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Effect of Problem-Based Learning on Senior Secondary School Students' Achievement in Trigonometry in Northern Educational Zone of Cross River State, Nigeria

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Abstracts: *The research was an experimental study carried out to determine the efficacy of Problem-Based Learning on senior secondary school students' achievement in trigonometry. A sample of 365 out of 4162 senior secondary school two students from four secondary schools in Northern educational zone of cross River State was used. The items of the instrument were validated by two mathematics educators, two experts in measurement and evaluation and one mathematics teacher. Mean and standard deviation were used to answer the research questions while ANCOVA was employed to test the hypotheses at .05 level of significance. The result was analyzed to verify whether any significant difference existed in the achievement of problem-based learning group and conventional group, as well as significant gender difference in their achievement. The study revealed that there existed a significant difference between the experimental and control groups in favour of the experimental class. The male and female SS students exhibit equal knowledge when taught trigonometry using PBL. The findings also revealed that there is no significant interaction effect between teaching method and gender on students' achievement in trigonometry. Based on the findings of the this study, it was recommended that problem-based learning may be integrated into mathematics curriculum for the pre-service mathematics teachers programme as well as authors of mathematics education methods should be encouraged to include PBL in their writings.*

I. Introduction

Mathematics education in Nigeria seems to be passing through the furnace of transformation. This could be inferred from the efforts of the Mathematical Association of Nigeria (MAN) in the last few decades to popularize the teaching and learning of mathematics at all levels of instruction. Consequently, the mere knowledge of mathematical concepts without the corresponding knowledge of their application to real life seems to be fading away. This among other things has influenced human learning and challenged educators, especially in the area of mathematics education, to experiment with innovative instructional methods for core curriculum across all levels of educational system. In Nigeria, mathematics has continued to be one of the core subjects at all levels of education so that, every child will acquire appropriate mathematical skills and knowledge to solve human problems in all spheres of life (Nigerian Educational Research and Development Council [NERDC], 2008).

Learning and understanding of some mathematics topics have not only been frustrated by the nature of the topics but also by clumsy methods and instructional materials used (Etukudo, 2000; Etukudo & Utin, 2006). The resultant effect is the poor achievement level of students both in internal and external examinations. In view of this, Iji (2002) in trying to find solution to this ugly situation of poor performance in mathematics in public examination identified teaching techniques by the teachers as one of the contributory factors. This point to the fact that good teaching helps the learners to learn more qualitatively and quantitatively and poor teaching would lead to poor learning and poor performance. One may associate this poor mathematics achievement by Nigerian students to some pedagogies adopted (Salau, 2002). He lamented on poor achievement of students in mathematics and points out that introduction of suitable instructional materials and methods are the likely solution. Literature and available records have shown a variety of efficacious innovative teaching strategies that have been identified by researchers to alleviate this problem of poor performance of students in mathematics, but their performance continues to deteriorate year after year. However, none of these research efforts has sought solution to this problem from the dimension of using student-centred and home-based activity approach to teaching- which is Problem based learning (PBL).

According to Shaibu and Usman in Kurumeh (2006), involvement of students in the teaching and learning process which means a departure from the traditional methods of teaching is another means of ensuring active learning in science and mathematics. The call for a departure from traditional methods of teaching with its attendant poor performance indices has been sounded by researchers (Okebukola, 2002; Iji, 2005; Etukudo & Utin, 2006; Abakpa, 2011 ; Mtsem, 2011). This is with the intension of obtaining admirable results.

However, this departure cannot come only through such means as Computer Assisted Instruction, Mastery learning, Logo and Basic Instructional Packages as well as Contextual Strategy in teaching mathematics. There is still poor performance of students in public examinations year after year. Thus, research on instructional strategies that will improve the quality of learning of mathematics has continued to generate interest among mathematics educators and scholars as the conventional method has failed to meet the learners' needs. The implication of these lapses identified in the conventional teaching method is that non-traditional teaching methods that will improve students' achievement have to be explored. Therefore, there is need to try out another Instructional Strategy like Problem-Based Learning (PBL) in giving trigonometric instructional method.

Proponents of mathematical problem based learning; Karl in Kurumeh (2009) insisted that students become good problem solvers by learning mathematical knowledge heuristically. A study by Achuonye (2004) on PBL strategy on higher cognitive skills performance in Biology revealed the emphasis of PBL curricula on application of previous knowledge, problem-solving, higher order thinking and self-directed learning skills. The above skills equip students with professional and life-long learning habits of mind are indispensable qualities of successful professional of this era. This position has necessitated the present study to be carried out on PBL effect on the teaching and learning of trigonometry at the senior secondary school education.

