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EFFECTS OF CLASSWIDE AND RECIPROCAL PEER TUTORING STRATEGIES ON STUDENTS' MATHEMATICAL PROBLEM-SOLVING ACHIEVEMENT IN ELECTRICITY CONCEPTS IN PHYSICS

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ABSTRACT: *The study was designed to determine the effects of classwide and reciprocal peer tutoring strategies on students' mathematical problem-solving achievement in electricity concepts in physics. The design of the study was experimental; specifically the randomized post-test only control group design. The sample consisted of one hundred and twenty senior secondary two (SS2) physics students drawn using simple random sampling technique from three out of the eight public secondary schools in th e study area and randomly assigned as the two experimental groups and one control group respectively. Three research questions and three hypotheses guided the study. Treatment consisted of teaching electricity concepts to the experimental groups using the classwide peer tutoring and reciprocal peer tutoring strategies while the control group was taught using a format not structured after the above strategies. Electricity problem solving test in physics (EPTP) was the instrument used for data collection. A One-way Analysis of Variance (ANOVA) was used to test the hypotheses at 0.05 level of significance. Results revealed a significant difference in the mathematical problem-solving achievement of students among the groups. Post hoc multiple comparison using LSD t-tests was carried out, showing that physics students exposed to classwide peer tutoring strategy performed significantly better than students that had been exposed to reciprocal peer tutoring strategy and control group strategy. Based on the findings, some recommendations were made.*

KEYWORDS: Peer tutoring, tutor, tutee, classwide peer tutoring (CWPT), reciprocal peer tutoring (RPT).

INTRODUCTION

The teacher as the pivot of the educational process is expected to employ measures that would impact favourably on classroom activities. He is expected to create a conducive atmosphere for meaningful interaction between students, and between the student and himself in the teaching and learning process in the classroom. This can be achieved in many ways including individualizing the instruction using peer tutoring (Akubue, 2010).

Peer tutoring which evolved from tutorial instruction as the first pedagogy among primitive societies occur in modern times when the teacher uses students as resources for other students based on the assumption that the later category of students can learn better and faster from fellow students in the former category who have mastered a particular concept or skill.

In peer tutoring, the professional teacher facilitates the activity of the non-professionals or student tutors as they teach their peers or tutees. It is used primarily in the classroom to afford students the opportunity to help each other to learn (Webb, Tropper and Fall, 2007) and it addresses the issue of individual differences in terms of rates of learning. Thus, a student who

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is adjudged to be effective in learning tasks could assist as a tutor in helping their novice classmate acquire and develop specific skills.

Peer tutoring are many and varied. But two types that are of interest to this study are the classwide peer tutoring and the reciprocal peer tutoring. In classwide peer tutoring, every student in the class belongs to a group and has the opportunity to get one-on-one help while students in a group alternate roles in reciprocal peer tutoring. There are however intra-variations for these approaches.

Existing peer tutoring studies reveals the benefits of the strategy to include: effective learning of academic skills, developing social behaviours and discipline and enhancing peer relationships (Greenwood, Carta and Hall, 2008); high level achievement and competence through structured activities (Fantuzzo and Rohrbeck, 2002), improved academic achievement (Utley and Mortweet, 2007); and moderate improvements in tutees and tutors achievement (Kalkowski, 2001). Moust and Schmidt (2004) found that peer tutors were preferred to staff tutors because they exhibited understanding of the tutees learning problems as well as show interest in their lives and personalities.

Problem solving which is fundamental to physics is a complex form of learning that utilizes in a hierarchical order, simpler form processes that were previously acquired (Gagne, 1966) to visualize, imagine, manipulate, analyze, abstract and associate ideas. Problem solving can be viewed as an instructional strategy or a skill/ability.

