Effectiveness of Computer-supported Jigsaw ii Cooperative Learning Strategy on the Performance of Senior Secondary School Students in Physics

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Abstract

This study investigated the effectiveness of computer-supported jigsaw II cooperative learning strategies on the performance of senior secondary students in physics. The study also determined how moderating variables of gender and attitude to physics when Jigsaw II cooperative learning is used as an instructional strategy. Purposive sampling technique was used to select two senior secondary school class II physics students from four intact classes in Minna, Niger State, Nigeria. 80 students from two intact classes were assigned into Jigsaw II and Individualized Computer Instruction (ICI) groups. Computer-Assisted Learning Package (CALP) on physics and Physics Achievement Test (PAT) were used as treatment and test instruments. Analysis of Covariance and Scheffe's test were used for data analysis. Findings indicated that students taught physics using computer-supported Jigsaw II performed better than those taught using individualized computer instruction. In addition, students exposed to Jigsaw II cooperative learning strategy had positive attitude to physics than those taught with ICI. However, students' gender had no influence on their performance. Based on the findings, it was recommended among other physics teachers should be encouraged to use computer-supported cooperative instructional strategy to improve students' cognitive and affective outcomes.

Key words: *Jigsaw II, Computer, Cooperative Learning, Performance, Physics, Attitude*

Introduction

Physics is one of the core science subjects in Nigeria educational system offered at senior secondary school level. Its importance in modern technological development of any nation made it imperative for its inclusion in the curriculum for science oriented students (FRN, 2004). In spite of the importance of physics as a requirement for many specialized science and engineering courses at the tertiary educational institutions, students' performance at the Senior Secondary Certificate Examinations (SSCE) in Nigeria has been poor. The percentage of students that passed physics at credit level has consistently being less than 50% for the past ten years (West African Examination Council [WAEC] Report, 2012).

Adegoke (2011) reported that students are not actively involved in developing knowledge; they receive information passively and are less motivated. The instructional method employed by the teacher plays an important role in the acquisition of skills and meaningful learning. However, the lecture method uses by teachers have been criticized because only hardworking students can benefit from it. The poor performance of students in physics can be improved with innovative teaching and learning methods integrated with technology and elements of problem solving (Gambari, 2010).

Computer has been found to be effective device for classroom instruction using different software (Gambari & Mogbo, 2006; Tekos & Solomonidou, 2009; Yusuf & Afolabi, 2010). Computer-Assisted Instruction (CAI) is designed normally for individual learning, but it has been found to be more effective with cooperative learning than individualized instruction (Johnson & Johnson, 2008). The use of computer as a medium for cooperative

learning is referred to as computer-supported cooperative learning and it has been embraced in developed nations (Johnson & Johnson, 2008, Johnson, Johnson & Stanne, 1996; & Schmidt, 2002).

Cooperative learning is an instructional strategy whereby students are encouraged to work together on learning tasks (Slavin, 1995). In cooperative learning, students work face to face to complete a given task collectively. Cooperative learning setting encourages students to work together to attain group goals, instead of working individually or competitively (Zakaria & Iksan, 2007). Students discuss subject matter, help each other learn, and provide encouragement for members of the group. Positive interdependence where each student must believe that they have a key role to play in the group; individual accountability where each student within a group must be accountable for mastery of the instructional content presented; group rewards that entails sufficient incentives for the group to work together; and group training that entails social skills for effective collaboration among others the key elements of cooperative learning (Johnson & Johnson, 2000; Slavin, 1995). Therefore, to enhance the understanding of physics concepts, students must be more active in the classroom and must creatively acquire knowledge, especially in understanding and solving physics problems. According to Zakaria, Solfitri, Daud & Abidin (2013) students should be given the opportunities to develop, interact, and share with friends through cooperative learning activity, so that the cognitive and affective development of students in science can be improved.

There are many cooperative learning strategies that are designed to achieve different objectives. This study focused on Jigsaw II cooperative learning strategy. There are four types of Jigsaw strategies currently in use but Jigsaw II had received attention and widely used for effective classroom instruction (Zakaria, Solfitri, Daud & Abidin, 2013). Jigsaw II requires students to work in group of five to six members. Each student in a group is given information to which no one else in the group has access, thus making each student an "expert" on his or her section of the subject matter. Members of different teams who have studied the same sections meet in "expert groups" to discuss their sections and learn how to teach their colleagues in home group. Then the students return to their original teams and take turn to teach their teammates what they have learnt. All students in a group are expected to learn all the subject matter assigned to each member of their group. After instruction in Jigsaw II, teachers test students individually and produce team scores based on each student's test performance.