The Nigerian secondary school mathematics curriculum is developed and structured around five main concepts namely: algebra, arithmetic, geometry, statistics and trigonometry. Trigonometry is an important branch of school mathematics that has everyday application in the life of the child especially in estimation, construction, technology and astronomical relationship (Sidhu, 2006). It is the aspect of school mathematics involving the measurement of distances, angles, lines, relationships and surfaces. Trigonometry enables the child to use the knowledge of mathematics in latitude and longitude, when he eventually becomes a pilot, sailor or navigator to locate position of landing or anchorage (Chire & Akem, 2010). This shows that without trigonometric knowledge in mathematics, the taking-off and landing of aeroplanes using angles of elevation and depression will be very difficult. This is as a result of the fact that the determination of altitude of an aeroplane uses angles of elevation and depression. The knowledge of bearings is a vital tool for the pilots, sailors and soldiers. This process helps soldiers to locate the position of enemies during wars and range of shelling.

The knowledge of trigonometry assists students to appreciate shapes and situations around their environment and helps to develop their inductive reasoning skills that become necessary ingredient for learning mathematics. Unlike geometry, trigonometry constitutes a substantial part of the senior secondary school mathematics curriculum, which forms a great part in their assessment (Abakpa, 2011). Achievement according to Elliot, Kratochwill, Cook and Traver (2002), Kurumeh (2006), Musa and Agwagah (2006) and Abakpa (2011) is the measure of accomplishment in a specific field of study. They argued that achievement in mathematics test is the demonstration of the child's ability to attain certain level of instructional objectives out of his classroom experiences. The low achievement in mathematics by the students has been a source of concern to the public and mathematics educators in view of importance attached to mathematics as a veritable tool for the overall development of the individuals and the society at large. The reports of WAEC chief examiner and mathematics education researchers revealed that most students including those who passed mathematics at credit level and those who failed, haphazardly attempted geometry and trigonometry questions or avoided them completely, mostly those of the essay questions(WAEC,2013).

Though researchers have revealed various techniques of teaching mathematics and some aspects of mathematics, they merely linked general skills of questioning and discussion with specific topics. They do not reveal ways of enriching the mathematical experiences of all students through discussion, problem-solving and mathematical investigation. Reports on various teaching techniques indicate that they improve students' learning and achievement. Yet results from public examination bodies on students' achievement are low. Thus, the need to explore other strategies that may enhance students' achievement in mathematics. Hence, this study examines if teaching using PBL on senior secondary school students will improve their achievement in trigonometry.

Problem-Based Learning, according to Debbie and Leanne in Wikipedia (2011), seeks to produce learners who not only remember Mathematical science theory, but to know how and when to apply it. This implies that providing a mathematics problem to a group of students, is not a guarantee that they will be able to solve it. Even more uncertain is whether the solution the students offer and the journey they undertake to arrive at it resulted in them learning the intended underlying concepts and theories. As students become increasingly poor in mathematics achievement test, they are less inclined towards a learning approach which requires them to be self-directed and motivated. PBL should be ideal for students working in groups and can benefit them as they are more likely to brainstorm and come up with ideas and thoughts before they reach possible solutions.

The need to explore means to close the gaps between students' mathematics achievement irrespective of sex had been a source of worry to educators, government and individuals. Review of studies shows consistency on results of male and female students' achievement in mathematics. Results in general mathematics (Etukudo, 2002; Ezeugo & Agwagah, 2000) and in geometry achievement test (Iji, 2002 and

Abakpa, 2011) and in Algebra (Ezeugo & Agwagah, 2000 ; Mtsem, 2011) do indicate that there is significant difference between the male and female students in mathematics achievement tests. Specifically most of these studies did not examine the achievement of male and female students' in trigonometry achievement tests but rather in general mathematics, algebra and geometry. Thus, mathematics educators are continuously conducting research on how to improve students' achievement in mathematics at the secondary school education level so that individual differences in achievement may be reduced irrespective of gender. This necessitated present study to investigate if both genders shall benefit equally in Trigonometry achievement test when taught with PBL.

With self-directed instructional method of problem-based learning, this study intends to find out if the teaching and learning of mathematics may generally be made simple to enhance students' interest and achievement. This study is aimed at finding out the effect of Problem-based learning method on students' achievement in trigonometric concepts in mathematics at the SS II level.

Statement of the Problem: Mathematics as the bedrock of all scientific and technological advancement is a pre-requisite to almost all courses in colleges of education, polytechnics and universities. Trigonometry as an aspect of mathematics is a human invention, borne out of human mind, resolve to solve human problems. Thus as a creation of mind, it is concerned primarily with ideas, process and reasoning. Of all the factors that affect teaching-learning in the educational system of any society, teaching method seem to constitute the primary issue. Perhaps, the teaching method in use in many schools such as lecture method, demonstration, and laboratory among others seem not to have brought about an effective teaching-learning, and could have resulted in students' poor achievement in WAEC and NECO examinations. Hence, the need to adopt a better teaching method that would positively influence candidates' achievement especially in trigonometry. Therefore, the problem to be investigated in this study posed as questions are: Would students improve upon their achievement in trigonometry if problem-based learning method is employed in teaching trigonometry? Would any of the sexes benefit more than the other in trigonometry as an aspect of school mathematics due to the use of this teaching method.