Problem solving skills in general terms are those skills conceived with the ‘know how’ of everyday life. According to Pemida (2005), it involves identifying the problem/need, examining possible solutions, considering constraints, producing partial solutions, evaluating and accepting. Mathematical problem solving skills as a subtype is both symbolic and closed because it deals with figures or values and has only one correct solution with specific ways of arriving at the solution (Atadoga, 2000). As a transferable skill in physics, mathematical problem solving involve students in solving computational problems with well-defined solution and in providing experience to them in tackling open-ended problems (McLerney, 2000). Physics as a discipline is problem-based owing to its mathematical nature (Egbugara, 1999 and Orgi, 2000). Electricity problems in physics falls under this category. And examination papers set by bodies such as JAMB, NECO and WAEC are replete with questions that require mathematical problem solving skills and largely contribute to measurable learning outcomes in physics. Unfortunately, WAEC Chief Examiners’ Report (CEF) within the last decade where questions have been drawn from this concept indicate students’ inability to figure out precisely with understandings, key variables, mathematical relations, formulae and translations needed to arrive at the right answers to questions in this content area. This is very worrisome when one consider the fact that developing learner’s problem solving skill is seen as a major objective of science instruction (Shaibu and Mari, 2001). This is why the classwide and reciprocal peer tutoring strategies should be experimented upon in classroom instruction to determine their effects on students’ mathematical problem-solving achievement gains.

Statement of the Problem

Students’ high failure rate in physics at school certificate and concessional examinations has been blamed on factors such as poor interest, poor acquisition of problem solving skills and poor attitude (Odikwe, 2001; Atadoga, 2005). This study sought to determine how classwide and reciprocal peer tutoring strategies designed with an admixture of clear tutoring procedures

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and their essential characteristics could guarantee tutees willingness to accept instructions from their peer tutor, thereby helping to examine their impact on students' mathematical problem solving achievement. It is a focused and goal-directed attempt at exploring the rich promises of peer tutoring strategy in improving students' mathematical problem solving achievement in physics.

Purpose of the Study

The purpose of the study was to find out the effects of classwide and reciprocal peer tutoring strategies on students' mathematical problem-solving achievement in physics.

Research Questions

Three research questions were posed to guide this study, viz:

1. Are the mean mathematical problem-solving achievement of physics students exposed to classwide peer tutoring (CWPT) and reciprocal peer tutoring IRPT) strategies significantly different?
2. Are the mean mathematical problem solving achievement of physics students exposed to reciprocal peer tutoring (RPT) strategy and the control group (CG) strategy significantly different?
3. Are the mean mathematical problem solving achievement of physics students exposed to classwide peer tutoring (CWPT) strategy and the control group (CG) strategy significantly different?

Research Hypothesis

The one research hypothesis formulated to guide the study was:

1. There is no significant difference in the mean mathematical problem solving achievement among students exposed to classwide peer tutoring, reciprocal peer tutoring and control group strategies.

Research Design

The study utilized the randomized posttest only control group design with two experimental groups and one control group.

Population

The population of this study was made up of 1000 senior secondary two (SS2) physics students in the eight public secondary schools in Etim Ekpo Local Government Area of Akwa Ibom State of Nigeria.

Sample and Sampling Technique

One hundred and twenty (120) physics SS2 physics students were chosen as representative sample for the study using simple random sampling technique. A table of random numbers was used to select three schools. Students in the three schools were also randomly chosen and similarly assigned to the two treatment (experimental) groups and the control groups. This control by randomization was used to ensure equality of the three research groups that had 40 students each.

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Instrumentation

The only instrument for data collection was the Electricity Problem Solving Test in Physics (EPTP) constructed by the researcher. It had 20 short essay mathematical problem-solving items drawn from electricity concepts in physics. The table of specification used in constructing the EPTP centred around the topics – electric force between point charges, concepts of electric field, electric field intensity and electric potential, capacitance, electric circuit series and parallel arrangement of cells and resistors, principle of potentiometer (metre bridge and wheatstone bridge), measurement of electric current, potential difference, resistance and e.m.f. of a cell - and the objectives of application, analysis and synthesis as given by Bloom (1956) and Anikweze (2014). Well written lesson notes on the concept of electricity with tutorial questions to aid the practical mathematical problem solving applications were also used.

Validation

The EPTP was validated by a team of experts comprising two physics educators and one physics teacher. The trial-testing of the instrument using 30 students in a school that satisfied the random sampling criteria but which were not used for the actual study yielded a reliability coefficient of 0.80 using the test-retest method. Inter scorer reliability was also pursued using Kendall's coefficient of concordance (w) and a high positive reliability coefficient of 0.85 was obtained.

Scoring

Each of the 20 questions which were not omnibus in nature was scored five marks each. The marks were carefully distributed for the marking scheme prepared using the analytical or point score method.

