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EFFECTS OF PROBLEM-SOLVING AND COOPERATIVE LEARNING STRATEGIES ON SENIOR SECONDARY SCHOOL STUDENTS' ACHIEVEMENT IN PHYSICS

(PROBLEM ÇÖZME VE İŞBİRLİKÇİ ÖĞRENME STRATEJİLERİNİN İLKÖĞRETİM SON SINIF ÖĞRENCİLERİNİN FİZİK BAŞARISI ÜZERİNE ETKİLERİ)

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ABSTRACT

The study investigated the effects of problem-solving and cooperative learning strategies on senior secondary two (SS.II) students' achievement in physics. The study employed a quasi-experimental research design represented by 3x2 factorial designs in a pretest, posttest control group setting. A multi-stage sampling technique was employed to select 141 physics students comprising of 78 males and 63 females. A validated Physics Achievement Test (PAT) instrument with reliability coefficient of 0.75 was administered. Also, three validated instructional materials namely: Instructional Packages on Problem-Solving Strategy (IPPS), Cooperative Learning Strategy (1PCLS) and Convention/traditional Method (IPCM) with reliability values of 0.82, 0.79 and 0.76 respectively were used. The experimental groups I and II were exposed to Problem-Solving Strategy (PS) and Cooperative Learning Strategy (CLS) while the Conventional/traditional method (CM) was used for the control group. The study which lasted for five weeks had the training of the participatory teachers and research assistants taken one week while treatment session took four weeks. Data collected were analysed using ANCOVA. Answers were provided to 3 research questions generated for the study. The results showed that there is a significant effect of treatment on achievement in physics among SS.II students with cooperative learning strategy (CLS) resulted in higher achievement followed by problem-solving strategy (PS). The study also reveals significant gender effect in favour of male and significant interaction effect of treatment and gender on physics achievement. The investigation concludes that CLS is an effective learning strategy, which physics teachers should be encouraged to use in their teaching/learning process. Based on this finding, it was recommended that practicing physics teachers at senior secondary level of education should use CLS and should as well be implemented in all teacher education programmes in Nigeria.

Keywords: Problem-solving, Cooperative learning, Gender, Achievement in Physics, Senior Secondary Students

ÖZ

Bu çalışma, problem çözme ve işbirlikçi öğrenme stratejilerinin ilköğretim ikinci kademe son sınıf (İİSS) öğrencilerinin Fizik'teki başarısına etkilerini araştırmaktadır. Çalışma, ön-test, son-test ve kontrol grubundaki 3x2 faktöriyel deseniyle temsil edilen yarı deneysel bir araştırma desenini kullanmıştır. 78 erkek ve 63 bayandan oluşan 141 Fizik öğrencisini seçmek için çok aşamalı bir örneklem tekniği kullanıldı. 0.75 güvenilirlik katsayısı olan geçerli bir Fizik Başarı Testi (FBT) uygulanmıştır. Ayrıca, sırasıyla 0.82, 0.79 ve 0.76 güvenilirlik değerlerine sahip Problem-çözme Stratejisiyle ilgili Yönergesel Paketler (PSYP), İşbirlikçi Öğrenme Stratejisi (İÖS) ve Geleneksel Yöntem (GY) adında üç geçerli yönerge materyali kullanılmıştır. Deney grubu I ve II üzerinde PS ve İÖS uygulanırken, kontrol grubunda GY kullanılmıştır. Beş haftalık çalışmanın bir haftasında araştırma görevlilerinin ve katılımcı öğretmenlerin eğitimi sürerken, diğer dört haftada da iyileştirme toplantısı yapıldı. Toplanan veriler ANCOVA kullanılarak analiz edildi. Çalışma için üretilen üç araştırma sorusuna cevaplar bulundu. Sonuçlara göre başarı sıralamasında Problem çözme Stratejisinin (PS) uygulandığı öğrencilerin takip ettiği İşbirlikçi öğrenme stratejisinin uygulandığı öğrencilerde daha yüksek başarının görülmesi ilköğretim ikinci kademe son sınıf öğrencileri (İİSS) arasında Fizik başarısı açısından önemli bir tedavi etkisinin olduğunu ortaya koymaktadır. Çalışma erkeklerin lehine bir cinsiyet faktörünün ve tedaviyle cinsiyet arasındaki etkileşimin fizik başarısına önemli etkisinin olduğunu da göstermektedir. Araştırma İşbirlikçi Öğrenme Stratejisinin (İÖS) öğretme/öğrenme sürecinde Fizik öğretmenleri tarafından kullanılmaya teşvik edilmesi gerektiği sonucuna varmıştır. Bu sonuca bağlı olarak, son sınıf ilköğretim seviyesindeki uygulama yapan Fizik öğretmenlerinin İÖS'yi kullanmaları tavsiye edilmiştir.

Anahtar Sözcükler: problem çözme, işbirlikçi öğrenme, fizik dersi başarısı, son sınıf ilköğretim öğrencileri.

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INTRODUCTION

Physics is and will remain the fundamental science (Weham, Dorlin, Snell and Taylor, 1984). This suggests that other sciences depend upon the knowledge obtained through the study of physics. Physics is therefore an important base in science and technology since it studies the essence of natural phenomena and helps people to understand the increasing technological changing society (Zhaoyao, 2002). In order for physics to perform its function properly, instructional strategies in physics must be centred on methods of seeking the truth which include those of problem detecting, problem-solving, decision making, learning by experimenting and discovery learning. A versatile and competent teacher of physics must acquaint himself or herself with physics methodology and be well groomed in the application of the various methods of teaching physics. Of great concern to the investigator is that physics teachers use mostly the lecture method otherwise known as conventional/traditional method. For impacting information under the lecture approach, the teacher, according to Fenton (1967), Bruner (1969), Berliner (1975) simply becomes only the expositor and drill master while the learner remains the listener and a storehouse of facts that can be retrieved when a student sees himself/herself being pointed to by his/her teacher to talk.