Purpose of the Study: The purpose of this study was to determine the efficacy of problem-based learning on senior secondary school students' achievement in trigonometry. It also tries to determine its differential effect of gender on students' achievement in trigonometry.

Research Questions: The following research questions were asked to guide the study.

1. What are the mean achievement scores of students taught trigonometry using PBL and those taught using the conventional method?
2. What are the mean achievement scores in TAT of male and female students taught Trigonometry using PBL?
3. What is the interaction effects of teaching methods and gender on students' achievement in trigonometry ?

Research Hypotheses: The following research hypotheses were formulated and would be tested at 0.05 level of significance.

1. There is no significant difference between the mean achievement scores in TAT of students taught trigonometry using PBL and those taught using the conventional method.
2. There is no significant differential effect of gender on the mean achievement scores in TAT students taught trigonometry using Problem – Based Learning.
3. There is no significant interaction effect between teaching method and gender on students' means achievement scores in trigonometry.

Design of the Study: The study employs a quasi-experimental design of non-equivalent group. Specifically, the study used a non-randomized pre-test post-test control group design. This design is selected because it is not possible to have a complete randomization of subjects as this would disrupt the normal classroom organization of the schools. Therefore, intact classes were randomly assigned to the experimental and control groups.

Area of the Study: The study was carried out in Northern Educational Zone of Cross River State. This consists of five Local Government Areas namely: Bekwarra, Obanliku, Obudu, Ogoja and Yala Local Government Areas. The area comprises two Federal Constituencies namely: Part A comprising schools in Bekwarra, Obanliku and Obudu Local Government Areas while Part B comprised schools in Ogoja and Yala L.G.As.

Population and Sample of the Study: The target population of the study was 4162 senior secondary school two (SS II) students in 72 secondary schools located in the five Local Government Areas of the Zone. The SS II

students were used because it is at this level that students are adequately and effectively prepared for public mathematics examination. The sample for this study consists of 365 students drawn from four Local Government Areas. It comprised of 203 males and 162 females SS2 students.

Intact classes in each of the four schools were randomly assigned to experimental and control groups in manner that each has equal and independent chance of being included in the sample. This was done by toss of a coin- head for experimental group and tail for control group. Two schools, one from each zone for the experimental groups were the Problem-Based Learning (PBL) groups while the other two schools for control groups were the conventional Method.

Instrument and Validation of the Study: The research instruments used in this study was Trigonometry Achievement Test (TAT). The TAT was administered twice, before (pre) and after (post) the experiment. There were pre-TAT and post-TAT tests. The pre-TAT was used to ascertain the level of trigonometry achievement at which the students were, before the treatment while the post-TAT was used to determine the extent of students' trigonometry achievement after the experiment. The content of TAT is based on the trigonometry content listed as: Trigonometric ratios of angles with and without using tables, sine and cosine rules, angles of elevation and depression, solving triangles using sine and cosine rules, bearings and distance.

The lesson plans were written as a guide for teaching the control group and the experimental group throughout the period of this study. There were two types of lesson plans. The control group lesson plan was written in the conventional way of preparing lessons. The experimental group lesson plan was written by the researcher using Problem Based Learning method. The lesson plans for both control and experimental groups retained the same content. They were based on trigonometry content of SS two that was taught during the period covered by the study. The instrument was teacher–made test constructed by the researchers as well as extracts of some items from past SSCE questions were used to collect data on the students' level of intellectual functioning in secondary school trigonometry aspect of mathematics**.** The TAT instrument for data collection was multiple-choice test consisting of 20 items and 5-essay items selected from trigonometry topics in mathematics curriculum. Each item of the instruments which was multiple choice in structure has five options lettered A-E with a pseudo-chance parameter of 0.2 probability of success for low ability students.

The marking scheme for the TAT and the lesson plans were developed for the study. The development of the lesson plans is done as described below: Ten lesson plans were prepared to facilitate the carrying out of the study. It was three lessons per week for 3 weeks; while post-test took week 4 and retention test took week 5 respectively. Each correct multiple choice test item attracts 3-marks while the essay part was scored in continuum according to the skills tested. A total obtainable mark for the multiple choice test items was 60 while that of essay items was 40. The test instrument constructed by the researchers was given for face and content validation to two mathematics educators, two experts in measurement and evaluation and one mathematics teacher.