Several studies revealed that Jigsaw II enhanced better performance among students in physics (Gambari, 2010; Berger & Hanze, 2009; Hanze & Berger, 2007; Keramati, 2010; Yusuf, Gambari and Olumorin, 2012), in biology (Altiparmak & Nakiboglu-Tezer, 2009), in chemistry (Mattinly, VanSickle & Ronald, 2009), in geography (Doymus, 2008; Jansoon, Somsook & Coll, 2008), in biology (Moreno, 2009), in mathematics Zakaria, Solfitri, Daud & Abidin, 2013) reported that Jigsaw II is considerably more effective than individualistic instructional strategy and conventional classroom instruction respectively. However, Shaaban (2006), Seaborn and Wilson (2002) and Thompson and Pledger (1998) found no significant difference in the achievement of students taught using Jigsaw II and those taught using conventional classroom and discussion methods respectively. The findings on the use of Jigsaw cooperative learning are inconclusive; therefore, this study examined the effects of computer-supported Jigsaw II on students' performance in physics.

Attitudes and values provide the framework for guiding our actions outside the classroom. In helping learners acquire from the basic cooperative attitudes and values they need to think independently inside and outside of the classroom (Ajaja & Eravwoke, 2010). Studies have proven that cooperative learning setting has been very effective in encouraging students' interaction and developing positive attitudes towards learning (Artut & Tarim, 2007;

Gomleksiz, 2007; Lai & Wu, 2006; Moreno, 2009). Zakaria, Solfitri, Daud & Abidin (2013) revealed that percentage of students who prefer cooperative learning is higher than the percentage of students who do not like cooperative learning. However, Arra, D'Antonio, & D'Antonio, (2011) reported that some students preferred not to work in group, meaning that cooperative learning is not for everyone.

Gender has been identified as one of the factors influencing students' performance in sciences at senior secondary school level. However, Olson (2002) reported females performed better than males students when taught mathematics using cooperative learning. Contrarily, Khairulanuar, Nazre, Sairabanu, and Norasikin (2010) found gender differences in favour of male students. On the other hand, Annetta, Mangrum, Holmes, Collazo and Cheng (2009), Kost, Pollock and Finkelstein (2009), Adeyemi (2008) and Ajaja & Eravwoke (2010) reported that gender had no effect on academic performance of students in cooperative learning. These contradictory findings have caused for inclusion of gender as one of the moderating variable for this study.

The reviewed show the inconclusiveness of the findings on cooperative learning on gender and attitude of the learners. Furthermore, previous studies focused on comparative effects cooperative learning strategy and conventional classroom instruction without examining the effectiveness computer-supported Jigsaw II cooperative learning setting in physics. Based on these facts the present study examined the effects of computer-supported Jigsaw II cooperative learning strategy on secondary school students' performance in physics.

Research Questions

The study addressed the following research questions.

(i). Is there any difference in the performance of secondary school students taught physics using computer-supported Jigsaw II cooperative settings and those taught using Individualized Computer Instruction (ICI)?

(ii). Is there any difference in the performance of male and female students taught physics using computer-assisted Jigsaw II cooperative setting?

(iii). Is there any difference in the attitude of secondary school students taught physics using computer-supported Jigsaw II cooperative setting and those taught using Individualized Computer Instruction (ICI)?

Research Hypotheses

The following null hypotheses were tested in the study.

(i). There is no significant difference in the performance of secondary school students taught physics using computer-supported Jigsaw II cooperative settings and those taught using Individualized Computer Instruction (ICI).

(ii). There is no significant difference in the performance of male and female students taught physics using computer-assisted Jigsaw II cooperative setting.

(iii). There is no significant difference in the attitude of secondary school students taught physics using computer-supported Jigsaw II cooperative setting and those taught Individualized Computer Instruction (ICI).

Methodology

The design of this study is a quasi-experiment consisting of treatment group and a control group, since the classes existed as intact groups. Pre-tests were used to determine the equality of the two groups.