Some of the researches conducted in Nigeria and abroad have shown that conventional/traditional method has negative effects on most of the students (Orji, 1998, Sotayo, 2002; Gok& Silay, 2008). It has been discovered even in well-developed countries that goals of science teaching cannot be reached through the conventional method (Dieck, 1997, Rivard and Straw, 2000). Regarding the situation in Nigeria, it can be said that most students have a negative attitude towards science lectures, especially physics, during their education (Okpala, 1985; Aina, 2006). Available evidences from literature in Nigeria indicated that students' enrolment and achievement in the subject at public examinations (i.e. Senior Secondary School Certificate Examination (SSCE), National Examinations Council (NECO), National Board for Technical Education and Business (NABTEB) and University Matriculation Examination (UME) have continued to decrease and worsen year after year (Egbugara,1985; Orji,1998; Adeoye,2000; Sotayo,2002). The problems of declining trend in students' enrolment and underachievement in physics is not peculiar to Nigeria alone. It has become international issue which must be tackled realistically. Maloney, 1994; Gaigher, 2004; Alant, 2004 also reported similar issues in their studies respectively.

Prominent among the factors which have been identified as contributing to the persistent low enrolment and poor level of achievement in physics are: poor teaching methods adopted by physics teachers (Olarinoye,1979; Daramola,1982; Orji,1998; Sotayo,2002), the predominant use of text and lecture instructional strategy by physics teachers (Iroegbu,1998; Orji,1998), learner variables such as gender and cognitive style (Okpala & Onocha,1995; Okpala & Adeoye,1999), lack of problem-solving ability (Adeoye,1993) etc.

It has therefore become apparent that the lecture method, which is currently the predominantly teaching approach in Nigerian secondary schools, is inappropriate and ineffective for achieving the high objectives of the physics education. In the light of this however, it would be necessary to search for more effective strategies which are suitable and efficient for promoting the level of secondary school physics achievement beyond contemporary limits and to the satisfaction of the current physics curriculum requirements. To this end, the use of teaching strategies such as problem-solving and cooperative learning could help to solve the problem of poor achievement in physics because these strategies have been found to enrich the personal experiences of students (Hollabaugh, 1995; Agbayewa, 1996; Alio & Paters, 2003; Saglam & Millar, 2006, Kolawole & Ilugbusi, 2007).

Problem-solving is an important activity in the teaching and learning of Mathematics and Science related courses. Jonassen (1997) defined problem-solving as a complex activity that engages a variety of cognitive components and skills, motivation/attitudinal components as well as psychological components. Bolton and Ross (1997) sees problem-solving as a complex, multi-layered skill, and not one that most students can be expected to develop unaided. Problem-solving according to Dhillon (1998) is an investigative task whereby the solver explores the solution path to reach a goal from give information. All the sciences, both pure and applied, are centrally concerned with developing and systematizing knowledge useful for solving various kinds of problems (Selçuk, Çaliskan and Erol, 2008). Thus, education in sciences must address the crucially important task of teaching students to become more proficient problem-solvers. The basic problem-solving process is a linear, hierarchical process. Each step is a result of the previous step and a precursor to the next step. A popular method of teaching problem-solving involves the use of “stage models”. Stage models are simplified lists of stages and steps used in general problem-solving (Johnson, 1994). Polya’s (1957) prescription for solving problems consists of four steps: The first step is ***description***, by identifying the unknown, the data and the condition and then drawing a figure and introducing suitable notation. The second step is ***planning***, in which the solver seeks a connection between the data and the unknown. If an immediate connection is not found, the solver considers related problems or problems that have already been solved and uses this information to devise a plan to reach the unknown. In the third step, ***implementation***, the steps outlined in part two are carried out and each step is checked for correctness. In the final step ***checking***, the problem solution is examined and arguments are checked. These four steps form the essential basic structure on which the constructions of various problem-solving models have developed (Maloney, 1994). The present study therefore is centred on the use of the four steps of problem-solving developed by Polya (1957).

Cooperative learning is the instructional use of small groups in which pupils /students work together to maximize and gain from each other (Johnson and Johnson, 1994; 1999). In cooperative learning, pupils are expected to help, discuss and argue with each other; assess each other's current knowledge; and fill any gaps in each other's understanding (Slavin, 1995). Cooperative learning is a mode of learning in which students of different levels of ability work together in small groups to achieve a purpose (Akinbobola, 2006).It involves the use of a variety of learning activities to improve their understanding of a subject (Slavin,1992). Students in a group interact with each other, share ideas and information, seek additional information, and make decisions about their findings to the entire class (Kort, 1992). Cooperative learning is a student centred versus teacher centred leading to a stronger emphasis on the goal of learning of a performance goals. It encourages teachers to use alternative assessment techniques further reducing the emphasis on competitive examinations (Slavin, 1992). Cooperative learning can be shown as a sample of education of this kind (Mills, McKittrick, Mulhall and Feteris 1999) and this method can easily be adapted to the current structure of physics education (Samiullah, 1995). There are many different cooperative learning techniques, however, all of them have certain elements in common as established by Johnson, Johnson and Holubec (1991). These elements are the ingredients necessary to ensure that when students do work in groups, they work cooperatively: first, the members of a group must perceive that they are part of a team and that they are all have a common goal; second group members must realize that the problem they are to solve is a group problem and that the success or failure of the group will be shared by all members of the group; third, to accomplish the group's goal, all students must talk with one another to engage in discussion of all problems; finally, it must be clear to all that each member's individual work has a direction effect on the group success. Team work is utmost important. Cooperative learning strategies have been shown to enhance students' learning and social relations relative to conventional/traditional whole class methods of learning (Esan, 1999; Adeyemi, 2002; Kolawole, 2008; Adesoji and Ibraheem, 2009). The present study therefore adopted Students Team-Achievement Division (STAD) cooperative learning strategy to teach the participants with a view to finding out its efficacy in the teaching of physics.

Researches (Balogun, 1994; Erinosho, 1994; Park and Norton, 1996; Raimi, 2002) have shown that both in Nigeria and abroad that learner characteristics such as gender affect learning outcomes in Mathematics and science. This issue of gender in relation to performance in Mathematics and Science had been a major concern to science educators and science education researchers for long (Adeoye, 2000; Raimi, 2002). This is due to three conflicting nature of results from researches that focus on gender issues in science and Mathematics achievement. The first trend portrays a significant gender difference in science achievement in favour of males (Lynch and Patterson, 1980; Howe and Shayer, 1981, Nworgu, 1985; Opyene and Okurut, 1995; Raimi, 2002); the second portrays a significant gender difference in science achievement in favour of females (Balogun and Olanrewaju, 1985; Deboer, 1986; Iroegbu, 1998), while the third portrays non-significant gender difference in achievement in both subjects (Ivowi,1983, Nworgu, 1986, Orji, 1998). These results suggest that gender stereotyping is still persisting in Nigeria learning environment (Obanya, 2004), thus, the study also sought to establish the impact of gender on physics achievement.