Reliability of Instruments: To establish the reliability of the instruments, the researchers used Cronbach Alpha (**α)** and Kuder-Richardson formula 20 ($K\text{-}R_{20}$) methods. The test scores for the instrument were computed using Cronbach-Alpha to obtain internal consistency measure **α.** The value of the internal consistency measure was calculated as 0.80 for TAT (essay). This indicates a positive internal consistency of the items of the instruments. This showed that the reliability values of the instruments are high and have good degree of stability. Kuder – Richardson ($K\text{-}R_{20}$) was used for the multiple choice TAT test items. This is because they are measured dichotomously. The internal consistency of the multiple choice instrument indices for TAT was {0.70}. Pallant (2005) stated that the acceptable alpha (**α**) value for large population should be 0.7 and above. It showed that the values obtained are positive and had enough potential to make predictive study worthwhile.

Procedure for Conducting the Study: The researchers used regular school mathematics teachers as Research Assistants for the study. A training programme was organized for them. They were properly coordinated on the necessary steps on the of Problem- Based Learning (PBL) approach and the conventional approach for the treatment and control groups respectively. The necessary instructional materials were made available for the study. Before the commencement of the lesson, TAT was administered to as a pre-test to both treatment and the control groups by the teachers. The teachers taught the treatment group trigonometry topics using PBL approach adhering strictly to the lesson procedure prepared by the researchers. The control group was taught the topics using normal lesson plans. The researchers supervised the teachers during the teaching process to be sure they do not deviate from the steps.

Method of Data Collection: A pre-test was conducted on all subjects in the sample. It was used as a comparing reference point to post-test to establish extent of effect of treatment. Before the post-test was administered, treatment was given to the experimental group for five weeks. The pre-TAT was administered to the subjects

before the commencement of the study. The post-TAT which is the same in content but different in organization from the pre-TAT was administered to the subjects after the last period of the study. The TAT was scored out of 100% using the marking schemes. In all, the researcher administered 365 questionnaires/test instruments, but after retrieval, it was discovered that 11 questionnaires had discrepancies and were discarded. A total of 354 copies of the questionnaires were used for analysis.

II. Method of Data Analysis

Τηε ρεσεαρχη θυεστιονσ ωερε ανσωερεδ υσινγ μεαν ανδ στανδαρδ δεπιατιον. Τηε αναλψσισ οφ Χοπαριανχε (ΑΝΧΟςΑ) ωασ υσεδ το τεστ τηε ηψποτηεσεσ ατ 0.05 λεπελ οφ σιγνιφιχανχε (π<0.05). Τηε χριτερια φορ τηε χηοιχε οφ ΑΝΧΟςΑ ιν τηισ στυδψ ισ τηατ σινχε τηε ινταχτ χλασσεσ ωερε υσεδ φορ τρεατμεντ ανδ χοντρολ ρεσπεχτιπελψ, τηε γαιν σχορεσ, τηε διφφερενχε βετωεεν τηε πρε ανδ ποστ τεστ μεανσ, ωασ αναλψζεδ το δετερμινε τηε στατιστιχαλ σιγνιφιχανχε βετωεεν ανδ ωιτηιν γρουπσ ασ χοπαριανχε βετωεεν πρε–τεστ ανδ ποστ τεστ.

Τηε τωο ασσυμπτιονσ τεστεδ το φυστιφψ τηε υσε οφ ΑΝΧΟςΑ φορ τηισ στυδψ αρε τηε λινεαριτψβετωεεν τηε δεπενδεντ παριαβλεσ ανδ τηε χοπαριατεσ , ανδ ηομογενειτψ οφ ρεγρεσσιον σλοπεσ.

Τηε Λινεαριτψ Βετωεεν τηε Δεπενδεντ ςαριαβλεσ ανδ Χοπαριατε :Τηε λινεαριτψ βετωεεν τηε δεπενδεντ παριαβλεσ ανδ τηε χοπαριατεσ ωερε εσταβλισηεδ βψ πλοτινγ ανδ ιντερπρετινγ τηε σχαττεργραμε οφ τηε πιοντσ οφ συβφεχτσ σχορεσ ιν τηε δεπενδεντ ανδ χοπαριατε παριαβλεσ. Τηε δεπενδεντ παριαβλε (ποστ–τεστ) ωασ πλοτεδ αγαινστ τηε χοπαριατε (Φιγυρεσ 1). Τηε ρελατιονσηιπ ιν τηε σχαττεργραμε ισ λινεαρ , σο τηε ασσυμπτιον οφ λεαριτψ ρελατιοσηιπ ωασ νοτ πιολατεδ (Παλλαντ, 2005).

