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ABSTRACT

This study investigated the relative effectiveness of computer-supported cooperative learning strategies on the performance, attitudes, and retention of secondary school students in physics. A purposive sampling technique was used to select four senior secondary schools from Minna, Nigeria. The students were allocated to one of four groups: Students Team Achievement Division (STAD), Jigsaw II, Team-Assisted Individualisation (TAI), or Individualised Computer Instruction (ICI). Computer-Assisted Learning Package (CALP) on physics was used as the treatment instrument and the Physics Achievement Test (PAT) and Physics Attitude Scale (PAS) were used as outcome measures. Analysis of Covariance and the Scheffe post-hoc test were used for data analysis. Some significant differences were found in the performance and attitudes of the groups, though cooperative learning strategies did not improve retention compared to ICI. These findings support the integration of computer-supported cooperative instructional strategies in secondary school classrooms.

INTRODUCTION

Physics is one of the science subjects taught at the senior secondary school level of the Nigeria educational system. After the Junior Secondary School class three (JSS III) examination, all qualified science students are compulsorily enrolled to study physics at senior secondary school level. The Federal Republic of Nigeria (FRN, 2013) stated in its National Policy on Education that physics can be taken as one of the "core" science subjects (i.e., one of biology, chemistry, physics, or health science), as one vocational elective, and as two non-vocational elective subjects.

Physics education is aimed at training students to acquire proper understanding of basic principles as well as their applications. It is also aimed at developing appropriate scientific skills and attitudes as a pre-requisite for future scientific activities. To achieve these objectives, active participation and collaborative learning activities become imperative and these need functioning instructional media to make physics instruction effective (Ogunleye, 2000; Onwioduokit, 2000)

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Olarinoye (2000) stressed that physics education is a pre-requisite for a country like Nigeria, which is still struggling to join a world where science and technology has become a way of life. According to him physics plays the following roles, among others:

1) It generates openness to new ideas in a world of rapid changes;
2) it illustrates the cumulative character of scientific thought; and
3) it identifies and arrives at solutions to problems.

The significance of physics in all fields of science and technology has therefore made it imperative to be included in the curriculum of senior secondary school and to be offered to science oriented students. To build a strong technological foundation, physics education needs to be given more attention and priority in the Nigerian educational system. Unfortunately, in spite of the importance of physics as a requirement for many specialised science and engineering courses at universities, students' performance at the secondary school level in the subject is not encouraging.

The percentage of students that passed physics in senior school certificate examination at credit level and above (A1–C6) was consistently less than 50% for the past 10 years (2003–2012) in Nigeria. In spite of the importance of physics to society and government's efforts to improve science instruction in schools, students' performance is still poor and below average compared to other sciences, such as biology, chemistry, and agriculture. This has become a great concern to physics educators in Nigeria (West African Examination Council, 2014).

The persistent poor performance in physics, if not checked, may jeopardise the placement chances of students in tertiary institutions, not only in physics education but also in other physics-related disciplines. This has serious implications for national development, security, economy, and manpower for a country with a vision of becoming one of the twenty leading nations in science and technology by the year 2020 (Yar'adua, 2008).

Many researchers have attempted to find out the causes of students' poor performance in physics. Problems identified include: poor instructional strategies (Adegoke, 2010), the abstract nature of physics concepts (Shehu, 2006), a lack of qualified teachers (Biodun, 2004; Besong & Obo, 2003), poor infrastructure and inadequate laboratory facilities (Shawl, 2003), teacher-centred instruction (Okeke, 2001), and poor availability and utilisation of instructional materials (Gambari & Gana, 2005; Yusuf, 2005).

In order to achieve the objectives of physics education at the senior secondary school (SSS) level, the guided-discovery method, student-activity-based, and inquiry-oriented mode of teaching strategies were recommended (FRN, 2013). Ivowi and Oladokun (2001) recommended an activity-oriented approach to the teaching of physics that has emphasis on skill acquisition and broad based principles and concepts. Students' achievement in physics can be improved with the use of cooperative learning strategies.

Cooperative learning can provide an instructional arrangement within which students can experience and practice many of the important skills inherent in the physics curriculum. It can also provide a basic philosophical orientation from which individuals can work to improve life for themselves and those around them (Millis & Cottell, 1998).

In a cooperative setting, students work together to attain group goals that cannot be obtained by working individually or by working competitively. In such classroom structure, students discuss subject matter, help each other learn, and provide encouragement for members of the group (Johnson, Johnson, & Holubec, 1994). Cooperative learning has been widely researched and used in classrooms around the world since the 1970s. Research has proven that this methodology has been very effective in encouraging student interaction, developing positive attitudes toward better learning, and producing positive effects on student achievement (Adesoji & Ibraheem, 2009; Lai & Wu, 2006; Mattingly, VanSickle, & Ronald, 2007; Moreno, 2009; Simsek, 2013; Somsook & Coll, 2008). The most practiced strategies include Students Team Achievement Division (STAD), Team Games Tournament (TGT), Jigsaw II, Learning Together (LT), Group Investigation (GI), Team-Assisted Individualisation (TAI), and many others. In this study, STAD, Jigsaw II, and TAI were used.

In STAD strategy, students are assigned to a heterogeneous group that consists of three members that are mixed in performance level and gender. The computer presents a lesson and then students work within their teams to make sure that all team members have mastered the lesson. Students take a group quiz during which they reach consensus in decision making. They also take individual quizzes on the material without helping one another. Students' scores are then summed to form team scores. Teams that meet certain criteria earn certificates or other rewards (Slavin, 1986).

In Jigsaw II cooperative instructional strategy, students are assigned to three member teams to work on academic materials. Initially all students are assigned to study and understand the basic concepts of the materials. Later, each student is given a section/topic on which to become an expert. Students with the same section/topic meet in expert groups to discuss their topic, after which they return to their original teams to teach what they have learnt to their teammates. Then students take group and individual quizzes that result in a team score based on the improvement score system (Slavin, 1986).

The Team-Assisted Instruction (TAI) strategy combines cooperative learning with individualised instruction. In TAI, students are assigned into a three-member heterogeneous group. Each team member is placed on a stand-alone computer and learns the materials individually and proceeds at their own pace. Teammates check each other's work against answer sheets and help each other with any problems. Finally, individual and group unit tests are taken and scored by the teacher. Each week, teachers total the number of units completed by all team members and give certificates or other team rewards to the best team (Slavin, 1985; Slavin, Leavey, & Madden, 1986).