A three-stage sampling technique was adopted. First, purposive random sampling was used to select two secondary schools in Minna, Niger State, Nigeria. These schools were selected based on the following criteria: equivalence (laboratories, facilities and manpower), school ownership (public schools), gender composition (mixed schools), ICT facilities (computer laboratories under the SchoolNet programme), and candidates' enrolment (Senior Secondary School Certificate in Education in physics for a minimum of ten years). Second, intact class in each of the two schools were selected and randomly assigned to experimental (Jigsaw II) and control (ICI) groups using simple random sampling technique. Third, the researcher arranged the participants into different strata based on gender (male & female).

This study consisted of 80 students from two groups consisting of 42 students in the control group and 38 students in the treatment group. Treatment groups were exposed to computer-supported jigsaw II cooperative learning (CSJCL), while the control group was taught with individualized computer instruction (ICI). The students in the experimental groups were heterogeneously divided into groups with three members each, composed of students of different gender. To avoid bias in grouping, team portrait, team vision statement, classmate scavenger hunt, and card sort team building structure were used in each school respectively.

The teacher who implemented the computer-supported jigsaw II cooperative learning strategy underwent training on the use of computer-assisted package and cooperative learning in order to ensure that it was implemented as planned. The teacher in the control group was trained on how to coordinate individualised computer instruction using the CALP package. The students were also extensively trained for two on the principles and practice of cooperative learning strategy.

Computer Assisted Learning Package (CALP) was used for test instrument. It was self developed package for senior secondary physics used at two different instructional settings (cooperative and individualised). It was validated by computer programmers and educational technology experts; subject content (physics) specialists; and finally field tested on sample representative similar to the students used for the final study. The package contained of two topics which were subdivided into sixteen lessons. The main menu of the package consisted of introduction, students' registration, list of lessons as in lesson 1, 2, 3, 4, … 16 and exit. It adopted the drill and practice modes of CAI.

Upon completion of instruction, post-tests were conducted to determine the difference between the groups. Physics Achievement Test (PAT) was used in collecting the data. The PAT consisted of 100 multiple choice objective items adopted from past examination of West African Examination Council (WAEC, May/June, 1988-2008) and National Examination

Council (NECO, June/July, 2000-2007). The Test (PAT) was based on the contents of the CALP package. Each of the stems of the PAT had five options (A - E) as possible answers to the question. Students were required to indicate their correct answers by ticking one of the letters (A - E) that corresponds to the correct option in each item. PAT was administered to the experimental and control groups as pre-test and again for the post-test after it had been reshuffled. The items were validated and tested for reliability using 40 randomly selected SSII students. A reliability coefficient of 0.90 was obtained using the Kudar Richardson (KR-21).

A questionnaire was used to measure the students' attitude towards physics. Physics Attitude Scale (PAS) was developed by the researchers to measure the students' attitude towards physics before and after exposed to computer-supported Jigsaw II cooperative learning strategy. PAS contained two sections. Section A included four questions and it focused on demographic information of physics student while Section B focused on students' attitude towards physics subject. The section contained 20-item four point response mode of Strongly Agree (coded 4), Agree (coded 3), Disagree (coded 2) and Strongly Disagree (coded 1) were used. To test the instrument's validity and reliability, the initial draft of 30-item of PAS was validated by experts. Also, it was administered on students drawn from a school outside the sampled schools. The feedback obtained from this first administration was used to modify the final instrument. The final instrument of 20-item questionnaire was tested for reliability using test-retest method of three weeks interval. The reliability coefficients obtained for the instruments was 0.86 using Kuder Richardson (KR 21).

The study covered twelve weeks but the treatment period for all groups lasted six weeks. During the study, the experimental groups were exposed CSJCL as treatment, while the control group students were individually exposed to the computer assisted instructional package. PAT and PAS were administered as pretest and posttest respectively. The data collected during the study 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.

Results

The results are presented based on the research hypotheses:

Hypothesis One: There is no significant difference in the performance of secondary school students taught physics using computer-supported Jigsaw II cooperative setting and those taught using Individualized Computer Instruction (ICI).

To determine whether there was significant difference in the post-test mean scores of the computer supported Jigsaw II and the control group (individualised computer instruction), data were analyzed using the analysis of covariance (ANCOVA). Table 1 contains the result of the analysis.

