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# Enhancing Students' Understanding of Algebra Concepts through Cooperative Computer Instruction

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*This study investigated how Cooperative Computer Instruction (CCI) could enhance students understanding of Algebra concepts. In addition, this study also determined the influence of gender on the performance of students exposed to cooperative and individualized instruction. 60 second year senior secondary school students (SSS II) were sampled from three public secondary schools, in Minna, Niger State, Nigeria. Pre-test, post-test, experimental, control group design was employed. Mathematics Achievement Test (MAT) was used to collect the data. The pre-test and the post-test data were analyzed using One-way ANOVA and t-test statistics. The findings of the study showed that the performance of students exposed to Cooperative Computer Instruction (CCI) were better than their counterparts exposed to the Individualized Computer Instruction (ICI), and conventional classroom instruction respectively. However, there was no significant difference between male and female students exposed to CCI and ICI. Based on the finding, it was recommended among others that teachers should be encouraged to use cooperative computer instruction to improve students' performance in mathematical concepts.*

*Keywords*: *cooperative learning, individualized instruction, computer instruction, algebra, student team achievement division*

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## INTRODUCTION

The knowledge of mathematics plays a significant role in enhancing the country's social economic development. Mathematics occupies a central place in the Nigerian educational system. Ojo (2002) pointed out that mathematics is the gate and key to science. The importance of mathematics to nation building has led the Federal Government of Nigeria to make mathematics a core subject to be offered by students at all levels of education in Nigeria (FRN, 2004). Okafor (2002) noted that mathematics is a compulsory subject for entry requirement into university education. Pass at credit level in mathematics is expected to qualify an individual for further study.

In spite of its importance, Mathematics is a subject that is considered difficult and boring by many students. For instance, weaker students feel anxiety toward mathematics, and this anxiety affects their performance in the subject (Van Wyk, 2012). According to Woodard (2004), students who lack mastery in mathematics are less successful in mathematics examination. Furthermore, students' performance in mathematics was found below average in the Senior Secondary School Certificate Examination (SSSCE) in Nigeria. West African Examination Council (WAEC) revealed that less than 30% passed at credit level from 2004 to 2012.

The West African Examination Council (WAEC), Chief Examiners' report (2012) confirmed that candidates had weak presentations on questions similar to triangle, this had some adverse effects on their performance. Also, the WAEC Chief Examiners (2007) report revealed that candidates lack interpretation and handling of trigonometric construction and its application to angles and triangles, this shows that the candidates did not show any firm grasp of detail needed to answer the questions. These problems emanate as a result of a lot of problems facing the effective teaching and learning of mathematics at all levels of Nigerian educational institution (Bankolere, 2006). Okafor (2002) and Okeke (2006) identify poor teaching methods as the major factor contributing to the poor performance of students in mathematics.

The instructional method employed by the teacher plays an important role in the acquisition of skills and meaningful learning. It is one of the factors that make students become passive and have less interaction with each other in doing tasks. Zakaria, Chin and Daud (2010) concluded that positive changes take place when a teacher changes his teaching method towards a more students-centered approach. Lecture method contribute to more than 85% of the instruction in schools in which students are isolated from one another and forbidden to interact

(Johnson, Johnson , Holubec , & Roy,1984). Sule (2003) reported that the teaching of mathematics without the instructional media contributes a lot to the failure in the mathematics.

Therefore, to enhance the understanding of mathematics, students must be more active in the classroom and must creatively acquire knowledge, especially in understanding and solving mathematical problems. Students should be given the opportunities to develop, to interact, and to share with friends through cooperative learning activity. Thus, the cognitive and affective development of students in mathematics can be improved. An alternative method for the delivery of material is cooperative learning (Zakaria, Solfitri, Daud & Abidin, 2013).

Cooperative learning allows students to communicate their ideas with each other, brainstorm responses, and work to solve problems together. The importance of students becoming more involved in the learning process has been emphasized and needs to be implemented in classrooms around the globe (Leikin & Zaslavsky, 1997). There are many cooperative teaching strategies in existence but the basic characteristics and components of cooperative teaching do not change in those strategies. STAD cooperative learning strategy was specifically chosen because it is the simplest method of cooperative strategy and it allows more active involvement of students in the teaching and learning process (Sarah & Cassady, 2012).