The use of a computer as a medium for cooperative learning is referred to as computer-supported cooperative learning and it has been embraced in developed nations (Hooper, 1992; Hooper, Temiyakan, & Williams, 1993; Johnson, Johnson, & Stanne, 1996; Mevarech, 1993; Xin, 1996). Students using computers for learning in groups have been found to perform better than students using the same program individually (Yusuf & Afolabi, 2010). It is also cost effective to have students learn in a small group with a single computer rather than allocating a computer to each student.

Numerous studies have found that a computer-supported STAD cooperative learning setting is effective at improving students' achievements, encouraging students' interaction, and developing their positive attitudes towards learning outcomes in various subjects. For instance, Pandian (2004), Taiwo (2008), and Yusuf, Gambari, and Olumorin (2012) reported that students in a cooperative computer-assisted instruction group outperformed their counterparts who learned the same concepts using individualised computer instruction. Fajola (2000) and Yusuf and Afolabi (2010) found that the performance of students exposed to CAI either individually or cooperatively were better than their counterparts exposed to the conventional classroom instruction, However, Armstrong and Palmer (1998) and Glassman (1989) found no significant difference in the achievement of students taught using STAD and those taught in a conventional classroom.

Several studies revealed that Jigsaw II enhanced performance among students in physics. For instance, Gambari (2010) and Berger and Hänze (2009) reported that Jigsaw II was considerably more effective than an individualistic instructional strategy. Keramati's (2010) findings indicated that the performance of students taught in a cooperative learning setting was significantly better than those taught using a conventional teaching method. However, Hänze and Berger, (2007), Mattingly et al. (2007), and Shaaban (2006) found no significant difference in the achievement of students taught physics using Jigsaw and those taught in a conventional classroom.

TAI was also found to be effective at enhancing mathematics achievement. For example, Tarim and Akdeniz (2007) and Gupta and Pasrija (2011) found a TAI cooperative learning strategy to be superior to more traditional methods of teaching, both in terms of achievement and retention. In a study on computer-supported TAI cooperative learning, Xin (1996) found an improvement in students' achievement and positive attitudes toward mathematics. Similarly, Slavin and Karweit (1984) found that students in a TAI group performed better in mathematics computation than the students in a control group. However, Karper and Melnick (1993) found no significant differences between students taught mathematics using TAI and those taught with conventional methods.

Retention is the ability to reproduce a learnt concept when the need arises. Appropriate instructional media may serve to increase retention (Osemwinyen, 2009). However, Moreno (2009) found no difference in botany students' retention between the Jigsaw cooperative learning approach and a traditional method. Majoka, Dad, and Mahmood (2010), Zakaria, Chin, and Daud (2010), and Gupta and Pasrija (2011) revealed the encouraging effects of co-operative learning (STAD) on students' achievement, retention, and attitudes towards mathematics. Salend and Washin (1988) reported that TAI increased students' on-task and cooperative behaviours and increased students' liking of their classmates when compared to working independently. Similarly, Slavin (1984b) found that the TAI approach had positive effects on mathematics achievement, behavioural ratings, and students' attitudes. Slavin (1984a) found that TAI improved social and academic behaviour and increased mathematics achievement more so than traditional methods. However, Rosini and Jim (1997) reported no significant difference in the achievement, retention, and attitudes of those taught home economics using a cooperative learning strategy and those taught with traditional methods.

According to Adegoke (2011), students perform better when they develop a positive attitude towards a course. Cooperative learning helps people to develop positive attitudes toward learning and to think independently inside and outside of the classroom (Ajaja & Eravwoke, 2010). Studies have proven that cooperative learning settings have been very effective in encouraging student interaction and developing positive attitudes towards learning (Artut & Tarim, 2007; Gomleksiz, 2007; Lai & Wu, 2006; Moreno, 2009). Zakaria, Solfitri, Daud, and Abidin (2013) revealed that the percentage of students who prefer cooperative learning is higher than the percentage of students who do not like cooperative learning. However, Arra, D'Antonio, and D'Antonio (2011) reported that some students preferred not to work in groups, meaning that cooperative learning is not for everyone.

Research on cooperative learning strategies in Nigeria is scant. Furthermore, existing studies on cooperative learning are limited to students' academic achievement. Empirical evidence for the effect of cooperative learning strategies on student retention and attitudes towards the course before and after the experiment appears to be limited. Therefore, this study examines the effects of computer-supported cooperative learning strategies (STAD, Jigsaw II, and TAI) on Nigerian senior secondary students' achievement, attitudes, and retention in physics.

RESEARCH HYPOTHESES

The following null hypotheses were tested in the study.

1) There are no significant differences in the post-test performance of students taught physics using computer-supported STAD, Jigsaw II, and TAI cooperative settings.
2) There are no significant differences in the delayed post-test performance of students taught physics using computer-supported STAD, Jigsaw II, and TAI cooperative settings.
3) There are no significant differences in the post-test attitudes of students taught physics using computer-supported STAD, Jigsaw II, and TAI cooperative settings.

METHODOLOGY

The design is a quasi-experimental study using a non-randomised, non-equivalent, pre-test, post-test, control group design. The participants were 167 second year physics students from four intact classes from four different senior secondary schools in Minna, Niger State, Nigeria. The schools were purposively sampled based on five criteria: (i) equivalence (laboratories, facilities, and manpower), (ii) school ownership (public schools), (iii) gender composition (mixed schools), (iv) ICT facilities (computer laboratories under the SchoolNet program), and (v) candidates' enrolment (Senior Secondary School Certificate in Education in physics for a minimum of ten years). The schools were randomly assigned to experimental groups I, II and III (computer-supported Jigsaw II, STAD, & TAI) and control (Individualized Computer Instruction, ICI) groups using a simple random sampling technique. The experimental group I (n = 46) was taught using a computer-supported STAD cooperative learning strategy; the experimental group II (n = 42) was taught through a computer-supported Jigsaw II cooperative learning strategy; and the experimental group III (n = 41) was exposed to a computer-supported TAI cooperative learning strategy. The control group (n = 38) was taught using ICI over six weeks. The data was collected through the Physics Achievement Test (PAT) and the Physics Attitude Scale (PAS). CALP (Computer Assisted Learning Package) was used as a treatment instrument.