This study therefore investigated the effects of problem-solving, cooperative learning and conventional/traditional strategies on senior secondary two (SS.II) students' achievement in physics. Specifically the study addressed the following research questions:

(i.) Is there any significant effect of treatment (Problem-solving, cooperative learning and conventional/traditional strategies) on achievement in physics among SS.II students?

(ii.) Do SS.II males and females exposed to the different treatments differ in their achievement in physics?

(iii.) Is there any significant interaction effect of treatment and gender on achievement in physics among SS.II students?

METHOD

Design

The study employed a quasi-experimental research design represented by 3x2 factorial design. Specifically, the study was non-randomized pre-test, post-test control group design. This design was chosen because intact classes were used instead of randomly composed samples. This is in view of the fact that secondary school classes exist as intact groups and school authorities do not normally allow the classes to be dismantled and reconstituted for research purposes (Fraenkel and Wallen, 2002). The advantage of this design over others is its ability to control the major threats to internal validity except those associated with interaction and history, maturity and instrumentation (Cook and Campbell, 1979). In the present study, no major event was observed in the sample schools to introduce the threat of history and interaction. The conditions under which the instruments were administered were kept as similar as possible across the 9 schools in order to control instrumentation and selection. The schools were randomly assigned to the treatments and control groups to control for selection, maturation and interaction (Ary, Jacobs and Razavien, 1996).
Symbolically, the design of the study may be represented as shown below.

O_1 X O_2 = Experimental group 1(E_1)
O_1 Y O_2 = Experimental group 11(E_2)
O_1 Z O_2 = Control group (C)
where O_1 = Pre-test
O_2 = Post-test
X = Problem-Solving Strategy (PS)
Y = Cooperative Learning Strategy (CLS)
Z = Conventional/Traditional Method (CM)

Selection of Content for the Study

The physics concepts selected for this study were Electricity and Magnetism. The choices were based on students' conceptual misunderstanding of electricity and magnetism as the most difficult topics within physics to learn and understand (Coftus, 1996; Aina, 2006; Chabay and Sherwood, 2006). According to students, the topic contains difficult mathematical operations and they find most of the concepts relating to the topic intangible and cannot directly be associated with daily life (Kocakulah, 1999; Raduta, 2005).

Eğitimde Kuram ve Uygulama
Journal of Theory and Practice in Education
2010, 6 (2):235-266

Population

The population of the study comprised of all the Senior Secondary Two (SS.11) physics students in all the co-educational secondary schools in Lagos Island Local Government of Lagos State, Nigeria.

Sample and Sampling Technique

The study involved the use of a multi-stage sampling technique. Firstly, a purposive sampling was employed to select 9 public secondary schools. The criteria used for the selection included:

i. schools that have at least one graduate physics teacher with at least twelve years of post-graduation teaching experience.
ii. schools that have fairly equipped and functional laboratory for physics teaching.
iii. schools that are co-educational
iv. schools located in the urban area of the local government area considered for the study.

Intact classes of the 9 schools were used for the study. 3 schools each were randomly assigned to problem-solving, cooperative learning and conventional/traditional method groups respectively. A total of 141 senior secondary two physics students consisting of 78 male and 63 female formed the sample of this study.

Research Instrument

The two measuring instruments used for the study are Physics Achievement Test (PAT) and Problem-solving Worksheets.

(i). **Physics Achievement Test (PAT)**

The PAT consisted of 40 Multiple Choice Items developed by the investigator from selected content for the study on Electricity and Magnetism (see Appendix 1). The face validity of PAT was determined by 3 experienced Physics educators from University of Lagos, Lagos, Nigeria and 2 seasoned and experienced physics teachers from two secondary schools in Ikeja Local Government Area of Lagos State. The PAT was constructed using a balanced table of specification inline with the classification of Education Testing Service (ETS) of United States to reflect three categories of cognitive tasks namely: remembering, understanding and thinking. PAT was trial tested on a group of students that had similar characteristics as the sample students and whose schools met the criteria used for selection of sample but not used for the main study. The reliability coefficient of PAT was calculated using Kuder-

Richardson Formula 21 (K-R 21) which gives a value of 0.75. This value is considered adequate for this study.

(ii). **Problem-solving Worksheets**

Problem-solving worksheets had been prepared to determine the problem-solving strategies used by students while solving a physics problem. The problems were arranged at different difficulty level and students in the 2 experimental and control groups were required to solve them i.e. physics problem-solving performance test (see Appendix 11). The responses to the problem-solving worksheets were to be solved individually. Evaluation of the problems solved by the 3 groups was made by the investigator. Common strategies of the students were determined while students were solving physics problems according to achievement and gender. Problem-solving performance of the students was evaluated according to "evidence of conceptual understanding, usefulness of description, match of equations with description, reasonable plan, logical progression, proper mathematics (Heller, Keith and Anderson, 1992). The characteristics in this scheme were graded equally and normalized to obtain a score over 100 scores. Problem prepared during this study were based on the classification of Education Testing Service (ETS) of United States to reflect three categories of cognitive tasks namely: remembering, understanding and thinking. Problem-solving steps which would be used to solve the problems were selected as, understanding (focus on the problem), planning (plan the solution), solving (execute the plan), and checking (evaluate the answer) (Polya, 1957; Heller, Keith and Anderson, 1992).

Instructional Materials Used for Study

Three instructional materials used for the study are:

(i) Instructional Package on Problem-Solving Strategy (IPPS)
(ii) Instructional Package on Cooperative Learning Strategy (IPCLS)
(iii) Instructional Package on Conventional/Traditional Method (IPCM)

The IPPS, IPCLS and IPCM were designed by the investigator based on the selected content of the study. The packages were validated by the set of experts used for PAT and the reliability coefficient of each was calculated using split half reliability method. The reliability indices of 0.82, 0.79 and 0.76 were obtained for the three packages respectively. The values were considered adequate for this study.

Research Procedure

This study was carried out in 4 stages namely training, pre-testing, treatment and post-testing.

