic relationship between mathematics and technology in general and ICTs in particular. Mathematics forms a major content of ICT while the latter has proved to be an effective teaching tool of the former. Technological development is highly rooted in the study of mathematics. Indeed, the evolution of information and communication technology (ICT) derives a lot from mathematics (Akinsola and Tella, 2001; Salawu, 2001). Technology has become a part of most of our activities in our daily life. Thus, its integration in the teaching and learning of a subject like mathematics cannot be delayed further especially in Nigeria with a dearth of professionally qualified mathematics teachers in the required quantity and quality.

In recent years, the focus has been on the improvement of mathematics education with the use of technology. For many years, schools have been facing many learning problems including poor performance of students in mathematics in various examinations. Many scholars like Akinsola and Ogunlayo (2003) have over the years carried out research on methods and ways of improving the teaching and learning of mathematics at the primary, junior and senior secondary school levels. Despite these numerous researches, as well as efforts at the instructional level, the performances of students at both the West African Senior Secondary School Certificate (WASSCE) and National Examination Council (NECO) examinations have not improved significantly. However, it was observed that poor performance in the mathematics is caused by the poor quality of mathematics teachers; Morakinyo (2003) believes that the falling level of academic achievement is attributable to teacher's non-use of verbal reinforcement strategy. Akpan and Andre (2000) observed that inadequate preparation of pupils in mathematics at the primary school level has its negative influence on the secondary school. This, they said was the primary school teachers exhibited limited knowledge of the subject matter, which then accounted for the inadequate preparation of pupils for secondary school and thus, leads to poor performance of pupil

in the subject. Other reasons they came up with, included large class size, lack of teaching facilities, non-use of concrete materials, and textbooks. 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.

Ertmer (1991), (as cited in Day, 2006) stated that "CAI benefits most students when compared with traditional instruction because it increases student interest, reduces anxiety, provides more time on task, and provides instant feedback for the student"'. Besides, CAI could also benefit students in the provision of self-sufficient content packaging in a variety of media. In computer- assisted environment, students can fix their pace of learning. Thus, with self-paced learning, students can progress as slowly or as quickly as they like through a programme. In addition to this, if students want to replicate some tasks or review some materials again, they can do so as many times as they wish. The programme will not get tired out or complain about repetitions as sometimes teachers do. Also, students can leave out a topic if content is already known or understood, making the learning process more efficient.

In a review of empirical studies on CAI, Cotton (2001) concluded, among others, that the use of CAI as a supplement to conventional instruction produces higher achievement than the use of conventional instruction alone and that research is inconclusive regarding the comparative effectiveness of conventional instruction alone and CAI alone. He further opined that computer-based education (CAI and other computer applications) produce higher achievement than conventional instruction alone. According to him, 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.

Mill's (2001) findings revealed that CAI was found to be as effective as classroom instruction 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).

Based on a review of several studies and shortcomings on studies comparing CAI with conventional instruction, CAI can be considered as effective as traditional instruction. 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 exists in computer use, access, career and attitude; that is why Davies, Klawe, Ng, Nyhus, and Sullivan, based on their review, suggested that current gender imbalance in technology and the role that technology will play 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 mathematics, physics, and chemistry (Danmole, 1998; Novak & Mosunda, 1991; Okeke & Ochuba, 1986) while others revealed that female students are better off than males (Kelly, 1978; Wonzencreaft, 1963).

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 counterpart. 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.

However, the use of 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. The computer and the internet

provide students with new ways to explore concepts at a depth that has not been possible in the past. These technological tools can trigger a new enthusiasm and motivation for learning, enable students to learn at their own pace and provide students with access to vast information sources.

However, little is known about the use of computer-assisted instructional package in the Nigerian education system. In addition, very few empirical studies exist in Nigeria regarding the use of CAI in mathematics.

Purpose of the Study

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

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

Research Hypotheses

Based on the stated problem, the following null hypotheses were tested at 0.05 alpha level of significance:

$H0_1$:   There would be   no   significant   effect of computer-assisted instructional strategy on students' achievement in mathematics
$H0_2$:   There would be   no   significant   effect of computer-assisted instructional strategy on students' attitude towards mathematics
$H0_3$:   There would be no significant effect between the performance of male and female students in mathematics when they are exposed to computer-assisted instruction.

Research Methodology

Research Design

A pre-test, post-test control group quasi-experimental design of Campbell and Stanley (1963) was adopted for this study. The design is suitable for this study as it enables the researcher to determine the effects of treatments on the dependent variables. This paradigm represents two levels of treatment: the Computer-assisted Instruction (experimental group), and the Conventional Instruction (control group); and two levels of gender (male and female).

Sample

The target population of this research was the second year senior secondary mathematics students in Ondo West Local Government Areas of Ondo State. Judgemental sampling procedure was used to select the six public secondary schools that were used in the study based on the under-listed criteria:

(i)   they have presented candidates for Senior Secondary School Certificate   Examination for at least ten consecutive years
(ii)   they have qualified mathematics teachers with at least one of them handling SS II
(iii)   they have at least 15 to 20 working computer systems; and
(iv)   they have at least one (1) generator, in case there is power failure

Two hundred and forty (240) students on the basis of 40 per school at 20 per gender type (male and female were randomly selected and participated in the study).

Research Instruments

The instruments for this research were three: Mathematics Achievement Test (MAT); Mathematics Students Attitudes Test (MSAT); and Computer-Assisted Instructional Package (CAIP).The package comprised three levels: the beginner, the intermediate and the advanced level. The topic covered in the package is probability; the player is expected to have

read and understood the instruction and the tutorial on probability before the start of the game. For every correct answer, the player gains 20points, and also for every wrong answer 5points will be subtracted from players point. The player that accumulates 50% of the points will be rewarded with additional l00points, 200points go for accumulated 50% from level 2 and extra 500 points will be added for successful accumulation of 50% from advanced level.