Instruments

(i) *Physics Achievement Test (PAT)* consists of 100 multiple-choice questions, adopted from a past examination of the West African Examination Council (WAEC, 2008) and the National Examination Council (NECO, 2007). The questions in the test were based on the content of the Computer Assisted Learning Package (CALP). Each of the stems of the PAT had five options (A–E) as possible answers to the question, and each question was worth one point. The instrument (PAT) was administered to the experimental and control groups as pre-test, post-test, and delayed post-test after it had been reshuffled. Test items were validated by experts before the test was administered to 40 randomly selected Senior Secondary class II (SS II) students who were not involved in the study. A reliability coefficient of 0.90 was obtained using Kuder Richardson (*KR20*).

(ii) *Physics Attitude Scale (PAS)* was developed by the researchers to measure the students' attitudes towards physics before and after exposure to computer-supported STAD, Jigsaw II, or TAI cooperative learning strategies. Section A of the PAS focused on demographic information of physics students while section B focused on students' attitudes towards the physics subject. This section contained a 20 item four-point response mode of Strongly Agree (coded 4), Agree (coded 3), Disagree (coded 2) and Strongly Disagree (coded 1). The initial draft of 25 items of PAS was reviewed by experts. The feedback obtained from this first administration was used to revise the final instrument. It was also administered to students drawn from a school outside the sampled schools to measure its reliability. A reliability coefficient of 0.86 was obtained using Kuder Richardson (*KR20*). A total of 129 copies of the questionnaire were distributed to physics students before and after the commencement of the study and a 100% return rate was achieved and used for data analysis.

(iii) *Computer Assisted Learning Package (CALP)* was the treatment instrument, used at two different instructional settings (cooperative and individualised). The CALP was developed by the researchers and a programmer using "Macromedia Dreamweaver 8" as the overall platform. Other computer programs and applications that were also utilised during the development process were Microsoft Word, Macromedia Fireworks 8, and Macromedia Flash 8. Macromedia Fireworks was used for specific texts, graphics, and buttons, while Macromedia Flash was used for simulation. The package was face and content validated by computer programmers and educational technology experts, subject content (physics) specialists, and by 40 sampled students from a school within the population who did not partake in the study. The package contained two topics that were subdivided into sixteen lessons. The main menu of the package consisted of introduction, student registration, list of lessons (as in lesson 1, 2, 3, 4, …

16), and exit. It adopted the drill and practice modes of Computer Assisted Instruction (CAI).

Experimental procedure

In collecting the data for this research, the objectives and the modalities of the study were specified and an operational guide was produced before the commencement of the treatment. Physics teachers in the experimental group were trained in the use of computer-assisted learning packages and cooperative learning strategies while the teacher in the control group was trained on how to coordinate individualised computer instruction using the CALP. The treatment period for all groups covered six weeks (2 hr 40 min per week). The students in the experimental groups were heterogeneously divided into groups with three members each.

At the beginning of the study, PAT and PAS were administered to students in the sampled schools as a pre-test. The CALP was installed on standalone computer systems in all the selected schools. The physics content was presented via the computer and the students interacted and responded to the computer prompts. The computer presented information and displayed animations to the students on each of the units after which the students attempted some multiple-choice questions. The students could only proceed in a lesson on the condition that the questions were satisfactorily answered. The students had to have at least 100% mastery of one topic before moving on to the next. If after three attempts they did not get the answer correctly, the package would immediately log them out and the instructor had to be called before they could continue through another log-in. During the study, the experimental groups were exposed to the use of computer-assisted cooperative learning strategies (Jigsaw II, STAD, & TAI) as treatment, while students in the control group were individually exposed to the ICI package. Immediately after the treatment, PAT and PAS were administered as post-test, and after four weeks, PAT was re-administered as a delayed post-test.

Procedures for each strategy

(i) *The computer-supported STAD cooperative learning strategy*: In this method, students were assigned to a three-member heterogeneous group. Each member was assigned different responsibilities (e.g., group leader, time-keeper, scribe, and quiet captain, who controlled the discussion). The groups were exposed to a CALP where members completed the reading of the materials and performed the tasks together. To ascertain that there was no free rider, students were given an individual task that was marked and recorded against group scores. After the completion of a lesson, students took a quiz as a team and reached consensus with respect to the correct answers after which one answer sheet was submitted by the team for which all team members received the same "team score." The scoring was done based on an individual quiz score and a team quiz score, which counted equally towards the student's final course grade. High scoring teams were recognised and rewarded in the class. The best team was recognised by (i) putting their names on the notice board and (ii) clapping for them in the class, among other methods. They were also rewarded with a "Merit Award Certificate" and stationery, among other gifts items. A group processing form was completed after each lesson to determine the group's behaviour and to correct any irregularity within the teammates.

(ii) *The computer-supported Jigsaw II cooperative learning strategy*: In this strategy, students were divided into small heterogeneous groups called home groups, with three members in each group. Each member was assigned different responsibilities. Initially all students were assigned to study and understand the basic concepts of the materials. After this process, the researcher divided the content (the tasks) of the lesson into three and assigned it to each member in the home group. The students met in their home groups and studied the assigned tasks using a CALP. Each member in the home group attempted to learn the assigned task as an expert by referring to the computer package and the available resources. After completing the learning task in the home group, each member moved into the expert group (Jigsaw II group) consisting of members from the other home groups who had been assigned the same portion of the material (task). In the Jigsaw II group (expert group), the participants discussed and shared their particular materials with other members of the group and discussed how to teach it to their members in the home group. The team members then returned to their home groups where they taught what they learned from the Jigsaw group to the other members of their groups. In case of any difficulty and misconception, the expert group conducted a second meeting to discuss and clarify any doubts. After the second round of discussion, the experts returned to their home groups to re-teach the members and reach a consensus. The group processing and scoring method was the same as the STAD condition. High scoring teams were recognised and rewarded in the class.