Training Stage: This involved a one week training programme for the 9 regular physics teachers who performed the teaching during treatment period. The training involved grouping the teachers to reflect the group of students they were to handle (i.e.3 teachers each for each of the two experimental and the control groups.

The experimental group 1 (E_1) teachers were trained by the investigator on how to use the IPPS, the experimental group 11 (E_2) teachers were trained on how to use the IPCLS while the control group (C) teachers were trained with the IPCM, that is, lesson notes prepared by the investigator. Hence, all the experimental and the control groups' teachers were very familiar with their respective assignments. Also trained were 9 research assistants who served as observers throughout the treatment period.

Pre-testing Stage: This involved the administration of PAT on the subjects in all the 9 selected schools. The PAT was administered to all the 3 treatment groups as Pre-test in order to ascertain the homogeneity of the treatment groups.

Treatment Stage: The 9 trained physics teachers commenced treatment after their pre-testing session. During treatment, all the trained teachers applied what they learnt from the training session in their various groups as stated below.

(i). **Experimental Group 1 (E_1)**

Treatment in this group involved the following steps.

- The trained physics teachers conduct practice sessions where they explain the problem-solving process and strategies to raise students' awareness of the purpose and rationale of strategy use.
- Teachers give students opportunities to practice the strategies which they are being taught.
- Teachers provide frequent feedback to students on the quality and strengths of the strategy being used.
- Teachers provide students with the content of instruction and then strategy application practices to implement within the regularly scheduled physics lectures.
- Teachers provide students a problem-solving worksheet which contained 10-multistep problems related with the selected contents of study during practice sessions to facilitate strategy application.

- Students were strongly encouraged to solve these problems individually by using strategies taught and complete the worksheets by handwritten.
- Teachers did not provide assistance in this process.
- Teachers collect all completed worksheets and examined to determine the extent to which students effectively use the strategies taught.
- In the first 10minutes of the next lesson, students should be given feedback showing how they responded and corrections if necessary.

(ii). **Experimental Group 11 (E_2)**

Treatment in this group involved the following steps.

- The trained physics teachers conduct practice sessions where he explains the problem-solving process and strategies to raise students' awareness of the purpose and rationale of strategy use.
- Students in 5 heterogeneous academic teams within the group engaged themselves in intensive cooperative study by practicing the strategies being taught.
- Teachers provide frequent feedback to students in the teams on the quality and strengthen of the strategy being used.
- Teachers provide students with the content of instruction and then strategy application practices to implement within the regularly scheduled physics lectures.
- Teachers provide students a problem-solving worksheet which contained 10-multistep problems related with the selected contents of study during practice sessions to facilitate strategy application.
- Students were directed to solve the problems individually without assistance from their teammate using strategies taught and complete the worksheets by handwritten.
- Teachers collect all completed worksheets and examine to determine the extent to which students effectively use the strategies taught.
- The average scores of members of each team are calculated to find the team's mark.
- In the first 10minutes of the next lesson, students should be given feedback showing how they responded and corrections if necessary.

(iii). Control Group (C)

Treatment in this group involved the following steps.

- Here students sat individually and not in group throughout the lesson.
- The trained physics teachers conduct practice sessions in form of lecture using conventional/traditional technique of teaching problem-solving.

- Students listened to the teachers and wrote down chalkboard summary.
- Students asked teachers questions on areas of the content that is not clear to them.
- Teachers provide students a problem-solving worksheet which contained 10-multistep problems related with the selected contents of study during practice sessions to facilitate strategy application.
- Students were strongly encouraged to solve these problems individually during the problem-solving hours without explicit problem-solving instruction and complete the worksheets by handwritten.
- Teachers did not provide assistance in this process.
- Teachers collect all completed worksheets and examined to determine the extent to which students effectively use the strategies taught.
- In the first 10minutes of the next lesson, students should be given feedback showing how they responded and corrections if necessary.

The subjects in the 2 experimental and control groups were taught the same content using the same length of time to learn the content. The trained physics teachers taught the 2 experimental groups with lesson notes prepared using the stages from Polya's prescription for solving problems.
During the treatment period which lasted for 4 weeks of 3 periods of 40 minutes per period per week, the 9 trained observers monitored the teaching in all the 9 schools to make sure the teachers were implementing the various teaching strategies. The investigator also paid unannounced visit to the 6 experimental and 3 control groups classes once a week to monitor the activities of both the teachers and observers so as to determine how accurate and consistent they are in operationalization of the treatment conditions.

Post-testing Stage

This involved the administration of PAT at the end of the 5^{th} week of treatment on the subjects in all the 9 selected schools. The test methodology and the time allotted for the post-test measures were equal to those of the pre-test measures. At the end, the investigator scored the pre-tests and post-tests and generated quantitative data, which were analysed.

Data Analysis

The post-test achievement scores were subjected to Analysis of Covariance (ANCOVA) using pre-test scores as covariates. The data were further subjected to the Scheffe post-hoc analysis to determine the sources of observed differences. Graphical illustrations were also employed as post-hoc measures to disentangle significant interaction effects.

RESULTS

Table 3.1. Summary of Analysis of Covariance (ANCOVA) of Physics Post-test Achievement Scores by Treatment and Gender

Sources of Variation	**Sum of Squares**	**df**	**Mean Square**	**F**	**Sig. of F**
Covariates	36.532	1	36.532	1.946	.165
Pre-test	36.532	1	36.532	1.946	.165
Main Effects	4422.050	3	1474.017	78.519	.000
Treatment	4267.012	2	2133.506	113.649	.000*
Gender	155.039	1	155.039	8.259	.025*
2-Way Interaction	1052.136	2	526.068	28.023	.000
Treatment X Gender	1052.136	2	526.068	28.023	.000*
Explained	5510.718	6	918.453	48.927	.000
Residual	2515.551	134	18.773		
Total	8026.270	140	57.330		

* Significant at $p < 0.05$

Table3.1 shows data on analysis of covariance of physics test scores by treatment (teaching strategies) and gender. The table shows a significant main effect of treatment ($F_{2, 140} = 78.519$; $p < 0.05$) as well as significant main effect of gender ($F_{1, 140} = 8.259$; $p < 0.05$). There is also a significant interaction effect of treatment and gender ($F_{2, 140} = 28.023$; $p < 0.05$).