Research Procedure

The two experimental groups and one control group were arrived at through proper randomization procedure. The physics teachers used for the study were then trained as research assistants using careful written lesson notes on the concept of electricity. The training lasted for 1 week. The experimental and control groups were taught for 4 weeks in two lesson periods of 40 minutes each in a week. The crux of the research procedure for the three groups centred on three phases namely: pre-tutoring session, tutoring session and post-tutoring session. These sessions were created using guidelines based on a crossbreed of ideas for successful implementation of peer tutoring in classroom setting, as advanced by Damon and Phelps (2009) and Akubue (2010).

The pre and post tutoring sessions were similar for the two experimental and one control groups in the study. The groups differed only in the tutoring session. Thus, the pre-tutoring session for the three groups entailed establishing the level of expectation for students learning by the research assistants through a highlight of the lesson topic, performance objectives and actual examination of the content elements to each of the groups using the lesson notes. Also, cautions to exercise in the tutoring process such as skill required for teaching the lesson and display of the desired achievement were clearly demonstrated.

The tutoring (treatment) sessions were conducted differently in the three groups. In experimental group 1 using the classwide peer tutoring (CWPT) strategy, the student tutors took turn to sole the tutorial questions. The research assistants provided assistance to the

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students so that each of them can solve the questions provided, wholly or partially, to their peers who remain engrossed in the tutoring process. The tutoring procedure was monitored with a view to providing advice on learning problems as well as suggest ways to overcome them. The subject using the reciprocal peer tutoring (RPT) strategy in experimental group 2 performed different roles such as prompting encouraging, etc while solving the tutorial questions provided. They also receive and utilize feedback from their peers. The research assistants also monitored the tutoring procedures, giving advice on learning problems and suggesting possible ways of overcoming them. In the control group, the subjects were given the tutorial questions to solve devoid of interaction because neither one-on-one help nor alternate roles following structured format was possible.

The post tutoring session consisted of giving useful mathematical hint on the concept of the study and also require the use of the EPTP to verify the mathematical problem solving achievement of the three groups of students in electricity concepts in physics.

Method of Data Analysis

The data collected were analyzed using one-way Analysis of Variance (ANOVA).

Result/Interpretation

The One-way ANOVA SPSS output is presented in Tables 1, 2 and 3. This output consists of the descriptive, ANOVA and multiple comparison.

Table 1: Means and Standard Deviation of Post-test Mathematical Problem Solving Achievement Scores of CWPT, RPT and Control groups

Strategy	N	Mean	Std. Deviation
CWPT	40	71.38	10.741
RPT	40	57.25	9.671
CG	40	34.50	13.388
Total	**120**	**54.38**	**18.971**

NB: CWPT = CLasswide peer tutoring strategy

RPT = Reciprocal peer tutoring strategy

CG = Control group

In Table 1, the descriptive output gives each group sample size, mean and standard deviation. The means and standard deviations (presented in parentheses) for the CWPT group, the RPT group and the control group are 71.38 (10.741), 57.25 (9.671) and 34.50 (13.388) respectively. Thus, eyeballing the data, it can be suspected that the CWPT group solved more mathematical problems than the other two groups.

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Table 2: Analysis of Variance for Post-test Mathematical Problem Solving Achievement Scores of CWPT, RPT and Control groups

Source	Sum of Square (SS)	df	Mean Square (MS)	F	Sig.
Between Groups	27691.250	2	13845.625	107.019	.000
Within Groups	15136.875	117	129.375		
Total	42828.125	119			

In Table 2, the between, within and total sum of squares are 27691.250, 15136.875 and 42828.125 with corresponding degree of freedom between groups, within groups and total as 2,117 and 119 respectively. The One-way ANOVA of the posttest mathematical problem solving achievement scores revealed a statistically significant main effect [$F(2,117) = 107.019$, $P < .001$] which falls well below the required .05 alpha level, indicating that not all three groups of the peer tutoring strategies resulted in the same mathematical problem solving achievement score. The null hypothesis is rejected, implying that the differences between the groups are significant. The measure of association (ω^2 omega squared) is 0.6386. This means that the independent variable in the ANOVA accounts for approximately 63.86% of the total variance in the dependence variable.