Ηομογενειτψ οφ Ρεγρεσσιον Σλοπε : Τηε ηομογενειτψ οφ ρεγρεσσιον σλοπεσ ωασ χομπυτεδ στστιστιχαλλψ ανδ τηε ρεσυλτ πρεσεντεδ ιν Απενδιχεσ Α. Στατιστιχαλλψ, τηε ιντεραχτιον βετωεεν τηε τρεαμεντ ανδ χοπαριατε ωασ νοτ σιγνιφιχαντ. Τηερεφορε, τηε ηομογενειτψ οφ ρεγρεσσιον σλοπε ωασ νοτ πιολατεδ. Τηε π–παλυε χομπυτεδ ωασ 0.28. Σινχε τηε π–παλυε ισ γρεατερ τηαν τηε .05 λεπελ οφ σιγνιφιχανχε, τηε ιντεραχτιον βετωεεν τηε τρεατμεντ ανδ τηε χοπαριατε ισ νοτ σιγνιφιχαντ. Τηερεφορε, τηε ηομογενειτψ οφ ρεγρεσσιον σλοπε ωασ νοτ πιολατεδ τηερεβψ ωαρραντινγ τηε υσε οφ ΑΝΧΟςΑ.**Ρεσεαρχη Θυεστιον 1 :** Ωηατ αρε τηε μεαν αχηιεπεμεντ σχορεσ οφ στυδεντσ ταυγητ τρ ιγονομετρψ υσινγ ΠΒΛ ανδ τηοσε ταυγητ υσινγ τηε χονπεντιοναλ μετηοδ? Τηε ρεσυλτ οφ τηε αναλψσισ ισ πρεσεντεδ ιν Ταβλε 1.

[illegible]

	Group of treatment type	Mean	Std. Deviation	N
Pre-TAT	Control group	43.12	5.53	244
	Experimental group	43.58	5.61	110
	Difference	0.46		
Post-TAT	Control group	57.03	7.72	244
	Experimental group	64.13	7.46	110
	Difference	7.10		

[illegible]

The question can be answered that there is a noticed difference between mean achievement scores of students taught using PBL and those taught using Conventional Method with students taught using PBL achieving higher.

Source	Type III Sum of Squares	df	Mean Square	F-value	Sig.
Corrected Model	21300.677[a]	2	10650.338	1215.751	.000
Intercept	176.903	1	176.903	20.194	.000
Pre-TAT	17480.155	1	17480.155	1995.385	.000
Group	3214.924	1	3214.924	366.988	.000
Error	3074.863	351	8.760		
Total	1266463.000	354			
Corrected Total	24375.540	353			

P = .00 < .05

Ταβλε 4 σηοωσ Φ(1,353) = 366.99, π = .00 < .05. Τηισ ιμπλιεσ τηατ τηερε ισ α σιγνιφιχανχε δι φφερενχε ιν τηε μεαν αχηιεϖεμεντ σχορεσ ιν τηε τωο γρουπσ. Ηενχε, τηε νυλλ ηψποτηεσισ οφ νο σιγ νιφιχανχε διφφερενχε ισ ρεφεχτεδ. The conclusion is that there is a significant difference between the mean achievement scores in TAT of students taught trigonometry using PBL and those taught using the conventional method.

ΤΑΒΛΕ 3: ΜΕΑΝΣ ΑΝΔ ΣΤΑΝΔΑΡΔ ΔΕςΙΑΤΙΟΝΣ ΟΦ ΜΕΑΝ ΑΧΗΙΕςΕΜΕΝΤ ΣΧΟΡΕΣ ΟΦ ΜΑΛΕ Α ΝΔ ΦΕΜΑΛΕ ΣΤΥΔΕΝΤΣ ΤΑΥΓΗΤ ΤΡΙΓΟΝΟΜΕΤΡΨ ΥΣΙΝΓ ΠΒΛ.

Source	Male or female	Mean	Std. Deviation	N
Pre- TAT	Male	44.11	5.18	55
	Female	43.05	6.01	55
	Difference	1.05		
Post-TAT	Male	64.40	7.65	55
	Female	63.85	7.33	55
	Difference	0.55		

From Table 3, it can be seen in the experimental group that, at prê-TAT the 55 male students had mean achievement of 44.11 with standard deviation of 5.18 while the 55 female students had 43.05 with standard deviation of 6.01. The calculated mean difference between the male and female students at pre-TAT is 1.05. This is an infinitesimal difference. This means that before the commencement of the treatment in the experimental group, male students have similar knowledge level in trigonometry with the female students. After the treatment, the mean achievement scores of male students in post-TAT were 64.40 with standard deviation of 7.65 and that of female students was 63.85 with standard deviation of 7.33. The difference is just 0.55. This means that there is no difference between male and female students in their achievement taught trigonometry using PBL.

Ηψποτηεσισ 2 : Τηερε ισ νο σιγνιφιχαντ διφφερενχε βετωεεν τηε μεαν αχηιεωεμεντ σχορεσ ιν τριγονο μετρψ αχηιεωεμεντ τεστ οφ μαλε ανδ φεμαλε στυδεντσ ταυγητ τριγονομετρψ υσινγ ΠΒΛ. Υσινγ τηε Αναλψσισ οφ Χοωαριανχε (ΑΝΧΟςΑ), τηισ ηψποτηεσισ ωασ τεστεδ. Τηε ρεσυλτ οφ τηε αναλψ σισ ισ πρεσεντεδ ιν Ταβλε 4.