(iii) *The computer-supported TAI cooperative learning strategy*: This was originally designed for teaching mathematics, but in this study it was adopted for physics since both have many things in common. In this strategy, students were divided into three member heterogeneous groups. Each student was assigned a stand-alone computer on an individual basis and then proceeded at his/her own pace. In other words, team members studied the same concept independently but moved around to seek assistance from team members, check each other's work on worksheets, and help one another to understand the concepts and solve the problems. An individual quiz was given to team members but the final unit test was taken without help from group members and scored by the researchers. The scores obtained by individual and group tests were summed and the average found. Certificates or other team rewards were given to the best team.

(iv) *Individualised Computer Instruction method*: This was used for the control group. In this method, students were taught the physics concepts using the CALP only. The computer presented the instruction on a human-to-computer basis. Students proceeded with the physics content and studied at their own rate without any assistance from their colleagues. Students answered the PAT test at the pre-test and post-test individually.

RESULTS

To test the hypotheses, the data were analysed using Analysis of Covariance (ANCOVA) 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.

Null Hypothesis One

Null hypothesis one can be stated as follows: There is no significant difference in the post-test performance of secondary school students taught physics using computer-supported STAD, Jigsaw II, and TAI in cooperative settings and those taught using individualised computer instruction.

To determine whether there were significant differences in the post-test mean scores of the computer supported STAD, Jigsaw II, TAI, and ICI groups, data were analysed using an analysis of covariance (ANCOVA). There was a significant main effect of learning strategy on post-test performance, F (3, 162) = 8.947, $p < 0.001$. This indicates that the method of instruction produced a significant effect on the post-test performance scores of students when the covariate effect (pre-test) was controlled. The result indicates that the treatment, using STAD, Jigsaw II, TAI, and ICI accounted for the difference in the post-test performance scores of the students. Based on the established significant difference in the post-test performance scores of the groups, Scheffe's test was used for post-hoc analysis to determine the direction of the difference. The results of this post-hoc analysis are as shown in Table 1.

The results in Table 1 indicate that there was no significant difference in the post-test mean scores of students exposed to STAD ($\bar{X}$ = 65.43) and those exposed to Jigsaw II ($\bar{X}$ = 68.38). A significant difference was not established in the post-test mean scores of students exposed to TAI ($\bar{X}$ = 62.73) and those exposed to ICI ($\bar{X}$ = 61.39). A significant difference was established between Jigsaw II (X = 68.38) and TAI ($\bar{X}$ = 62.73) and between Jigsaw II ($\bar{X}$ = 68.38) and ICI ($\bar{X}$ = 61.39) in favour of Jigsaw II. Student performance was also compared based on the mean gain scores between the pre-test and post-test for each group. The results of this comparison are shown in Table 2 and are graphically illustrated in Figure 1.

Table 1
Scheffe's post-hoc analyses of the groups' mean post-test performance scores

Groups	Mean Scores	Group I (STAD)	Group II (Jigsaw II)	Group III (TAI)	Group IV (ICI)
Group I (STAD)	65.43		0.324	0.408	0.1054
Group II (Jigsaw II)	68.38	0.324		*0.008	*0.001
Group III (TAI)	62.73	0.408	*0.008		0.885
Group IV (ICI)	61.39	0.105	*0.001	0.885	

*The mean difference is significant at 0.05 level.

Table 2
Mean Gain Scores of students' performance in STAD, Jigsaw II, TAI, and ICI groups

Group	Pre-test	Post-test	Mean Gain Score
STAD	20.72	65.43	44.71
Jigsaw II	20.07	68.38	48.31
TAI	21.05	62.73	41.68
ICI	19.82	61.39	41.57

Table 2 shows that Jigsaw II had the highest mean gain score of 48.31, followed by STAD with a mean gain score of 44.71, TAI with a mean gain score of 41.67, and ICI with a mean gain score of 41.57. This indicates that all the groups benefited from the treatment, with Jigsaw II having the best performance.

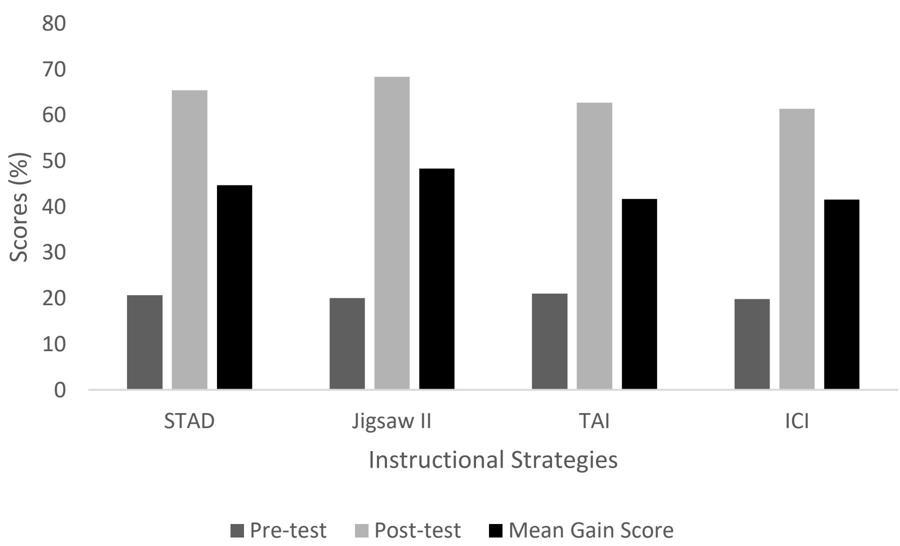

Figure 1. Graphical illustration of students' performance using STAD, Jigsaw II, TAI, and ICI.

Null Hypothesis Two

Null hypothesis two can be stated as follows: There is no significant difference in the delayed post-test performance of students taught physics using computer-supported STAD, Jigsaw II, and TAI in cooperative settings and those taught using individualised computer instruction.

To determine whether there were significant differences in the delayed post-test mean scores of the computer supported STAD, Jigsaw II, and TAI groups, and the ICI control group, data were analysed using an analysis of covariance (ANCOVA). There was a significant main effect of learning strategy on delayed post-test performance, F (3, 162) = 7.689, $p < 0.001$. This indicates that the method of instruction produced a significant effect on the delayed post-test scores of students when the covariate effect (pre-test) was controlled. The result indicates that the treatment, using STAD, Jigsaw II, TAI, and ICI accounted for the difference in the delayed post-test scores of the students. Based on the established significant difference in the delayed post-test scores of the groups, Scheffe's test was used for post-hoc analysis. The results of this post-hoc analysis are shown in Table 3.