The package was developed by the researchers, with the assistance of a professional programme developer using Dream weaver and flash that is, written in Hypertext Mark-up Language (HTML) with illustrations converted to Graphic Interchange Format (GIF). Intrinsic programming sequence in which single alternative frame exists to reinforce concepts that appear difficult to some students was adopted. Validation involved the evaluation by mathematics 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 the improvement of the package. The results of the pilot study which were based on the reactions of the piloted students to such issues like: appropriateness of the topic, ease of usage of the computer package, simplicity of the instructions to be followed in using the package, and the timing of completion of the game produced a variety of results-90, 65, 75 and 60% in terms of positive scoring of the responses to the four issues respectively.

The MAT instrument contained fifty structural multiple-choice questions with five options each which were drawn from the past West African Examination Council (WAEC) Mathematics paper II questions while the MSAT was based on a four-point Likert scale. These are Strongly Agree (SA), Agreed (A), Disagree (D) and strongly Disagree (SD). The four-point Likert type scale had a scoring key.

Procedure for Data Collection

Both the experimental and control groups were subjected to the MAT as pre-test. Then, the students in the experimental group were exposed to CAIP which had been installed on desktop computers using a web browser

(Explorer), with two students working on a desktop computer. Other applications such as Internet access, CAI packages, games, and so on were disabled or removed. The students in the experimental group 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 the experimental group. They were taught using the conventional classroom format.

Results

The scores of students in the 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 would be no significant effect of computer-assisted instructional strategy on students' achievement in mathematics.

Table1:   **Analysis of Covariance of Mean Score of Students Exposed to CAI**

Sourceof Variation	Sum of Squares	df	Mean Squares	F	Significance ofF
Covariates (Pre test)	981.571	1	981.571	433.589	.000
Main effect (treatment-CAI)	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 $F (2, 117) = 36.920$, $a = 0.000$ 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 CAI modes as well as the conventional method of instruction

(CMI) produced significant difference on the post-test performance of students when the covariate effect (pre-test) was statistically controlled. Hypothesis one was therefore rejected.

Hypothesis Two; There would be no significant main effect of computer-assisted instructional strategy on attitude of students towards mathematics. This hypothesis was tested using chi-square statistics.

Table 2:   Summary of Chi-Square Table for Attitude between Experimental and Control Groups

Df	24
Significant level	0.5
Table value X^2 value	36.41
Calculated X" value	26.1

* denotes F is not significant at 0.05 alpha level

It could be observed that there is no significant difference in students' attitude in mathematics because the calculated value 26.1 is less than the table value of 36.41 (Table 2). It is therefore concluded that, there is no significant difference in the attitude scores between experimental and control groups. Based on the result, the null hypothesis 2 is retained.

Hypothesis Three: There would be no significant main effect between the performance of male and female students in mathematics when they are exposed to computer-assisted instruction.

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

Sourceof Variation	Sum of Squares	df	Mean Squares	F	Significance of F
Covariates(Pretest)	213.621	1	213.621	85.793	*.000
Main effect(treatment)	1.074	1	1.074	.437	**.515
Explained	214.695	2	107.328		
Residual	92.129	37	2.490		
Total	**306.824**	**39**	**7.8671**		

** denotes F is not significant at 0.05 alpha level

An examination of Table 3 shows that an F (1, 37) = 0.437, a = 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 counterpart when both were taught using Computer-assisted Instruction (CAI) when the covariate (pre-test) was statistically controlled. Hypothesis three was therefore rejected.

Discussion

The result of the analysis of covariance on the performance of students taught in mathematics using computer-assisted instructional packages and those taught with conventional classroom instruction indicated a significant difference in favour of the students in the experimental group. These findings agree with earlier findings of Udousoro (2000) in mathematics 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, 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.

The result of finding on students' attitude shows that there was no significant difference for learner exposed to CAI package and conventional method. It then means that computer-assisted instructional strategy may not affect or change attitude better than conventional method with respect of learning mathematics by learners. These findings agree with the earlier finding of Akinsola and Animashun (2007), Ruffin (2000), and Value and Leder (2004) on attitude and achievement in mathematics.

The influence of gender on the academic performance of students in mathematics when taught with CAI package in learning settings was examined using hypothesis three. The result of the analysis of covariance (ANCOVA) showed no significant gender difference for learners exposed to CAI package. These findings show that gender had no influence on the performance of students in mathematics with CAI. These findings nr gender agree with the earlier findings of (Idowu, 1991) on gender and performance in mathematics and Bello (1990) in biology. It also

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 enhance 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 the learning of mathematics by senior secondary students drawn from six public secondary schools in Ondo West Local Government Area. 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 topic used for the study was "Probability". The choice of the topic hinged on the personal experience of the researcher as mathematics teacher and WAEC and NECO examiner, and interaction with a good number of mathematics teachers and students. Fourth, computer use was limited to the presentation of curriculum contents only, as the two 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:

(i)   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

(ii)   professional associations (e.g. Association of Secondary School Teachers of Nigeria - ASSTN; Nigeria Union of Teacher - NUT; Science Teacher Association of Nigeria - STAN; Mathematics Association of Nigeria - MAN, Nigeria Association of Educational Media and Technology -NAEMT e.t.c) should organise seminars, workshops, symposia and in service training more regularly to

update the knowledge of their members on the importance of classroom interactions as related to the computer-assisted instructional strategies on learners learning outcomes

(iii)   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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