ΤΑΒΛΕ 4: ΑΝΧΟςΑ ΟΦ ΕΞΠΕΡΙΜΕΝΤΑΛ ΓΡΟΥΠ ΠΟΣΤ–ΤΑΤ ΔΥΕ ΤΟ ΣΕΞ

Dependent Variable: PostTaT

Source	Type III Sum of Squares	df	Mean Square	F-value	ig.
Corrected Model	5153.75[a]	2	2576.88	300.20	.00
Intercept	195.43	1	195.43	22.78	.00
PreTAT	5145.57	1	5145.57	599.45	.00
Sex	15.39	1	15.39	1.79	.18
Error	918.47	107	8.58		
Total	458426.00	110			
Corrected Total	6072.22	109			

P = .18 > .05

Table 4, reading across row heading **Sex** and column heading **Sig. (Group: Sig** =.18) for the significant difference between male and female students taught using PBL. The associated probability is 0.18 = p. Since p is greater than 0.05 the difference noticed between male and female students achievement scores noticed in Table 3 is statistically not significant. So the hypothesis is not rejected. The conclusion is that there is no significant difference between the mean achievement scores of male and female students taught trigonometry using PBL.

Ρεσεαρχη Θυεστιον 3 : Ωηατ ισ τηε ιντεραχτιον εφφεχτ οφ τεαχηινγ μετηοδ ανδ γενδερ ον στυδεντσə μεαν αχηιεωεμεντ σχορεσ ι ν Τριγονομετρψ? Interaction effect of gender and teaching method is read from Table 5 using row heading **Group * Sex** and column heading **Partial Eta Squared** which the value is .005. In percentage, it is$0.005 \times 100 = 0.5\%$. So, interaction effect of gender and method on students' achievement scores is only 0.5%.

TABLE 5 : INTERACTION OF TEACHING METHOD AND GENDER ON MEAN ACHIEVEMENT SCORES OF STUDENTS IN TRIGONOMETRY.

Dependent Variable: Post-TAT

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	21318.483[a]	4	5329.621	608.441	.000	.875
Intercept	170.474	1	170.474	19.462	.000	.053
Group	3182.973	1	3182.973	363.375	.000	.510
Sex	9.216	1	9.216	1.052	.306	.003
Pre-TAT	17487.400	1	17487.400	1996.398	.000	.851
Group * Sex	14.687	1	14.687	1.677	.196	.005
Error	3057.057	349	8.759			
Total	1266463.000	354				
Corrected Total	24375.540	353				

a. R Squared = .875 (Adjusted R Squared = .873)

ΡΕΣΕΑΡΧΗ ΗΥΠΟΤΗΕΣΙΣ 3 : Τηερε ισ νο σιγνιφιχαντ ιντεραχτιον εφφεχτ οφ τεαχηινγ μετηοδσ ανδ γ ενδερ ον μεαν αχηιεωεμεντ σχορεσ οφ στυδεντσ ιν ΤΑΤ. Τηε ηψποτηεσισ ωασ τεστεδ υσινγ τωο–ωα ψ ΑΝΧΟςΑ στατιστιχ ασ σηοων ιν Ταβλε 5. Φρομ τηε ταβλε, $\Phi(1,353) = 1.68$ ανδ $\pi = .20 > .05$ λεωελ ο φ σιγνιφιχανχε. Τηισ ιμπλιεσ τηατ τηερε ισ νο σιγνιφιχαντ ιντεραχτιον εφφεχτ οφ τηε ΠΒΛ ανδ γενδε ρ ον στυδεντσ' αχηιεωεμεντ ιν τριγονομετρψ (Φιγυρε 2). Τηατ ισ τηε αχηιεωεμεντ οφ βοτη μαλε ανδ φεμαλε στυδεντσ ιν τριγονομετρψ χονχεπτ ισ νοτ αφφεχτεδ βψ γενδερ φαχτορ.

Συμμαρψ οφ ρεσυλτσ: Τηε φολλοωινγ αρε τηε μαφορ φινδινγσ οφ τηε στυδψ:

1. Τηερε ισ α σιγνιφιχαντ διφφερενχε βετωεεν τηε μεαν αχηιεωεμεντ σχορεσ ιν ΤΑΤ οφ στυδεντσ τα υγητ τριγονομετρψ υσινγ ΠΒΛ ανδ τηοσε ταυγητ υσινγ τηε χονωεντιοναλ μετηοδ.
2. Τηερε ισ νο σιγνιφιχαντ διφφερενχε βετωεεν τηε μεαν αχηιεωεμεντ σχορεσ οφ μαλε ανδ φεμαλε στυδεντσ ταυγητ τριγονομετρψ υσινγ ΠΒΛ.
3. Τηερε ισ νο σιγνιφιχαντ ιντεραχτιον εφφεχτ βετωεεν τεαχηινγ μετηοδ ανδ στυδεντσə αχηιεωεμεν τ ιν τριγονομετρψ.