The results shown in Table 3 indicate that there was no significant difference in the delayed post-test mean scores of students exposed to STAD ($\bar{X}$ = 60.43) and those exposed to Jigsaw II ($\bar{X}$ = 63.02). There was a significant difference in the delayed post-test mean scores of students exposed to Jigsaw II ($\bar{X}$ = 63.02) and those exposed to TAI ($\bar{X}$ = 57.88) in favour of the Jigsaw II group. A significant difference was not established in the delayed post-test mean scores of students exposed to TAI ($\bar{X}$ = 57.88) and those exposed to ICI ($\bar{X}$ = 56.66). A significant difference was established between Jigsaw II ($\bar{X}$ = 63.02) and ICI ($\bar{X}$ = 56.66) in favour of Jigsaw II.

Table 3
Scheffe's post-hoc results of students' mean delayed post-test scores of STAD, Jigsaw II, TAI, and ICI groups

Groups	Mean Scores	Group I (STAD)	Group II (Jigsaw II)	Group III (TAI)	Group IV (ICI)
Group I (STAD)	60.43		0.425	0.442	0.134
Group II (Jigsaw II)	63.02	0.425		*0.017	*0.002
Group III (TAI)	57.88	0.442	*0.017		0.905
Group IV (ICI)	56.66	0.134	*0.002	0.905	

* The mean difference is significant at 0.05 level

In order to examine retention, the performance of students in the four groups was further compared based on the mean loss scores between the post-test and delayed post-test for each group. The results are shown in Table 4 and graphically illustrated in Figure 2.

Table 4 shows a decrease in delayed post-test scores of the four groups as compared to post-test scores. Jigsaw II had the highest decrease in the form of a mean loss score of 5.36, followed by STAD with a mean loss score of 5.00, TAI with a mean loss score of 4.85, and ICI with a mean loss score of 4.73. This indicates that all the groups still largely retained the physics concepts, but cooperative groups did not outperform the ICI group on retention.

Table 4
Mean loss scores between post-test and delayed post-test for STAD, Jigsaw II, TAI and ICI groups

Group	Post-test	Retention-test	Mean Loss Score
STAD	65.43	60.43	5.00
Jigsaw II	68.38	63.02	5.36
TAI	62.73	57.88	4.85
ICI	61.39	56.66	4.73

Figure 2. Graphical illustration of mean loss scores between post-test and delayed post-test for STAD, Jigsaw II, TAI, and ICI groups.

Null Hypothesis Three

Null hypothesis three can be stated as follows: There is no significant difference in the post-test attitudes of secondary school students taught physics using computer-supported STAD, Jigsaw II, and TAI in cooperative settings and those taught using individualised computer instruction.

To determine whether there were significant differences in the mean attitude scores of the computer supported STAD, Jigsaw II, TAI groups, and the ICI control group, data were analysed using an analysis of covariance (ANCOVA). There was a significant main effect of learning strategy on students' attitude, F (3, 162) = 12.861, p < 0.001. This indicates that the method of instruction produced a significant effect on the attitude scores of students when the covariate effect (pre-test) was controlled. This result indicates that the treatment, using STAD, Jigsaw II, TAI, and ICI accounted for the difference in the attitude of students. Based on the established significant difference in the attitude scores of the groups, Scheffe's test was used for post-hoc analysis. The results of this post-hoc analysis are shown in Table 5.

As shown in Table 5, there was no significant difference in the mean attitude scores of students exposed to STAD ($\bar{X}$ = 58.43) and those exposed to Jigsaw II ($\bar{X}$ = 60.12). There was also no significant difference in the mean attitude scores of students exposed to Jigsaw II ($\bar{X}$= 60.176) and those exposed to TAI ($\bar{X}$ = 63.48). A significant difference was established in the mean attitude scores of students exposed to TAI ($\bar{X}$ = 63.45) and those exposed to ICI ($\bar{X}$ = 51.42) in favour of the TAI group. A significant difference was also established between STAD ($\bar{X}$ = 58.43) and ICI ($\bar{X}$ = 51.42) and between Jigsaw II ($\bar{X}$ = 60.12) and ICI ($\bar{X}$ = 51.42) in favour of STAD and Jigsaw II respectively.

The attitude of students in the four groups was further compared based on the mean gain scores between the pre- and post-attitude test for each group.

The results of this comparison are shown in Table 6 and graphically illustrated in Figure 3.

Table 5
Scheffe's post-hoc results of students' mean post-test attitude scores of STAD, Jigsaw II and ICI groups

Groups	Mean Scores	Group I (STAD)	Group II (Jigsaw II)	Group III (TAI)	Group IV (ICI)
Group I (STAD)	58.43		0.868	0.119	*0.014
Group II (Jigsaw II)	60.18	0.868		0.491	*0.001
Group III (TAI)	63.48	0.119	0.491		*0.000
Group IV (ICI)	51.42	*0.014	*0.001	*0.000	

*The mean difference is significant at 0.05 level

Table 6 shows that the groups had improved performance in post-attitude test. Jigsaw II had the highest mean gain score of 27.84, follow by STAD with a mean gain score of 28.13, TAI with a mean gain score of 29.93, and ICI with a mean gain score of 16.24. This indicates that students in cooperative learning groups developed more positive attitudes towards physics after the treatment than those in the control group.