Table 3: Least Square Difference (LSD) Multiple Comparison for Post-test Mathematical Problem Solving Achievement Scores by Peer Tutoring Strategy

Experiment Group (I)	Experiment Group (J)	Mean Difference (I – J)	Std. Error	Sig.
CWPT	RPT	14.125*	2.543	.000
	CG	36.875*	2.543	.000
RPT	CWPT	-14.125*	2.543	.000
	CG	22.750*	2.543	.000
CG	CWPT	-36.875*	2.543	.000
	RPT	-22.750*	2.543	.000

** The mean difference is significant at the 0.05 level*

Since the null hypothesis is rejected, Table 3 shows the use of LSD post hoc procedure to determine whether unique pairwise comparisons are significant. The multiple comparison output block presents the results of the LSD t-tests in three major rows (with the remaining two variables comprising minor rows of their own). The first and second column of data labeled mean difference (I-J) and standard error presents the numerator and denominator of the LSD t-test respectively while the third column of data presents the exact level of significance associated with the obtained LSD t-value. A keen observation of CWPT row showed a mean difference, standard error and significance level of 14.125, 2.543 and .000 indicating that the difference between the CWPT group and RPT group means is significant at least at the 0.001 alpha level (which falls well below the required .05 alpha level). Thus, physics students exposed to classwide peer tutoring (CWPT) strategy achieved significantly in mathematical

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problem solving in electricity than those exposed to reciprocal peer tutoring (RPT) strategy. This answer research question 1.

In the second row of the CWPT major row, the mean difference, standard error and significance level of 36.875, 2.543 and .000 respectively are recorded. Thus, the physics students in the CWPT group gained significantly more mathematical problem solving achievement than did the students in the control group where neither one-on-one help nor alternate roles following structured format was employed.

In the second major row, the first comparison (RPT-CWPT) is redundant with the comparison made between CWPT and RPT present in the CWPT major row. The negative sign notwithstanding, this comparison answer the question: Are the mean mathematical problem solving achievement of physics students exposed to CWPT and RPT significantly different? The significance level is the same as obtained for the CWPT-RPT comparison. Evaluating the RPT-CG comparison gives the mean difference, standard error and significance level as 22.750, 2.543 and .000. And since the significance level is still within the required .05 alpha level, it is concluded that the difference in mathematical problem solving achievement in electricity for the RPT group and CG group is significant. This observation also answers research question 2. The final major row in the output (labeled CG) presents the CG-CWPT and CG-RPT comparisons. These comparisons are redundant with the CWPT-CG and the RPT-CG comparisons presented above and so there is no need to interpret these results. In summary, the LSD multiple comparison indicates that the physics students who were exposed to the classwide peer tutoring (CWPT) strategy gained more mathematical problem solving achievement than those students who had either reciprocal peer tutoring (RPT) strategy or control conditions. Furthermore, physics students who had RPT exposure in electricity concepts achieved more in mathematical problem solving than those in the control group where none of the structured formats was applied.

Discussion

Results showed that the classwide and reciprocal peer tutoring strategies were both effective than the control strategy with regards to improving students' mathematical problem solving achievement in electricity concepts in physics. This could be explained by the fact that both peer tutoring strategies afforded students the opportunity to help each other to learn by addressing the students' individual differences. The students were thus challenged to figure out variables and relations that enabled them to solve mathematical problems and open-ended problem in electricity concepts which hitherto was difficult to utilize and associate ideas to arrive at well-defined solutions. This is in agreement with the work of Fantuzzo and Rohrbeck (2002) and Utley and Mortweet (2007). The certainty of the strategies in bringing about effective learning of academic skills such as mathematical problem solving may serve as justification for using peer tutoring strategies especially the classwide and reciprocal peer tutoring in physics instruction.

CONCLUSION AND RECOMMENDATIONS

The findings of this study revealed that the use of classwide peer tutoring strategy for teaching electricity concepts in physics enabled students to achieve mathematical problem solving better than in using the reciprocal peer tutoring strategy or the control strategy without any structured

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formats above. There was more achievement gains in mathematical problem solving of physics students exposed to reciprocal peer tutoring strategy than those exposed to the control strategy. The findings of this study has brought to the fore those peer tutoring strategies that enhances students achievement especially in mathematical problem solving. Based on the findings of this study, the following recommendations were made:

1. Classwide peer tutoring and reciprocal peer tutoring strategies should be adopted by physics teachers in presenting electricity concepts to students.

2. Classwide/reciprocal peer tutoring strategies should be incorporated into the physics curriculum and physics textbooks by curriculum planners and authors of textbooks as potent and facilitative strategies for teaching electricity concepts in physics.

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