ΔΙΣΧΥΣΣΙΟΝ : Τηε ρεσυλτ πεσεντεδ ιν Ταβλε 1 σηοωσ τηατ τηε μεαν αχηιεωεμεντ σχορεσ οφ τηε χον τρολ ανδ εξπεριμενταλ γρουπσ ωερε 43.12 ανδ 43.58 ιν τηε πρε–ΤΑΤ. Αφτερ τρεατμεντ, τηε μεαν αχηι εωεμεντ σχορεσ οφ τηε χοντρολ ανδ εξπεριμενταλ γρουπσ ωερε 57.03 ανδ 64.13 ωιτη τηε μεαν δι φφερενχε οφ 7.10 ιν τηε ποστ–ΤΑΤ. Τηε λοω μεαν σχορεσ ιν τηε πρε–ΤΑΤ σηοωεδ τηατ τηε συβφεχτσ ωερε εξηιβιτινγ λοω κνοωλεδγε οφ τριγονομετρψ χομπαρεδ το τηειρ ποστ–ΤΑ μεανσ.Φρομ Ταβλεσ 1 & 2, τηε ηιγη μεαν αχηιεωεμεντ σχορεσ οφ τηε ΠΒΛγρουπ ιν τηε ποστ–ΤΑΤ ωασ στατιστιχαλλψ σιγνιφιχαντ χομπαρεδ το τηε χοντρολ γρουπ. Τηισ ινδιχατεσ τηατ ΠΒΛ ενηανχεδ αχηιεωεμεντ οφ στ υδεντσ ιν τριγονομετρψ χονχεπτσ βεττερ τηαν τηε χονωεντιοναλ τεαχηινγ μετηοδ.

Τηισ φινδινγ ισ ιν αγρεεμεντ ωιτη Αβδυλλαη, Ταρμιζι ανδ Αβυ (2010) ωηο φουνδ τηατ τηε α ππλιχατιον οφ ΠΒΛ ασ αν αλτερνατιωε ινστρυχτιοναλ μετηοδ οφ τεαχηινγ ματηεματιχσ ενηανχεδ φ ορμ φουρ στυδεντσə ματηεματιχσ περφορμανχε Μαλαψσια. Οτηερ ρεσεαρχηερσ λικε Αχηυονψε (200 4), Βαφυρο, Νορτον ανδ Χοπερ (2004) ,Ακινογλυ ανδ Τανκογαν(2007), ανδ Εζε (2008) φουνδ τηατ ΠΒ Λ ενηανχεδ αχηιεωεμεντ ιν ματηεματιχσ ανδ σομε οτηερ σχιενχε συβφεχτσ. Αλσο, ρεσεαρχηερσ συχη ασ Ιφι (200), Ιφι ανδ Ηαρβορ–Πετερσ (2005), Κυρυμεη (2006), Μυσα ανδ Αγωαγαη (2006) ανδ Αβακπα (2011) φουνδ τηατ αλτερνατιωε μετηοδ το χονωεντιοναλ μετηοδ ενηανχεδ αχηιεωεμεν τ ιν γεομετρψ ανδ ματηεματιχσ ιν γενεραλ.

Τηε ηιγη μεαν αωηιεωεμεντ σχορεσ οφ ΠΒΛγρουπ ιν τηε ποστ–ΤΑΤ μαψ βε δυε το προπερ φο ρματιον οφ χονχεπτσ, εξπλανατιονσ, απππλιχατιονσ ανδ υνδερστανδινγ οφ τριγονομετριχ φορμ υλαε, ιδεντιτιεσ ανδ νοτατιονσ ωηιχη γαωε ροομ το στυδεντσə δεεπερ υνδερστανδινγ οφ τριγονομ ετρψ χονχεπτσ. Τηισ ισ ιν λινε ωιτη τηε εξπλανατιον οφ τηε τηεορψ οφ Χονχεπτ Φορματιον (Σκε μπ ιν Αβακπα , 2011) ωηιχη στατεσ τηατ ματηεματιχσ τεαχηινγ ρεθυιρεσ στυδεντσ το φορμ τηε ριγητ ματηεματιχσ χονχεπτσ ανδ τηατ ματηεματιχσ τεαχηερσ χαν ηελπ στυδεντσ φορμ τηεσε ριγητ χονχ επτσ μυστ κνοω ηοω το εφφεχτιωελψ χομμυνιχατε τηε χονχεπτσ. Αλσο, συππορτινγ τηε υσε οφ ΠΒΛ ισ Βρυνερ ιν Ιφι (2002) τηεορψ οφ Δισχοωερψ ωηιχη στατεσ τηατ ανψ συβφεχτ (ματηεματιχσ) χαν βε ταυγητ εφφεχτιωελψ ιν ηονεστ φορμ το ανψ χηιλδ ατ ανψ σταγε οφ δεωελοπμεντ. Τηισ ιντε λλεχτυαλ δεωελοπμεντ οφ τηε χηιλδ ισ ον χλοχλωισε σεθυενχε οφ εωεντσ, ρεσπονδσ το ινφλυενχ ε φρομ τηε ενωιρονμεντ, νοταβλψ τηε σχηοολ ενωιρονμεντ.