Table 6
Mean attitude gain scores of students in STAD, Jigsaw II, TAI and ICI groups

Group	Pre-test	Post-test	Mean Gain Score
STAD	30.59	58.43	27.84
Jigsaw II	32.05	60.18	28.13
TAI	33.55	63.48	29.93
ICI	35.18	51.42	16.24

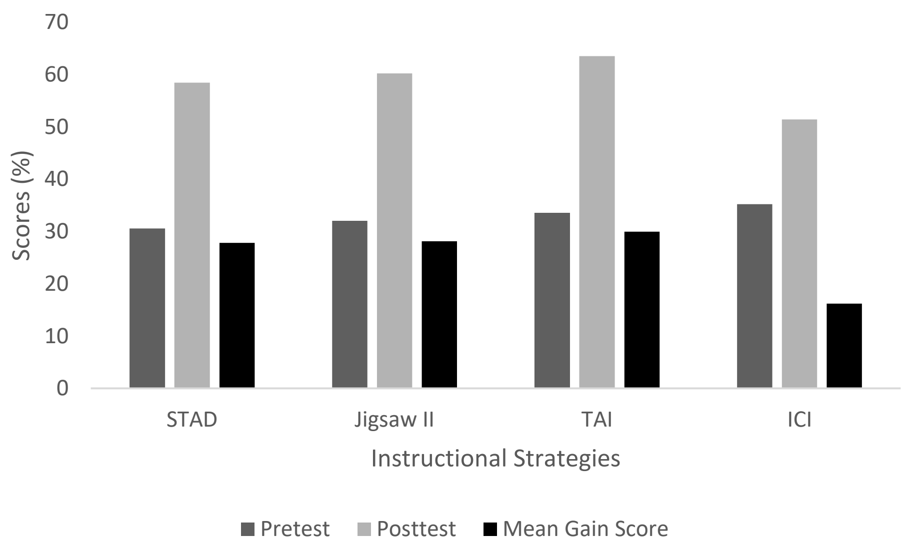

Figure 3. Graphical illustration of students' mean attitude gain scores of STAD, Jigsaw II, TAI, and ICI groups.

DISCUSSION OF FINDINGS

The results of hypothesis one revealed a significant difference between the performance of students in Jigsaw II and TAI cooperative learning strategies in favour of Jigsaw II. It also revealed a significant difference between the performance of students in Jigsaw II cooperative learning strategy and ICI in favour of Jigsaw II. The findings on students' performance in the Jigsaw II group compared to those taught using ICI are in line with the earlier findings of Fajola (2000) and Keramati (2010) who found that students taught biology and physics respectively using cooperative learning strategies performed better than those taught with conventional teaching methods. This also agrees with the findings of Yusuf and Afolabi (2010) in biology who reported that students taught using a computer-assisted cooperative learning strategy performed better than those taught using computer-assisted instruction in individualised settings. Furthermore, the findings are consistent with the findings of Lai and Wu (2006) in nursing education, Moreno (2009) in botany, and Doymus (2008) in chemistry who found that Jigsaw II was more effective than other cooperative instructional strategies. However, the finding that Jigsaw II outperformed TAI contradicts Tarim and Akdeniz's (2007) study where TAI performed better than STAD.

The difference between Jigsaw II from other cooperative learning strategies may stem from the fact that Jigsaw II is a task structured (task specialisation) and incentive structured (group rewards for individual learning, group reward for group product, and individual rewards) cooperative strategy. It produces a positive outcome when properly implemented. We observed that the Jigsaw II instructional strategy provides no room for free riders; each member of the group must do all or most of the work (Dingel, Wei, & Huq, 2013).

In relation to retention, we found that cooperative learning strategies did not increase retention compared to ICI. Our findings contrast with the findings of Salend and Washin (1988) and Slavin (1984a, 1984b) who found that the TAI approach had positive effects on mathematics achievement, behavioural ratings, and student attitudes. However, Rosini and Jim (1997) reported no significant difference in the achievement, retention, and attitude of those taught home economics using a cooperative learning strategy and those taught with a traditional method. Similarly, Moreno (2009) found no difference in botany students' retention between the Jigsaw cooperative learning approach and a traditional method.

In relation to hypothesis three, we found significant differences in the students' attitude between cooperative learning strategies (STAD, Jigsaw II, and TAI) and ICI in favour of cooperative learning strategies. The most positive change in attitude toward physics was observed in the TAI group, followed by the Jigsaw II and STAD groups. This result aligns with the findings of Artut and Tarim (2007), Gomleksiz (2007), Lai and Wu (2006), Moreno (2009), and Zakaria et al. (2013) who found that students exposed to cooperative learning had more positive attitudes than those taught with traditional methods. However, Arra et al. (2011) reported that some students preferred not to work in groups, meaning that some have negative attitudes towards cooperative learning.

Our findings have strong implications for teaching and learning physics in secondary schools in Nigeria using computer-supported cooperative learning strategies. Our results suggest that computer assisted instruction is better in cooperative learning settings than in an individualised setting. Furthermore, our results suggest that exposing students to a computer supported cooperative learning strategy may improve students' performance in physics as well as their attitude toward the subject.

CONCLUSION

This study has delved into three types of computer-supported cooperative learning strategies (STAD, Jigsaw II, and TAI) as a way to overcome poor performance in physics at the senior secondary school level in Nigeria. All three computer-supported cooperative learning strategies had a positive effect on student attitudes towards physics compared to individualised computer instruction (ICI). However, Jigsaw II was the only computer-supported cooperative learning strategy to have a positive effect on student performance compared to ICI. Furthermore, cooperative learning strategies did not increase retention compared to ICI.

RECOMMENDATIONS

In this digital age, schools and educators are expected to explore technologically enhanced strategies to improve students' performance. Our findings provide some support for the adoption of computer-supported cooperative instructional strategies so as to promote social interaction, active learning, discovery learning, motivation, learning by doing, and learning by experience among students. However, the effective use of computer-supported cooperative learning strategies also depends on the provision of appropriate training for physics teachers through seminars, workshops, and conferences.

REFERENCES

Adegoke, B. A. (2010). Integrating animations, narrations and textual materials for Improving students' learning outcomes in senior secondary school physics. *Electronic Journal of Research in Educational Psychology, 8*(2), 725–748.

Adegoke, B. A. (2011). Effect of multimedia instruction on senior secondary school students' achievement in physics**.** *European Journal of Educational Studies, 3*(3), 537–541.

Adesoji, F. A., & Ibraheem, T. L. (2009). Effects of student teams-achievement divisions strategy and mathematics knowledge on learning outcomes in chemical kinetics. *Journal of International Social Research, 1*(6), 15–25.

Ajaja, O. P., & Eravwoke, O. U. (2010). Effects of cooperative learning strategy on junior secondary school students achievement in integrated science. *Electronic Journal of Science Education, 14*(1). Retrieved from http://ejse.southwestern.edu

Armstrong, S., & Palmer, J. (1998). Student teams achievement division (STAD) in a twelfth grade classroom: Effect on student achievement and attitude. *Journal of Social Studies Research, 22(1),* 3–6.