Table3.2. Multiple Classification Analysis (MCA) of Post-test Achievement Scores by Treatment and Gender
Grand Mean = 18.35

Variable + Category	N	Unadjusted Deviation	Unadjusted Deviation 'Eta'	Adjusted for Independent + Variable	Beta
Treatment					
(i). Problem-solving Strategy	48	.92		.95	
(ii). Cooperative Learning Strategy	42	6.95		6.95	
(iii).Conventional/Traditional Method	51	-6.59		-6.61	
			.73		.73
Gender					
(i).Male	78	.85		.94	
(ii). Female	63	-1.05		-1.17	
			.13		.14
Multiple R Squared					**.555**
Multiple R					**.745**

Table 3.2 shows data on MCA of PAT Scores by treatment and gender groups. The data show that the cooperative learning strategy group has the highest adjusted post-test mean scores of 25.30 followed by the problem-solving strategy group and the conventional/traditional method group with adjusted post-test mean scores of 19.30 and 11.74 respectively. The MCA table also shows that male students had higher adjusted post-test mean scores of 19.29 than their female counterparts with 17.18. In all, the MCA reveals a multiple R squared value of 0.555 and beta values of 0.73 and 0.14 for treatment and gender respectively. It means that the treatment alone is able to account for 53.29% $(0.73)^2$ of the variation in students achievement in physics. The beta value of gender influence is 0.14 indicating that only 1.96% $(0.14)^2$ of the variation in students (generally) can be accounted for by gender.

Table 3.3. Scheffe Test Comparison of Treatment Groups

Mean	Strategies Group	Treatment Groups C/TM	PS	CL
11.7647	C/TM			
19.2708	PS	*		
25.3095	CL	*	*	

* Denotes pairs of groups significantly different at $p< 0.05$
C/TM = Conventional/Traditional Method
PS = Problem-Solving
CL = Cooperative Learning

The results from the post-hoc analysis (Table3.3) show that students in the cooperative learning strategy group performed significantly better than their counterparts in either of the problem-solving strategy or conventional/traditional method groups. The result also shows that students in problem-solving strategy group performed significantly better than those in conventional/traditional method group. The table also shows that significant differences in students' achievement existed between students exposed to cooperative learning (CL) (experimental group 11) and conventional/traditional method (C/TM) (control group), students exposed to problem solving (PS) (experimental group 1) and conventional/traditional method (C/TM) as well as between students exposed to cooperative learning (CL) (experimental group 11) and problem solving (PS) (experimental group 1). These results are indications that students' achievement in physics could be significantly improved by exposing the students to cooperative learning strategy and problem solving strategy. Thus, cooperative learning is the most preferred strategy of all the methods considered in this study.

The significant two-way interaction of treatment and gender was disentangled as shown in Figure 1.

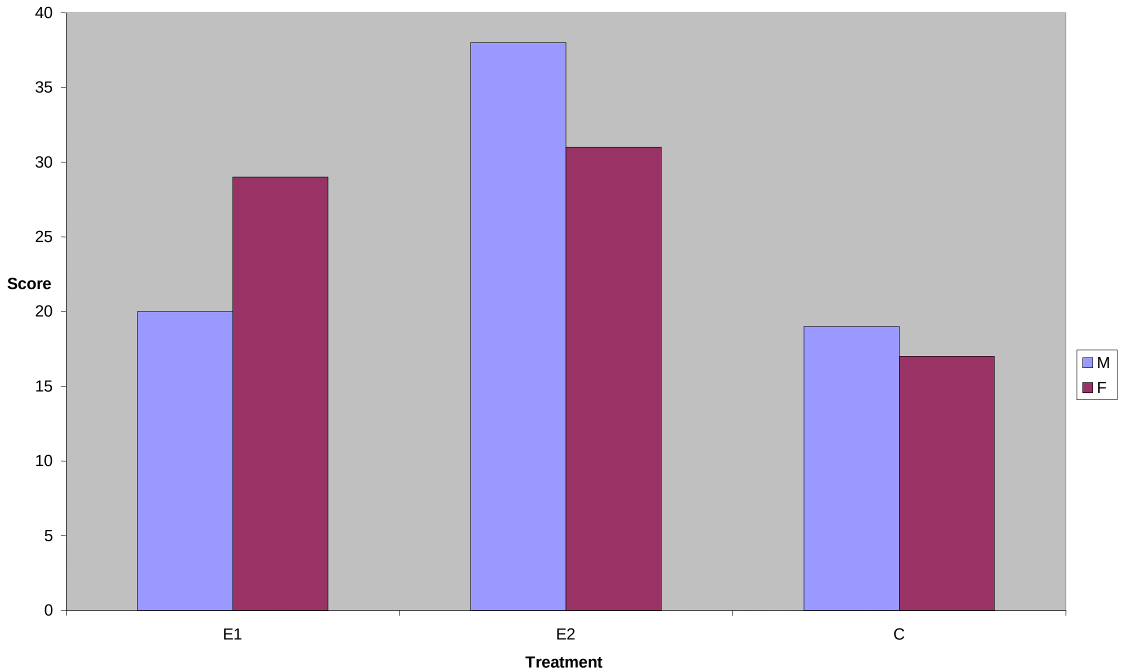

Figure 1: Graphical Illustration of Effect of Treatment and Gender on Achievement in Physics

RESULTS AND DISCUSSION

First, the analysis showed that there was no significant difference in the pre-test mean scores of students in the 3 groups (i.e. PS, CL and C/T methods).Hence; the groups were homogenous since the highest and lowest means do not differ by more than the shortest significant range within the group (Best and Kahn, 1989).

A significant difference has been detected between pre-test and post-test achievement scores for the 3 groups of students selected for the study. The differences are in favour of post-test scores indicating that at the end of the teaching (treatment) there was an improvement in academic achievement of the students of the 3 groups. However, when the post-test achievement scores of the 3 groups were compared, it was found that cooperative learning strategy (E_2) students had higher achievement score than the problem solving strategy (E_1) students while problem solving strategy (E_1) students also had higher achievement score than conventional/traditional method (C) students. At this point, it was found that cooperative learning strategy increased academic achievement of students to a higher level followed by the problem- solving strategy and conventional/traditional method in that order. This finding is in agreement with the results of other studies such as Okebukola (1984), Alebiosu (1998), Johnson, Johnson & Smith (1998), Esan (1999), Boxtel, Linden & Kanselaar (2000), Balfakih (2003), Daubenmire (2004).