Studies have proven effectiveness of cooperative learning on mathematics achievements of students. For example, Zakaria, Chin, and Daud (2010) found that cooperative learning enhanced students' achievement in mathematics. Shimazoe and Al-Drich (2010) reported that cooperative learning promotes deep learning of materials and helps students to achieve better grades. According to Johnson and Johnson (1989), in cooperative learning, students tend to enjoy mathematics, and this enjoyment motivates them to learn. Ajaja and Eravwoke (2010), Melihan and Sirri (2011), and Zakaria, Solfitri, Daud and Abidin, (2013) reported that cooperative learning method is more effective than the traditional teaching method in the academic success of students and increased their confidence.

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 (Yusuf & Afolabi, 2010). Therefore, the position of mathematics makes it necessary for the use of innovative pedagogical

strategy that will enable teachers meet the challenges of teaching and learning of the subject especially in this era of information age. Several researches have shown that using Computer-Assisted Instruction (CAI) has a positive effect on students' achievement compared to traditional methods. For instance, Anyamene, Nwokolo, Anyachebelu, and Anemelu (2012) found that students taught mathematics using CAI package performed better than those taught using the conventional method of instruction. Bayturan and Keşan (2012) reported that teaching mathematics with a computer assisted instruction method increased student success significantly in mathematics lesson. Pilli and Aksu (2013) found that students taught mathematics at the primary school level in North Cyprus performed better than those taught using conventional method. 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). 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). Yusuf, Gambari and Olumorin (2012), Yusuf and Afolabi (2010), Fajola (2000) and Dalton, Hannafin and Hooper (1989) reported from their various researches that students who worked cooperatively using computer-assisted instruction significantly outperformed those who worked individually using CAI.

Gender bias in Nigeria and Africa as a whole is still very prevalent (Arigbabu & Mji, 2004). However, some researchers still found that there are still significant differences in the cognitive, affective and psychomotor skill achievements of students in respect of gender (Aguele and Uhumniah (2008); Croxford (2002); Kolawole, (2007). Viann (2004) found no significant gender related differences, but female achieved slightly higher grades than male students. However, Kolawole (2007) found that boys performed better than girls in both cooperative and competitive learning strategies when he conducted a research on the effects of competitive and cooperative learning strategies on Nigerian students' academic performance in mathematics. Contrarily, Aguele & Uhumniah (2008) and Croxford (2002), found, in their studies at various times, that male students achieved significantly better than female students in science education. Garduno (2001) found no statistically significant differences in achievement or self-efficacy in seventh and eighth-grade students in mathematics in single-or-mixed-gender groups. Fajola (2000), Gambari (2010) and Yusuf and Afolabi (2010) reported that gender had no effect on academic performance of students in computer-assisted cooperative learning. These

contradictory findings have caused for inclusion of gender as one of the moderating variable or this study.

Evidences from studies in Nigeria indicated that very little research efforts had been directed at cooperative learning. This approach has been highly recommended for teaching at all levels, as stated by the Federal Government of Nigeria (2004) in the National Policy on Education. If the CCI and ICI methods of teaching are used to teach mathematics concepts, what would be their effects on students' academic achievement in mathematics? In view of this, the effects of CCI and ICI on Nigerian Senior Secondary students' academic achievement in mathematics were investigated in this study.

**Purpose of the study**

The purpose of this study was to determine whether cooperative computer-assisted instruction (CCI) would enhance understanding of algebra concepts. Specifically, the study examined:

(i) the differences in the mean achievement scores of students taught using algebra using cooperative Computer-Assisted Instruction (CCI), Individualized Computer Instruction (ICI) and Conventional Teaching Method (CTM).

(ii) the difference between the mean achievement scores of male and female students taught algebra using CCI.

(iii) the difference between the mean achievement scores of male and female students taught algebra using ICI.

**Research questions**

The following research questions guide the study:

(i) What are the differences between the mean achievement scores of students taught using algebra using CCI, ICI and CTM?

(ii) Is there any difference between the mean achievement scores of male and female students taught algebra using CCI?

(iii) Is there any difference between the mean achievement scores of male and female students taught algebra using ICI?

**Research hypotheses**

The following hypotheses were raised in this study:

(i) There are no significant difference between the mean achievement scores of students taught algebra using CCI, ICI and CTM.

(ii) There is no significant difference between the mean achievement scores of male and female students taught algebra using CCI.

(iii) There is no significant difference between the mean achievement scores of male and female students taught algebra using ICI.