Table 1: ANCOVA post-test on experimental (Jigsaw II) and control (ICI) groups

Source of Variation	Sum of Square	df	Mean Square	F	Significance of F
Covariate (Pre-test)	587.599	1	587.599	12.003	0.001
Main Effect (Treatment)	933.609	1	933.609	19.072	0.000
Model	1561.303	2	780.652	15.947	0.000
Residual	3769.384	77	48.953		
Total	343981.000	80			

Table 1 shows the main effect of treatment group (computer-supported Jigsaw II) on students performance produced an F (1, 77) = 19.072, p = 0.000) for the main effect (treatment) was significant, this indicates that the method of instruction produced a significant effect on the post-test achievement scores of students when covariate effect (pre-test) was controlled. The result indicated that the treatment, using Jigsaw II and ICI accounted for the difference in the post-test achievement scores of the students. Hence, Hypothesis one was rejected. Therefore, there was significant difference between students taught using computer-supported Jigsaw II cooperative strategy and ICI. The performance of students in the two groups were further compared using the mean gain scores between the pre-test and posttest for each group, the results are shown in Table 2 and graphically illustrated in Figure 1.

Table 3: Mean gain scores of students taught physics using Jigsaw II and ICI

Group	Pretest	Posttest	Mean Gain Score
Jigsaw	20.07	68.38	48.31
ICI	19.82	61.39	41.57

From Table 2 showed that all the groups had improved performance in post-test. For instance, Jigsaw II had highest mean gain scores of 48.31 while the (ICI) had the mean gain scores of 41.57. This indicates that the two groups benefited from the treatment, with Jigsaw II having better performance.

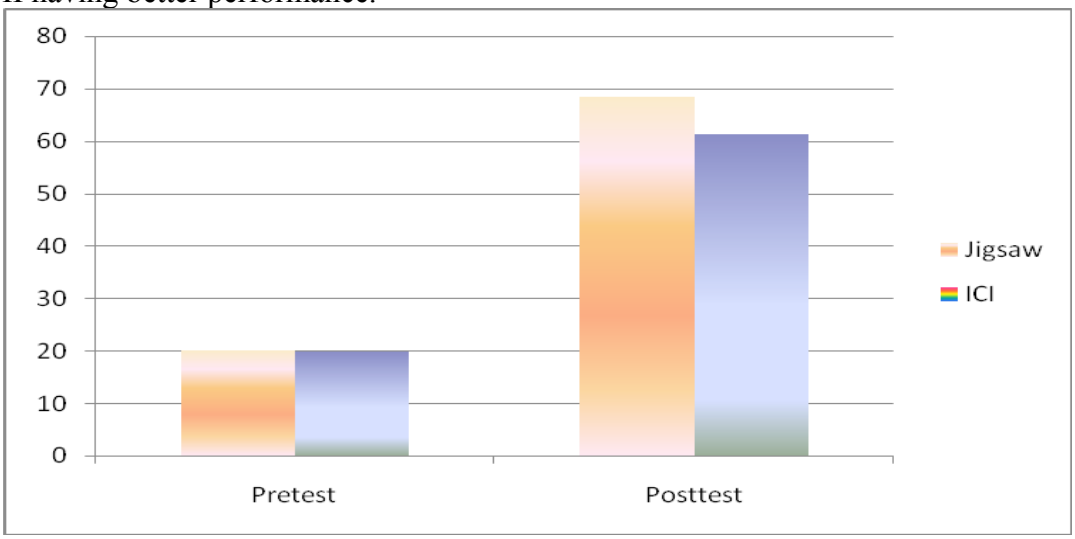

Figure 1: Graphical illustration of students' performance in Jigsaw II and ICI

Hypothesis Two: There is no significant difference in the performance of male and female students taught physics using computer-supported Jigsaw II cooperative setting.

To determine whether there was significant difference in the post-test mean scores of the computer-supported Jigsaw II and the control group (ICI), data were analyzed using the analysis of covariance (ANCOVA). Table 3 contains the result of the analysis. The results on this hypothesis are as shown in Table 3.