The result that cooperative learning strategy is the most successful among the 3 teaching strategies is explicable considering the views of Tanel & Erol (2008) that cooperative learning strategy provides a better learning environment with discussions while learning physics topics and helps students to learn in an easily, effective and meaningful way. In addition, the interaction of students with each other when solving problems, deciding on a solution by discussing with each other and evaluating different views provide them a better understanding atmosphere as pointed out by other studies (Heller & Hollabaugh, 1992; Yu & Stokes, 1998; Alebiosu, 1998; Esan, 1999.

On the issue of significant gender difference, the mean scores of both the male and female students in the post-test reflect that there were improvement in the achievement from what they were in the pre-test for the 3 groups in physics. However, the improvement was more to the side of the male students. That is, the post-test mean score of the male students is greater than that of the female students in physics achievement. This significant effect of gender in favour of male students corroborates the findings of Golbeck (1986), Okpala & Onocha, (1988), Onafowokan & Okpala (1998). In the light of this result, it seems that the gender issues associated with physics achievement is traceable to numerical ability of the testees (Iroegbu, 1998; Adeoye, 2000). This result seems explicable considering the study results of Iroegbu and Okpala (1998) and Okpala and Adeoye (1999) that males would achieve better than females when test items are based on physics concepts that require learners of high numerical ability while the reverse would be the case when the test is based on physics concepts that require learners of low numerical ability.

The result of significant interaction effect of treatment and gender on physics achievement simply suggests that the effects of using cooperative learning strategy followed by problem solving strategy while teaching physics seems to be students gender sensitive. The reported interaction (see figure 1) is such that students exposed to cooperative learning strategy (E_2) followed by problem solving strategy (E_1) performed better than their counterparts in the conventional/traditional method group irrespective of the student's gender. In addition, figure 1, shows that the differential effect of treatments taking together (i.e. E_1, E_2 & C) on physics achievement across the students' gender group was such that the impact was more on male than female. That is, the differences that exist in the scores of male students in the three groups are more than that of the female students. Nevertheless, a critical look at the figure 1 would reveal that male and female students exhibited highest achievement under cooperative learning strategy (males= 38, females = 31) as against their achievement under problem solving strategy (males = 20, females = 29) and the conventional/traditional method (males = 19, females = 17). The figure also shows that male students appear to benefit more from cooperative learning than female students; while female students tend to benefit more from problem-solving strategy than male students. That is, the male students have advantages over their female counterparts in cooperative learning strategy while the reverse is the case in the problem-solving strategy. Both male and female students in the control group were at disadvantage when compared with their colleagues in other two groups. These are irrespective of the tendency for both male and female students to exhibit highest performance in physics when exposed to cooperative learning strategy.

CONCLUSIONS

Based on the results of this study, it can be concluded that the use of cooperative learning strategy as the most suitable method for teaching physics and hence it should be preferred. It is obvious from the results of this study that improved learning ability of male and female students depends on their exposure to many teaching strategies. Therefore, in order to improve senior secondary school males and females learning ability in physics, all the stakeholders in teaching and learning should embrace the cooperative learning strategy in our schools. In view of these findings, the idea of the physics teachers limiting students to only conventional/traditional method should be discouraged. Physics teachers should encourage team work among physics students in order to work together cooperatively.

RECOMMENDATIONS

Based on the above findings, the following recommendations are made:

(i) Pre-service and in-service method courses aimed at facilitating teachers' capacity in integrating cooperative learning strategy in teaching should be organised for physics teachers in Nigerian secondary schools.

(ii) Educational policies and practices should be made to ensure that cooperative learning strategy is used while teaching for acquisition of knowledge of physics concepts.

(iii) Curriculum developers would find the study helpful in designing appropriate instructional strategies involving cooperative learning, which would enhance the learning of physics.

(iv) Practising physics teachers should be encouraged to use cooperative learning strategy as a remedial treatment for female students who are under-achievers in physics because of their gender orientation.

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APPENDIX 1

PHYSICS ACHIEVEMENT TEST (PAT)

1. Which one/ones of the following expression(s) is(are) correct where the resultant force vector applied on the positive unit charge at point K by q_1 and q_2 charges was as in the figure above?.

I. q_1 has positive charge q_2 has negative charge
II. Magnitude of the forces applied on the unit charge at point K by q_1 and $q_2$charges are equal
III. $q_1 – 2q_2$

(a) Only II (b) I and II (c) I and III (d) II and III (e) I, II and III

2. Two plates having surface area of 20 x 10^{-4} m^2 and distance of 0.4 x 10^{-3}m between them are connected to a 120 V battery. How much charge flows to the plates in nC?

(a) 5.31 (b) 4.12 (c) 2.30 (d) 8.56 (e) 12

3. An air capacitor is connected to a battery, and charged, and after charged, it is disconnected from the battery, and then, connected to an ideal voltmeter. If a non conducive material having higher dielectric constant is placed between its plates, then, which one/ones of the following(s) occur(s)?

I. Its capacity increases
II. Its energy increases
III. The potential difference between its ends increases
IV. Its charge does not change

(a) Only III (b) Only II (c) Only II and III (d) I and IV (e) I, II, III and IV

4. A point charge of -8$_{\mu}$C is located at the center of a sphere with a radius of 20cm. What is the electric flux through the surface of this sphere in N.m^2/C

(a) 19 x 10^5 (b) 8 x 10^5 (c) 2 x 10^5 (d) 10^5 (e) 6 x 10^5

5. Find i_2, i_2 and i_3 currents at the circuit in the figure. (The internal resistances of the batteries are neglected)

	i_1	i_2	i_3
(a)	2	-1	-1
(b)	1	1	2
(c)	1	2	1
(d)	2	-1	1
(e)	-1	2	1

6. A circular surface with a radius of 30cm is turned to a position where the maximum flux was

obtained in a regular electric field. At this position, the flux is measured as 5.4 x 10^4 N.m^2/C. How many N/C is the magnitude of the electric field?