## METHODOLOGY

The research design adopted for the study is a pretest-posttest experimental group design. Three levels of independent primary variable (two treatments and a control), two levels of gender (male and female) were investigated on students' performance in algebra. The design layout is as shown in Table 1.

*Table 1: Research design layout*

| Groups | Pretest | Treatment | Postest |
|---|---|---|---|
| Experimental Group I | $O_1$ | CCI | $O_2$ |
| Experimental Group I | $O_3$ | ICI | $O_4$ |
| Control | $O_5$ | CTM | $O_6$ |

Multi-stage sampling techniques were adopted. Firstly, purposive sampling procedure was adopted to obtain three secondary schools in Minna metropolis, Niger State Nigeria. These schools were sampled based on facilities (computer laboratories, and manpower), school type (public schools), and gender composition (coeducational schools). The three schools were randomly assigned to experimental group I (CCI group), experimental group II (ICI) and control group (traditional teaching methods) respectively. Finally, stratified sampling technique was used to select 60 SS1I students. The experimental group I had 20 (10 male – 10 female), experimental group II had 20 (10 male – 10 female) students and control 20 (10 male – 10 female) students.

Algebra Achievement Test (AAT) was used as a test instrument, while Computer-Assisted Instructional Package was used as a treatment instrument. The test instrument used in

collecting data for the study was researcher adopted Algebra Achievement Test (AAT). The MAT consists of 20 multiple choice objective items with five options (A–E) adopted from past examinations of West African Examination Council (WAEC, May/June) and National Examination Council (NECO, June/July). MAT was validated by experts in Mathematics, and test and measurement experts and its reliability coefficient determined as 0.87 using Pearson Product Moment Correlation Coefficient.

Treatment instrument (CAIP) was developed by researchers and programmer. CAIP was used for cooperative learning and individualized instruction respectively. The CAIP consists of four topics in mathematics (pythagoras theorem) in Nigeria Senior Secondary School curriculum. These concepts were identified as one of the difficult concepts that students find difficult to understand (WAEC Chief Examiners' report, 2012). The necessity for researcher-made computer package was based on the fact that the commercially produced computer-assisted instructional packages are not common in Nigeria. Even the available foreign CAI packages were not relevant to the topics or objectives to be achieved in this study. As a result of this, developing a computer package for use by the researcher was inevitable.

**Experimental procedure**

The objectives and the modalities of the experiments were specified and operational guide was produced before the commencement of the treatment. The Computer Assisted Instructional Package (CAIP) with the mathematics content was installed in the system. The computer presents information and displays animation to the learner on each of the units after which the students assessed themselves with objective questions at the end of each unit. The students could only proceed to the next unit, if they satisfactorily answered the questions. When a student fails a question after three attempts, the computer will log-out the students until the instructor log-in again. The students must have 100% mastery of the content before proceeding to the next unit.

The researcher administered the Mathematics Achievement Test (MAT) on sample students as pre-test to ascertain the equivalence of the students before the treatment. During the four weeks treatment, the CCI and ICI groups were exposed to the use of cooperative computer instruction and individualized computer instruction as treatments, while students in control group were exposed to conventional teaching method. Each of the lesson lasted for forty minutes

duration (200 minutes per week) with five lessons per week. The following are the specific procedures for each group:

*(i) The cooperative computer instruction using Students Team Achievement Division (STAD) cooperative learning strategy*: students were taught the mathematics concepts using CAIP only. In this strategy, students were assigned into three member heterogeneous group. Each member was assigned with different responsibilities (e.g, group leader, time-keeper, scribe/quiet captain). The groups were exposed to CAIP where members complete the reading of the materials and perform the tasks together. To ascertain that there was no free rider, students were given individual task which was marked and recorded against group scores. After the completion of a lesson, students take quiz as a team and reach consensus with respect to the correct answers after which one answer sheet were submitted by the team for which all teammates receive the same 'team score'. The scoring was done based on individual quiz score and team quiz score which were counted equally towards the student's final course grade. High scoring teams is recognized and rewarded in the class. Group processing form was completed after each lesson to determine the group behaviour and correct any irregularity within the teammates.

*(ii) Individualized Computer Instruction method:* In this method, students were taught the mathematics concepts using CAIP only. The computer presented the instruction on human-to-computer basis. Students proceeded with the physics contents and study at their own rate without any assistance from their colleagues. Students answered the MAT at pre-test and post-test individually.

*(iii) Control Group: Conventional Teaching Method:* The control group was exposed to lecture method. The researcher taught students in control group using some instructional materials to explain the concept of Pythagoras theorem. Students answered the MAT at pre-test and post-test after four weeks of the teaching.