Table 3: ANCOVA results of male and female students in Jigsaw II group

Source of Variation	Sum of Square	df	Mean Square	F	Significance of F
Covariate (Pretest)	225.022	1	225.022	5.567	0.023
Main Effect (Gender)	76.051	1	76.051	1.882	0.178
Model	323.606	2	161.803	4.003	0.026
Residual	1576.299	39	40.418		
Total	198290.000	42			

Table 3 indicates that the main effect of treatment (Computer-Supported Jigsaw II) on gender produced an F (1, 39) = 1.882, p = 0.178 which was not significant at 0.05 alpha level. This shows that there was no significant difference between the posttest means scores of male and female students. Male students' scores did not differ significantly from their female counterparts when both were taught using computer-supported Jigsaw II. Therefore, hypothesis two was not rejected. The mean gain scores between the pretest and posttest for the male and female students were further compared graphically as illustrated in Table 4 and Figure 2.

Table 4: Mean gain scores of male and female students in Jigsaw II group

Group	Pretest	Posttest	Mean Gain Score
Male	20.36	69.46	58.72
Female	19.50	66.21	58.24

Table 4 showed that both the male and female students exposed to computer-supported Jigsaw II setting benefited from the treatment. The mean gain scores of male students were 58.72 while the mean gain scores of the female students were 58.24. The mean gain scores of female students were different from the mean gain scores of the male students by 0.48. This indicates that computer-supported Jigsaw II improved both male and female, with male students having better posttest performance and mean gain scores than female students. Furthermore, the comparison in the mean gain scores between their pretest and posttest is shown in Figure 2.

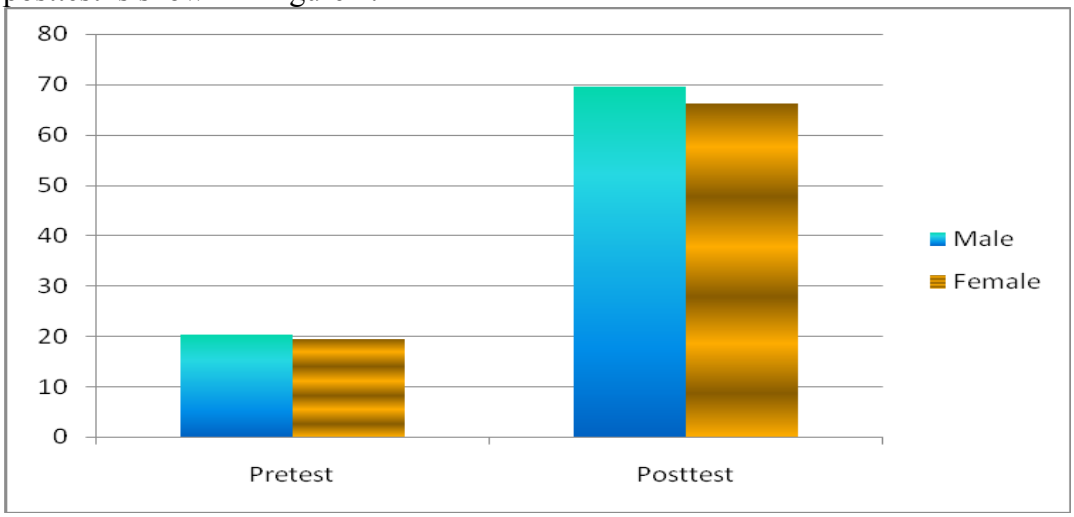

Figure 2: Graphical illustration of male and female students in Jigsaw II group

Hypothesis Three: There is no significant difference in the attitude of secondary school students taught physics using computer-supported Jigsaw II cooperative strategy and those taught Individualized Computer Instruction (ICI).

To determine whether there was significant difference in the pretest and postttest attitude mean values of students exposed to computer-supported Jigsaw II cooperative strategy, data were analyzed using the analysis of covariance (ANCOVA). Table 5 contains the result of the analysis. The results on this hypothesis are as shown in Table 5.