Arra, C. T., D'Antonio, M. D., & D'Antonio Jr., M. (2011). Students' preferences for cooperative learning instructional approaches: Considerations for college teachers. *Journal of Research in Education, 21,* 114–126.

Artut, P. D., & Tarim, K. (2007). The effectiveness of Jigsaw II on prospective elementary school teachers. *Asia-Pacific Journal of Teacher Education*, *35*(2), 129-141. doi:10.1080/13598660701268551

Berger, R., & Hänze, M. (2009). Comparison of two small group learning methods in 12th grade physics classes focusing on intrinsic motivation and academic performance. *International Journal of Science Education, 31*, 1511–1527. doi:10.1080/09500690802116289

Besong, F. F., & Obo, U. B. (2003). Students’ performance in science, technology and mathematics in the era of globalization. *Education Today, 3*(1) 37–49.

Biodun, K. (2004). *A comparative study of the effect of teacher's qualification and teaching methods on students' achievement in chemistry* (Unpublished PhD Thesis). University of Calabar, Calabar, Nigeria.

Dingel, M. J., Wei, W., & Huq, A. (2013). Cooperative learning and peer evaluation: The effect of free riders on team performance and the relationship between course performance and peer evaluation. *Journal of the Scholarship of Teaching and Learning*, *13*(1), 45–56.

Doymus, K. (2008). Teaching chemical equilibrium with the Jigsaw technique. *Research in Science Education*, *38*(2), 249–260.

Fajola, O. O. (2000). *Effect of three modes of computer based instructional strategies on students’ learning outcomes in biology* (Unpublished Ph.D Thesis). University of Ibadan, Ibadan, Nigeria.

Federal Republic of Nigeria (FRN) (2013). *National policy on education*. Lagos, Nigeria: Federal Government Press.

Gambari, I. A. (2010). *Effect of computer-supported cooperative learning strategies on the performance of senior secondary students in physics, in Minna, Nigeria* (Unpublished PhD Thesis). University of Ilorin, Ilorin, Nigeria.

Gambari, A. I., & Gana, E. S. (2005). The role of instructional media in enhancing teaching and learning of engineering education and training. In *Proceedings of the 6th Annual Engineering Conference of School of Engineering & Engineering Technology, Federal University of Technology (FUT), Minna* (pp. 118–142). Minna, Nigeria: FUT.

Glassman, P. (1989). *A study of cooperative learning in mathematics, writing and reading in the intermediate grades: A focus upon achievement, attitudes, and self-esteem by gender, race, and ability group.* (Unpublished Doctoral Dissertation). Hofstra University, New York, NY.

Gomleksiz, M. N. (2007). Effectiveness of cooperative learning (Jigsaw II) method in teaching English as foreign language to engineering students (Case of Firat University, Turkey). *European Journal of Engineering Education, 32*(5), 613–625.

Gupta, M., & Pasrija, P. (2011). Cooperative learning versus traditional learning: Effect on achievement in mathematics. *New Frontiers in Education, 44*(4), 427–436.

Hänze, M., & Berger, R. (2007). Cooperative learning, motivation effects, students’ characteristics: An experimental study comparing cooperative learning and direct instruction in 12th grade physics classes. *Learning and Instruction, 17*(1), 29–41. doi:10.1016/j.learninstruc.2006.11.004

Hooper, S. (1992). Effects of peer interaction during computer-based mathematics instruction. *Journal of Educational Research, 85*(3), 180–89.

Hooper, S., Temiyakarn, C., & Williams, M. D. (1993). The effects of cooperative learning and learner control on high- and average-ability students. *Journal of Educational Technology Research and Development,* *41*(2), 5–18. doi:10.1007/BF02297309

Ivowi, U. M. O., & Olodokun, J. S. O. (2001). The status of women in physics in Nigeria. In O. O. Busari (Ed.), *Women in science, technology and mathematics education in Nigeria* (pp. 338–343). Ibadan, Nigeria: Heinemann Educational.

Johnson, D. W., Johnson, R. T., & Holubec, E. J. (1994). *Cooperative Learning in the Classroom.* Ann Arbor, MI: Association for Supervision and Curriculum Development.

Johnson, R. T., Johnson, D. W., & Stanne, M. B. (1996). Comparison of computer-assisted cooperative, competitive, and individualistic learning. *American Educational Research Journal, 23*(3), 382–392.

Karper, J., & Melnick, S. A. (1993). The effectiveness of team accelerated instruction on high achievers in mathematics. *Journal of Instruction Psychology, 20*(1)*,* 49-54.

Keramati, M. (2010). Effect of cooperative learning on academic achievement of physics course. *Journal of Computers in Mathematics and Science Teaching, 29*(2), 155–173.

Lai, C. Y., & Wu, C. C. (2006). Using handhelds in a jigsaw cooperative learning environment. *Journal of Computer Assisted Learning*, *22*(4), 284–297. doi:10.1111/j.1365-2729.2006.00176.x

Majoka, M. I., Dad, M. H., & Mahmood, T. (2010). Student team achievement division (STAD) as an active learning strategy: Empirical evidence from mathematics classroom. *Journal of Education and Sociology*, *4*, 16–20.

Mattingly, R. M., VanSickle, R. L., & Ronald, L. (2007). *Cooperative learning and achievement in social studies: Jigsaw II* (US Department of Education Report). Retrieved from ERIC Database (ED348267).

Mevarech, Z. R. (1993). Who benefits from cooperative computer-assisted Instruction? *Journal of Educational Computing Research, 9, 451-64.*

Millis, B. J., & Cottell, Jr., P. G. (1998). *Cooperative learning for higher education faculty*. Phoenix, AZ: American Council on Education and Oryx Press.

NECO (2007). *Past questions and answers for June/July NECO examination from 2000-2007.* Lagos, Nigeria: Johnson Publishers.

Pandian, S. S. (2004). *Cooperative learning in biology: The effect of computers.* Namsai, Indian: Department of Education, Arunachi University.