Immediately after four weeks of treatment, MAT was administered as posttest to measure the achievement of different groups. The scores obtained were subjected to data analysis based on the stated hypotheses using One-way Analysis of Variance and Scheffe's post-hoc analysis was employed to analyze data. The significance of the various statistical analyses was ascertained at 0.05 alpha level.

## RESULTS

To test for the hypotheses, the data were analysed using Analysis of Variance (ANOVA) and Scheffe's test using Statistical Package for Social Sciences (SPSS) version 11 at 0.05 alpha level. The results are presented based on the research hypotheses.

*Table 1: ANOVA pre-test on CCI, ICI and control groups*

| Source of variables | Sums of square | df | Mean ($\bar{x}$) | F-calculated | p-value |
|---|---|---|---|---|---|
| Between Groups | 7.900 | 2 | 3.950 | | |
| Within Groups | 232.950 | 57 | 4.087 | $0.967^{ns}$ | 0.387 |
| Total | 240.850 | 59 | | | |

ns: Not Significant at 0.05 level

Table 1 shows the result of ANOVA comparison of the two experimental groups and control group. From the table, the calculated F-calculated (0.967, p = 0.387) was not significant at 0.05 alpha level. This implies that there was no significant difference among the mean scores of the experimental group I; experimental group II and the control group at 0.05 level of significance. This results shows that students in the experimental groups and control group have the same entry level with regards to previous knowledge of the topic treated. Thus, they are compatible groups.

**Hypothesis one:** *There are no significant differences in the performance of secondary school students taught mathematics using Cooperative Computer Instruction (CCI), Individualized Computer Instruction (ICI) and conventional teaching method.*

To determine whether there were significant differences in the post-test mean scores of the CCI, ICI and control groups, data were analyzed using the analysis of variance (ANOVA). Table 2 contains the result of the analysis.

*Table 2: ANOVA post-test on CCI, ICI and control groups*

| Source of Variables | Sum of Squares | df | Mean Square | F-ratio | P-value |
|---|---|---|---|---|---|
| Between Groups | 17823.333 | 2 | 8911.667 | | |
| Within Groups | 15370.000 | 57 | 269.649 | 33.049* | 0.000 |
| Total | 33193.333 | 59 | | | |

* Significant at 0.05 level

Table 2 present the result of ANOVA comparison of the two experimental groups and control group. From the table, the calculated F-calculated (33.049, p = 0.000) was significant at

0.05 alpha level. This indicates that statistically significant difference was established among the experimental groups and control group. Hence the null hypothesis one ($HO_1$) was rejected.

Based on the established significant difference in the post-test achievement scores of the groups, Scheffe's test was used for post-hoc analysis. The results of this post-hoc analysis are as shown in Table 3.

*Table 3: Scheffe's post-hoc analyses of the groups mean scores*

| Groups | Mean Scores | Group I (CCI) | Group II (ICI) | Group III (Control) |
|---|---|---|---|---|
| Group I (CCI) | 84.50 | | 0.574 | *0.000 |
| Group II (ICI) | 79.00 | 0.574 | | *0.000 |
| Group III (Control) | 45.50 | *0.000 | *0.000 | |

* The mean difference is significant at the 0.05 level.

The result in Table 3 indicates that there was no significant difference in the posttest mean scores of students exposed to ICI (X = 84.50) and those exposed to CCI (X = 79.00). It indicates significant difference in the posttest mean scores of students exposed to ICI (X = 79.00) and those exposed to conventional lecture method (45.50). Significant difference was also established in the posttest mean scores of students exposed to CCI (X = 84.50) and those exposed to conventional lecture method (X = 45.50).

**Hypothesis two:** *There is no significant difference in the mean achievement scores of male and female students exposed to cooperative computer instruction.*

To test this hypothesis, t-test statistic was also used to analyze the mean scores. The summary of this analysis is shown in table 4.