Table 5: ANCOVA results of attitude mean values of students in Jigsaw II and ICI groups

Source of Variation	Sum of Square	df	Mean Square	F	Significance of F
Covariate (Pretest)	2119.880	1	211.880	33.386	0.000
Main Effect (Attitude)	2741.531	1	2741.531	43.177	0.000
Model	4259.096	2	2129.548	33.593	0.000
Residual	4889.159	77	63.496		
Total	9148.258	80			

From Table 5, the main effect of treatment group (computer-supported Jigsaw II cooperative strategy) on attitude produced an $F(1, 77) = 43.167$, $p = 0.000$. This result was significant at the 0.05 alpha level. This indicates that there was significant difference in the attitude of physics students taught using Jigsaw II computer-supported cooperative strategy and ICI. The hypothesis three is therefore rejected. This indicates that students' attitude towards physics before the treatment (pretest) differ significantly from attitude after the treatment (posttest) when exposed to computer-supported Jigsaw II cooperative strategy and ICI.

The mean gain values between the pretest and posttest of students' attitude using computer-supported Jigsaw II cooperative strategy and ICI were tabulated and graphically illustrated as shown in Table 6 and Figure 3 respectively.

Table 6: Mean gain values of students' attitude towards physics using Jigsaw II

Group	Pretest	Posttest	Mean Gain Score
ICI	32.524	60.176	27.632
Jigsaw II	35.205	49.821	14.616

From Table 6, it was observed that attitude of students' towards physics was increased after taught using computer-supported Jigsaw II cooperative learning. The students' pretest attitudes mean gain values of 1.63 while the posttest attitudes mean gain value of 3.01. This indicated that the students benefited from the treatment and like Jigsaw II computer-supported cooperative setting. Furthermore, the comparison in the mean values between students pretest and posttest is shown in Figure 3.

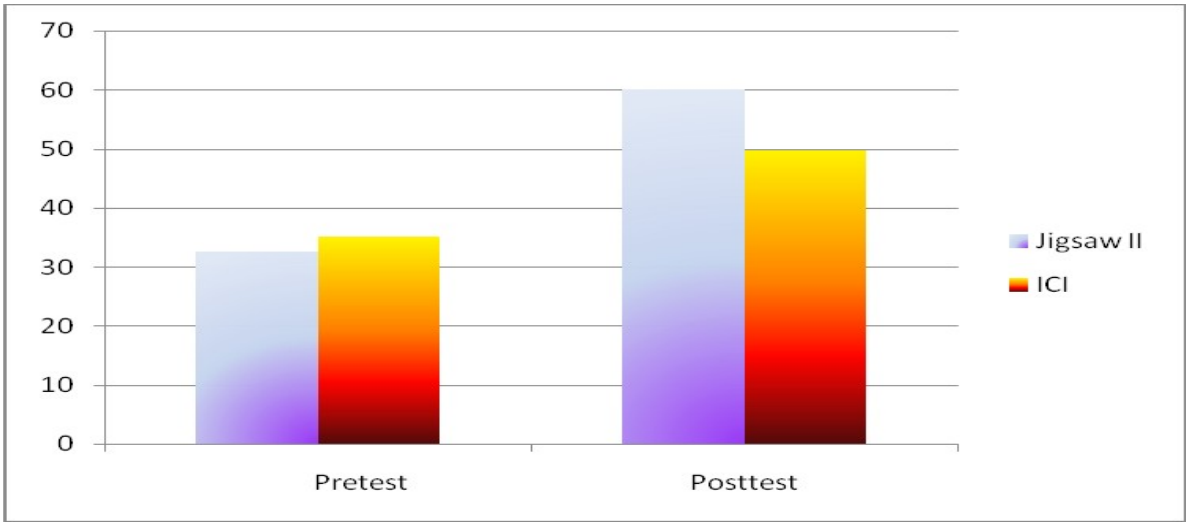

Figure 3: Graphical illustration of students' attitude towards physics using Jigsaw II and ICI

Discussion of Findings

The results of the analyses related to the hypothesis one indicated a significant difference in students' performance of in favour of those in the experimental group (Jigsaw II). Findings indicated significant difference between the performances of students exposed to Jigsaw II and ICI. The findings as regards better performance of students in the Jigsaw II as compared to the ICI agree with earlier findings of Keramati (2010), Yusuf, Gambari and Olumorin (2012) in physics and Yusuf and Afolabi (2010) in biology which reported that students taught using computer-supported CAI performed better than those taught using computer assisted instruction in individualised settings. Furthermore, this finding is supported by the findings of Lai and Wu (2006) in nursing education, Hanze and Berger (2007) and Berger and Hanze (2009), (Gambari, 2010) in physics, Altiparmak & Nakiboglu-Tezer (2009) in chemistry, Mattinly, VanSickle and Ronald (2009) in geography, Moreno (2009), Doymus, (2008) and Jansoon, Somsook and Coll (2008) in biology, Zakaria, Solfitri, Daud & Abidin (2013) in mathematics reported that Jigsaw II is considerably more effective than individualistic instructional strategy and conventional classroom instruction respectively. However, the finding disagree with the findings of Shaaban (2006), Ross, Seaborn and Wilson (2002) and Thompson and Pledger (1998) who found no significant difference in the achievement of students taught using Jigsaw and those taught using conventional classroom and discussion methods respectively.