(a) 1.10^5 (b) 2.10^5 (c) 4.10^5 (d) 6.10^5 (e) 8.10^5

7. Which one/ones of the followings are <u>not</u> the features of a conductor in an electrostatic equilibrium?

I. The electric field in a conductor is zero
II. Excess charge is collected at the surface
III. Distribution of the charges is regular and independent of the geometry of the conductor
IV. No charge exists within the conductor

(a) Only II (b) Only III (c) Only IV (d) I, II and III (e) III and IV

8. Among the electrical charged spheres K.L.M.N; K attracts L, and repels N, and M attracts N. According to this, which ones of the following spheres have the same charge sign?

(a) K and L, M and N (b) K and M, L and N © K and N, L and M
(d) L, M, N (e) K, L, M

9. How many ohms is a resistance of a silver wire having a vertical cross section area of 0.4mm^2 and a length of 40m at 20^oC temperature? (At 20^0C, the resistively of the silver is p=1.6.0^{-8} Ωm)

(a) 4 (b) 10 (c) 1.6 (d) 1.2 (e) 50

10. Which one/ones of the following information given for the electric field lines constituted by the standing charges are correct?
I. The lines must begin on positive charges and terminates on negative charges
II. The electric field vector is tangent to the electric field line at each point
III. E is small when the field lines are close together and large when they are far part.

(a) Only I (b) Only II (c) Only III (d) I and II (e) II and III

11. The total electric flux passing through a cylinder shape closed surface is 8.6 x 10^4 N.m^2/C. How many nC is the net electric charge within the cylinder?
(a) 860 (b) 124.2 (c) 570 (d) 213 (e) 761.1

12. A thermocouple has an e.m.f of 3mV. It can not be balanced directly on a potentiometer wire of length 100cm connected to a driver (supply) of 2.0V because

(a) the current in the wire is too low
(b) the balance – length would be too high
(c) the wire p.d. is too high
(d) the balance – length would be near the middle of the wire
(e) the thermocouple e.m.f needs to be lower.

13. A 0-10m A moving –coil meter of 5ohm resistance can be coverted into a 0-2A meter by a resistance R with the meter when

(a) R= 0.025uL in parallel
(b) R = 0,025uL in series
(c) R = 190uL in series
(d) R=0.050uL in parallel
(e) R = 0.10uL in parallel

14. A 50V d.c motor has a coil of 0.1uL. At 30rev min^{-1}, the current flowing is 5.0A. When the current flowing is less than 5.0A, the number of rev min^{-1} is

(a) less than 30
(b) more than 30
(c) 30
(d) 10
(e) 0

15. The flux linking a solenoid is 10Wb when the steady current flowing is 2A. If the inductance of the coil is L henries, H, then the best is as follows:

(a) L =5H and the solenoid core is air
(b) L = 5H and the solenoid core is iron
(c) L =0.2H and the solenoid core is air
(d) L = 0.02H and the solenoid core is air
(e) L = 20H and the solenoid core is iron

16. The angle between the magnetic and geographical (longitudinal) meridians is called the angle of dip

(a) Inclination
(b) Elevation
(c) Depression
(d) Declination (variation

17. It is adequate to protect a building from lightning by

(a) fixing a long wooden pole with sharp spikes to the outside wall
(b) fixing a long copper strip from the ground along the outside wall to a sharp vertical spike on the roof
(c) fixing a long, thick rubber strip with sharp spikes to the outside wall
(d) using a long, wire to suspend high resistances diagonally across the roof
(e) using no metal materials for the roof of the house

18 A transformer is connected to a 24OV supply. The primary coil has 2, 4000 turns and the secondary voltage is found to be 30V. Calculate the number of turns in the secondary coil.

(a) 57,600 (b) 3000 (c) 30 (d) 10 (e) 1

19. The defect in simple cell which results in a back e.m.f. and increase in internal resistance is known as

(a) Local action (b) Reduction (c) polarization (d)oxidation (e) depolarization

20. Calculate the electric field intensity 40cm from a point charge of 10C

(a) $5.62NC^{-1}$ (b) 10^{-2} NC^{-1} (c) $5 \times 10^{3}NC^{-3}$ (d) $5.62 \times 10^{5}NC^{-1}$ (e) 10^{10} NC^{-1}

21. Which of the following statements about electric field strength and potential is incorrect?

(a) Electric field intensity is force per unit charge
(b) An electric field is an area where an electric force is felt
(c) The electric potential is force used in taking a positive unit charge from infinity to the point
(d) The electric field = $\frac{\text{Potential difference}}{\text{Distance apart}}$
(e) Work done = Charge x Potential difference

22. Calculate the potential at a point 1m from a charge of 10-0 C in vacuum
(assume $\frac{1}{4\Omega F} = 9 \times 10^{9}$ m)

(a) $1/9 \times 10^{-18}$ V (b) 9×10^{-18}V (c) 9V (d) 9×10^{18}V (e) 1/9V

23. Two plate conductors are placed parallel and 50cm apart. One of the plates is earthed and the other is at a potential of + 10KV. What is the electric intensity between them?

(a) 2×10^{-1}V (b) 2V (c) 20V (d) 2×10^{2}V (e) 2×10^{4}V

24. Which of the following statements about a capacitor is incorrect?

(a) It is used for strong electric charges
(b) It is mostly made of two parallel plates
(c) It is charged by connecting a battery across the terminals
(d) The charge on it is inversely proportional to the p.d across the terminals
(e) The capacitance of the capacitor is the ratio of charge to the p.d across it.

25. Two capacitors of capacitance 3uF and 6uF are connected in series. Calculate the equivalent capacitance

(a) 9μF (b) 6μF (c) 2μF (d) ½ μF (e) 1/4μF

26. A capacitor stores 10^{-4}C of charge when the p.d between the plates is1KV, what is the capacitance?

(a) 10^{-4}μF (b) 0.1μF (c) 4μF (d) 10μF (e) 10^{-7}μF

27. Which of A-E is suitable for converting an a.c generator to a d.c generator?

(a) By replacing the magnet with iron
(b) By replacing the slip rings with brushes
© By replacing the slip rings with split ring or commutator
(d) By replacing the brushes with split ring or commentator
(e) By replacing the armature with a commutator or split ring.