*Table 4: t-test analysis on achievement scores of male and female students exposed to CCI*

| **Variable** | **N** | **df** | **Mean ($\bar{x}$)** | **SD** | **t-value** | **p-value** |
|---|---|---|---|---|---|---|
| Male | 10 | | 84.00 | 8.111 | | |
| | | 18 | | | $0.113^{ns}$ | 0.912 |
| Female | 10 | | 85.00 | 8.445 | | |

ns: Not Significant at 0.05 level

Table 4 presents the t-test of male and female students of experimental group I (CCI). The mean scores of the male students were (84.00) and female (85.00) for female. The calculated t-value of 0.113 was not significant at the 0.05 level. This indicates that there is statistically no

significant difference between the male and female students taught with CCI, (t= 0.113,df = 18,P = 0.912). Hence, $HO_2$ was not rejected. Therefore, there is no significant difference between male and female students taught algebra with cooperative computer instructional package.

**Hypothesis three:** *There is no significant difference in the mean scores of male and female students exposed to individualized computer instruction.*

To test this hypothesis, t-test statistic was also used to analyze the mean scores. The summary of this analysis is shown on table 5.

*Table 5: t-test analysis on achievement scores of male and female students exposed to ICI*

| Variable | N | df | Mean ($\overline{X}$) | SD | t-value | p-value |
|---|---|---|---|---|---|---|
| Male | 10 | | 78.00 | 17.512 | | |
| | | 18 | | | 0.259 | $0.798^{ns}$ |
| Female | 10 | | 80.00 | 16.997 | | |

ns: Not Significant at 0.05 level

Table 5 presents the t-test of male and female students of experimental group II (ICI). The mean scores of the male students were (78.00) and (80.00) for the female students. The calculated t-value of 0.259 was not significant at the 0.05 level. This indicates that there is statistically no significant difference between the male and female students taught with ICI, (t= 0.259,df = 18, p = 0.798). Hence, $Ho_3$ was upheld. Therefore, there is no significant difference between male and female students taught with individualized computer instructional package.

## DISCUSSION

The results of the analysis of ANOVA on the performance of students taught Algebra using CCI, ICI and those taught using conventional method of instruction indicate a significant difference in favor of the students taught with CCI and ICI. The students exposed to CCI and ICI performed better than those exposed to conventional method of instruction respectively. The findings agree with Yusuf, Gambari and Olumorin (2012), Yusuf and Afolabi (2010), Fajola (2000) and Dalton, Hannafin and Hooper (1989) that students taught with cooperative computer-assisted Instruction in physics, biology, and mathematics respectively performed better than those taught with individualized computer-assisted instruction. The result also indicates that those taught with CAI in individualized instruction outperformed those taught using conventional teaching method. The finding agree with the findings of (Basturk, 2005), (Akour,

2006), Anyamene, Nwokolo, Anyachebelu, and Anemelu (2012), Bayturan and Keşan (2012), Pilli & Aksu (2013) found that students taught mathematics using CAI package performed better than those taught using the conventional method of instruction.

**The influence of gender on the academic performance of student**

The results of analysis of t-test on the performance of male and female taught using CCI and ICI indicate no significant difference. The finding agrees or disagrees with the findings of Viann (2004) reported that females achieved slightly higher grades than males. Contrarily, Kolawole (2007) found boys performed better than girls in both cooperative and competitive learning strategies in mathematics. Similarly, Aguele and Uhumniah (2008) and Croxford (2002), found, that male students achieved significantly better than female students in science education. Furthermore, this study agrees with the findings of Fajola (2000), Gambari (2010), Garduno (2001) and Yusuf and Afolabi (2010), Yusuf, Gambari and Olumorin (2012) reported that gender had no effect on academic performance of students in computer-assisted cooperative learning. Thus, this shows that computer- assisted instruction enhanced the performance of both male and female students.

## CONCLUSION

The paper has critically examined mathematics and its problems especially within the secondary school level in a rapidly changing world. There is still a wide gap to be bridged in the area of teaching and learning using innovative technology such as CAI in cooperative and individualized environments. The use of computer-assisted instruction in either cooperative or individualized settings seems to be the answer. CCI and ICI were more effective in teaching the mathematical concepts of Algebra and are also gender friendly.

**Recommendations**

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

(i) Since the findings of this study showed that students who worked on the computer cooperatively and individually performed better than those taught using conventional teaching method, teachers should be encourage to employ cooperative computer to improve students' performance in Algebra. In addition, the use of CCI is cost effective

because few computers can accommodate many students. A class of 30 would not need only ten computers systems for instructional needs.

(ii) Further empirical studies should be carried out on the use of CCI for instructional purposes on different subjects and at different levels to provide sound basis for the integration of computer in Nigerian schools.

(iii) Science teachers should be trained on the effective use of computer for individualized and cooperative instruction through seminars, workshops and conferences.

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