The superiority of Jigsaw II strategy stems from the fact that it was a task structured (task specialization) and incentive structured (group rewards for individual learning, group reward for group product, and individual rewards) cooperative strategy in such a way that if well implemented will produce a positive outcome. It was observed that Jigsaw II instructional strategies provides no room for free rider, in which some group members do all or most of the work while others go along for the ride (Slavin, 1995). Every member of the team must have learned the whole lesson in the home group, learn a portion in the Jigsaw group, then, takes turn to teach the portion to his teammates, complete individual and group tasks (Moreno, 2009).

The results of the analyses related to the hypothesis two indicated no significant difference in the performance of male and female students taught physics using computer-supported Jigsaw II cooperative learning. The findings as regards the performance of male and female students in the Jigsaw II group differ from the earlier findings of Olson (2002) which reported that females performed better than males students when taught mathematics

using cooperative learning. Also disagree with Khairulanuar, Nazre, Sairabanu, and Norasikin (2010) which found gender differences in favour of male students. Furthermore, it agree with the findings of Annetta, Mangrum, Holmes, Collazo and Cheng (2009), Kost, Pollock and Finkelstein (2009), Adeyemi (2008) and Ajaja & Eravwoke (2010) which reported that gender had no influence on academic performance of students in cooperative learning.

The results of the analyses related to the hypothesis four indicated significant difference in the attitude of students taught physics using computer-supported Jigsaw II cooperative learning before and after the treatment. The findings agree with the earlier findings of Ajaja and Eravwoke (2010), Artut and Tarim (2007), Gomleksiz (2007), Lai and Wu, (2006) Moreno (2009) and Zakaria, Solfitri, Daud and Abidin (2013) which revealed that cooperative learning setting increased students' positive attitudes towards learning. However, it disagree with the findings of Arra, D'Antonio and D'Antonio (2011) which revealed that some students did not prefer to work in group, meaning that cooperative learning is not for everyone. The better attitude exhibited by students in the cooperative learning classroom may have been achieved because feedback, reinforcement, and support come from students' peers in the group. Again, students in cooperative learning performing better in test of attitude towards studies may perhaps be because of imbibing of role expectations and responsibility, which are two very important features of cooperative learning (Ajaja & Eravwoke, 2010).

On the interaction effect, there is non-significant interaction effects on performance were found between treatment (method) and gender; and gender and achievement levels. However, significant interaction effect on performance was found between treatment (method) and achievement level. It is believed that the higher thought processes as required for higher achievement, are induced by the interaction with one another more than with the traditional treatment from books and classroom teachers. This, again, may have contributed to the noticed significant difference in achievement scores between students taught physics using Jigsaw II cooperative learning strategy and those in the individualized computer instruction (ICI).

These findings have strong implications for teaching and learning of physics in secondary schools in Nigeria using computer supported cooperative learning strategies. Major implication of these findings is that computer assisted instruction is better in cooperative learning settings than in individualized setting. Furthermore, the findings provide sound empirical basis which indicate that performance of students in physics and other science subjects would be greatly improved if students are exposed to computer-supported Jigsaw II cooperative learning strategy.

Recommendations

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

(i) Teachers should expose physics students to computer-supported Jigsaw II cooperative instructional strategy so as to improve students' performance in physics. In addition, government, educational agencies and other education stakeholders should organize workshops on the use of computer-supported cooperative learning strategy to enhance better performance of secondary school students.

(ii) Teacher education programme in Nigerian tertiary institutions should be improved upon to prepare teachers who can apply innovative teaching approach (computer-supported instructional strategy), which will promote effective teaching and learning.

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