Moreno, R. (2009). Constructing knowledge with an agent-based instructional program: A comparison of cooperative and individual meaning making. *Learning and Instruction, 19*(5), 433–444. doi:10.1016/j.learninstruc.2009.02.018

Ogunleye, A. O. (2000). Towards the optimal utilization and management of resources for the effective teaching and learning of physics in schools*. In Proceedings of of the 41st Annual Conference of Science Teachers Association of Nigeria (STAN)* (pp. 313–322). Abuja, Nigeria: STAN.

Okeke, E. A. C. (2001). Women in science, technology and mathematics education in Nigeria. In *Proceedings of the 42nd Annual Conference of the Science Teachers Association of Nigeria (STAN)* (pp. 3–11). Abuja, Nigeria: STAN.

Olarinoye, R. D. (2000). Strategies for effective teaching of modern physics. In *Proceedings of the 41st Annual Conference of the Science Teachers Association of Nigeria (STAN)* (pp. 24–29). Abuja, Nigeria: STAN.

Onwioduokit, F. A. (2000). Enriching physics education in Nigeria to cope with the challenges of the present millennium. In *Proceedings of the 41st Annual Conference of the Science Teachers Association of Nigeria (STAN)* (pp. 322 – 333). Abuja, Nigeria: STAN.

Osemwinyen, A. C. (2009). *Effects of e-learning on retention and achievement in secondary school mathematics in Abuja, Nigeria* (Unpublished PhD thesis). University of Nigeria, Nsukka, Nigeria.

Rosini, B. A., & Jim, F. (1997). The effect of cooperative learning methods on achievement, retention, and attitudes of home economics students in North Carolina. *Journal of Vocational and Technical Education, 13*(2), 1–7.

Salend, S. J., & Washin, B. (1988). Team assisted individualization with handicapped adjudicated youth. *Exceptional Children, 55*(2), 74–80. doi:10.1177/001440298805500209

Shaaban, K. (2006). An initial study of the effects of cooperative learning on reading comprehension, vocabulary acquisition, and motivation to read. *Reading Psychology, 27*(5), 377–403. doi:10.1080/02702710600846613

Shawl, A. (2003). An adoption of problem based teaching and problem-based learning to improve the teaching of radioactivity. *Chinese Journal of Elementary Science, 3*(1), 14–18.

Shehu, A. T. (2006). Community resources materials for teaching physics. In Y. Aiyesimi, I. N. Mogbo, G. A. Ololi (Eds.), *Challenges in science and technological advancement and economic reforms: Proceedings of 2nd Annual School of Science & Science Education Conference, Federal University of Technology (FUT), Minna* (pp. 326–331). Minna, Nigeria: FUT.

Simsek, U. (2013). Effects of cooperative learning methods on social studies undergraduate students' achievement in political science. *Energy Education Science and Technology Part B: Social and Educational Studies, 5*(1), 619–632.

Slavin, R. E. (1984a). Combining cooperative learning and individualized instruction: Effect on student mathematics achievement, attitude and behaviours. *Elementary School Journal, 84*(4), 409–422.

Slavin, R. E. (1984b). Students motivating students to excel: Cooperative incentives, cooperative tasks, and student achievement. *The Elementary School Journal*, *85*(1), 53–63.

Slavin, R. E. (1985). Team assisted individualization: Combining cooperative learning and individualized instruction in mathematics. In R. E. Slavin, S. Sharan, S. Kagan, R. Hertz-Lazarowitz, C. Webb, and R. Schmuck (Eds.), *Learning to cooperate, cooperating to learn* (pp. 177–210). New York, NY: Springer.

Slavin, R. E. (1986). *Using student team learning* (3rd ed.). Baltimore, MD: Johns Hopkins University.

Slavin, R. E., & Karweit, N. (1984). Mastery learning and student teams: A factorial experiment in urban general mathematics classes. *American Educational Research Journal*, *21*(4), 725–736. doi:10.302/00028312021004725

Slavin, R. E., Leavey, M. B., &. Madden, N. A. (1986). *Team accelerated instruction mathematics.* Watertown, MA: Mastery Education Corporation.

Somsook, E., & Coll, R. K. (2008). Thai undergraduate chemistry practical learning experiences using the Jigsaw II method. *Journal of Science and Mathematics Education in Southeast Asia, 31*(2), 178–200.

Taiwo, O. A. (2008). *Relative effectiveness of ICI and CCI packages on the performance of students in senior secondary school mathematics in Minna* (Unpublished B.Tech. Project). Department Science Education, Federal University of Technology, Minna, Nigeria.

Tarim, K., & Akdeniz, F. (2007). The effects of cooperative learning on Turkish elementary students' mathematics achievement and attitude towards mathematics using TAI and STAD methods. *Educational Studies in Mathematics, 6*(1), 77-91. doi:10.1007/s10649-007-9088-y.

West African Examination Council (WAEC) (2008). *Past questions and answers for May/June WAEC examination from 1988-2008.* Lagos, Nigeria: Johnson Publishers.

West African Examination Council (WAEC) (2014). *Chief examiner's report.* Lagos, Nigeria: Author.

Xin, F. (1996). *The effects of computer-assisted cooperative learning in mathematics in integrated classrooms for students with and without disabilities.* Rowan College of New Jersey, Special Education Department. Retrieved from ERIC Database (ED412696).

Yar'adua, U. M. (2008). *The presidential speech.* Retrieved January 9, 2009, from http://www.centralbank.org.

Yusuf, M. O. (2005). Integrating information and communication technologies (ICTs) in Nigerian tertiary education. *The African Symposium, 5*(2), 42-50.

Yusuf, M. O., & Afolabi, A. O. (2010). Effects of computer assisted instruction (CAI) on secondary school students' performance in biology. *The Turkish Online Journal of Educational Technology, 9*(1), 62–69.

Yusuf, M. O., Gambari, A. I., & Olumorin, C. O. (2012). Effectiveness of computer-supported cooperative learning strategies in learning physics. *International Journal of Social Sciences and Education, 2*(2), 94–109.

Zakaria, E., Chin, L. C., & Daud, M. Y. (2010). The effects of cooperative learning on students' mathematics achievement and attitude towards mathematics. *Journal of Social Sciences, 6*(2), 272–275.

Zakaria, E., Solfitri, T., Daud, Y., & Abidin, Z. Z. (2013). Effect of cooperative learning on secondary school students' mathematics achievement. *Creative Education, 4*(2), 98–100. doi:10.4236/ce.2013.42014.