28. Which of the followings is *not* correct?
Large e.m.f. can be produced with a.c. or d.c generators by:

(a) Increasing the number of turns of coil
(b) Increasing the strength of the magnet
(c) Winding the coil on soft iron core
(d) Using a solenoid instead of a magnet
(e) Increasing the rate of rotation of that coil

29. Which of the following is not correct about the indication coil?

(a) It is used in ignition system of motor vehicles
(b) It has a make –and break device
(c) An e.m f of about 10,000V would be obtained at the secondary coil by applying a voltage of 50,000V at the primary coil?
(d) The induced e.m.f. in the secondary coil is large enough to cause a spark across the gap;
(e) One main advantage is that it works from d.c.

30. Which of A-E below is correct about the transmission of electrical power over long distances?
I. It is distributed at low current and high voltage
II. A step-up transformer is used to reduce the voltage at the point of use
III. A step –ip transformer is used before the power is fed into the transmission line

(a) I only (b) III only (c) I and III only (d) II and I only (e) II and III only

31. If an object weighs 96kgf on the surface of the earth what is it likely to weigh on the moon's surface? ($g_m = 1/6g_E$)

(a) *6kgf* (b)9kgf (c)16kgf (d) 96kgf (e) 26kgf

32. A boy cleared a height of 1.5m on the earth's surface. What height is he likely to clear if taken to the moon? ($g_m = 1/6g_E$)

(a) 1.5m (b) 3.0m (c) 4.5m (d) 9.0m (e) 10.05m

33 When an object is undergoing a free fall in a vacuum, its acceleration after 2 seconds is

(a) $9.8ms^{-2}$ (b) $19.6ms^{-2}$ (c) $29.4ms^{-2}$ (d) $39.2ms^{-2}$ (e) $49.4ms^{-2}$

34 Which of the following materials is non-magnetic?

(a) Steel needle (b) Wood (c) Steel pin (d) Iron nail (e) Brass

35 The attractive force of a bar magnet tend to concentrate at the

I. N-pole
II. S-pole
III. Middle of the bar

(a) I only (b) II only (c) I and II only (d) II and III only (e) I, II and III

36 Two reason, 6Ω and 3Ω are connected in parallel. A battery of e.m.f 12V and internal resistance 3Ω is connected across the combination. Calculate the current delivered by the cell.

(a) 1.0A (b) 1.3A (c) 2.0A (d) 2.4A (e) 14.4.A

37 Which of the following instruments is most accurate for comparing e.m.f. of two cells?

(a) Wheatstone bridge (b) Galvanometer (c) Potentiometer (d) Metre bridge
(e) Volumeter

38 A resistor is connected in series with a battery of two cells each having an e.m.f of 1.5V and an internal resistance of 0,5 Ω.
What is the resistance of the resistor if a current of 0.3 A flows through it?

(a) 0.9 (b) 4.5 (c) 9.0 (d) 9.5 (e) 10.0

39. Three resistors, each of resistance 1Ω, are connected in parallel. The combination is connected in series with 1Ω resistor. Calculate the effective resistance of the combination.

(a) 4Ω (b)3Ω (c) 4/3Ω (d) 1Ω (e) 0.5 Ω
(a)

40 Calculate the resitivity of a wire 4.00m long which has a cross sectional area of 0.500mm2 and resistance of 3.5Ω

(a) 1.75×10^{-7} (b) 2.80×10^{-7} (c) 4.38×10^{-7} (d) 4.38×10^{-6} (e) 4.38×10^{-5}

APPENDIX II

PHYSICS PROBLEM-SOLVING PERFORMANCE TEST

Question 1
An electron moving parallel to the x axis has an initial velocity of 3.7 x 10^{6} m/s at the origin. The velocity of the electron is reduced to 1.5 x 10^{5} m/s at the point x = 2 cm. Calculate the potential difference between the origin and the point x = 2 cm. Which point is the higher potential?

Question 2
Two charged concentric spheres have radii of 10.0 and 15.0 cm. The charge on the inner sphere is 4.00 x 10^{-8}C and that on the outer sphere is 2.00 x 10^{-8} C. Find the electric field (a) at r = 12.0 cm and (b) at r = 20.0 cm.

Question3
A parallel-plate capacitor is constructed using three different dielectric materials, as shown in figure below,
(a) Find the expression for the capacitance of the device in terms of the plate area A and d, K_1, K_2 and K_3.
(b) Calculate the capacitance using the values A=1 cm^2, d = 2 mm, K_1= 4.9, K_2 = 5. 6 and K_3 = 2.1

Question 4
A certain toaster has a heating element made of nichrome resistance wire. When first connected to a 120^0V voltage source (and the wire is at a temperature of 20 °C) the initial current is 1.8 A, but the current begins to decrease as the resistive element heats up. When the toaster has reached its final operating temperature, the current has dropped to 1.53A.
(a) Find the power he toaster consumes when it is as its operating temperature
(b) What is the final temperature of the heating element?

Question 5
An electron, with speed 1.9 x 10^6 ms^{-1}, is circulating in a plane at right angles to a uniform magnetic field of 1.0 x 10^{-4}T. Given that mass of electron is 9.1 x 10^{-31}kg and change of electron is 1.6 x10^{-19}C.
Determine:
(i) the radius of the orbit of the electron
(ii) the cyclotron frequency
(iii) the period of revolution and
(iv) the direction of circulation as viewed by an observer sighting along the field

Question 6
A motor has an armature resistance of 4.0Ω. On a 240V supply and a light load, the motor speed is 200 rev. min^{-1} and the armature current is 5A. Calculate the motor speed at a full load when the armature current is 20A

Question 7
A motor operating on a 100-volt circuit develops a back e.m.f. of 90 volts. If the resistance of the armature is 2Ω, calculate
(i) the electric current which flows in the armature, and
(ii) the power that is delivered by the motor

Question 8
The primary and secondary windings of a transformer have 400 and 2000 turns respectively. If the primary is connected to a 220V a. c. Supply, what will be the voltage across the secondary? If the secondary had been connected to the 220V supply what voltage would be developed in the primary coil?

Question 9
A series of R-L-C circuit is connected to 50-cycle a.c. mains of voltage 240V. If R=50Ω, C=8μF and L = 0.80H. Find
(i) the current and
(ii) the power used in the circuit

Question 10

A toroid is 100cm long and has a cross sectional area of $30.0cm^2$. It is wound with a coil of 800 turns of wires and there is a current of 2.50A in it. The iron core has a relative permeability under the given condition of 300. Calculate the magnetic field strength in the coil, the total flux and the flux density.