The result in Table 3 shows the pre-TAT mean achievement scores of 44.11 and 43.05 for the male and female students respectively in the PBL group were low compared to the their post-TAT mean scores of 64.40 and 63.85 for males and females. This implies that before treatment, the experimental group male students had similar knowledge level of trigonometry with the female students. This also shows that after treatment, the PBL group had brought about improvement in their mean achievement scores. Moreso, their standard deviations of 7.65 and 7.33 for males and females had shown their equal spread around their means. Table 4 shows the associated probability value of .18 which is greater than .05 level of significance. Therefore, there is no significance difference between the mean achievement scores of male and female students taught trigonometry using PBL. This implies that both male and female students in the experimental group performed equally in the study of trigonometry. This finding is in agreement with Olagunju (2002), and Etukudo and Utin (2006) who found no significance relationship between male and female students' achievement in general mathematics. However, the finding is in variance with Kurumeh (2006) and Achor,Imoko and Ajai (2010) who found the existence of significant difference between male and female students, with female students benefiting more significantly than their male counterparts

From Table 5, $F(1,353) = 1.68$ and $p = .20 > .05$ level of significance along the Group*sex row , implies there is no statistical interaction effects of PBL and gender on students' achievement in trigonometry (Figure 2). The implication is that achievement of both male and female students in trigonometry concept is not affected by gender factor. Therefore, the change in the achievement scores of male and female students in PBL group was the same within the period of this study. This finding is in agreement with Olagunju (2001) who found no significant difference between the general performance of boys and girls in mathematics achievement test. Also, this finding is in conformity with Musa and Agwagah (2006) who found that there was no significant interaction effect between mode of evaluation and gender students' achievement in mensureation and geometry. The reason for this finding may be due to the fact that PBL is gender friendly. However, this finding is at variance to the findings of Iji (2002) and Abakpa (2011) who found that there was a significant interaction effect of teaching method and gender on students' achievement in geometry aspect of school mathematics in favour of males.

III. Conclusion And Recommendations

Based on the analysis of the data in the study, the following conclusions have been reached: The Use of Problem-Based Learning9PBL) method enhanced significantly students' achievement in SS2 trigonometry than the Conventional Teaching Method (CTM). Male and female students achieve higher scores in TAT, their mean gain achievement scores taught using PBL was not statistically significant.
In general, the method (PBL) has positive influence on the subjects of this study as indicated in their mean performance.

The findings of this study and their educational implications have necessitated the following recommendations:

1 Since PBL appears to be relatively new, it may be integrated into mathematics curriculum for the pre-service mathematics teacher education programme. This may help them to learn and use it in their teaching-learning process.
2 Workshops and seminars should be organized for pre-service mathematics teachers on the principle of problem-based learning.
3 Teacher trainers in Colleges of Education, Faculty of Education, Institute of Education and Ministries of Education and professional bodies should be encouraged to promote PBL method of teaching as an innovation in the teaching-learning process.
4 Authors of mathematics education methods should be encouraged to include PBL in their writings.

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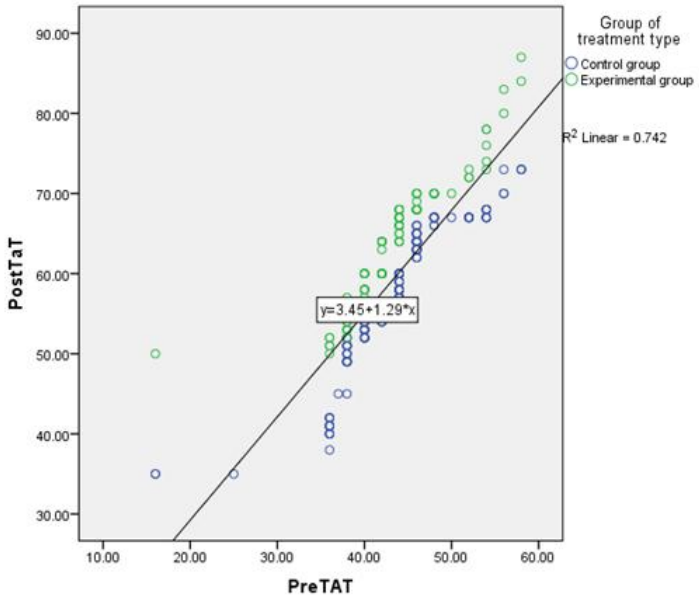

Figure 1: Linearity Of Tat.

Appendix A

Homogeniety Of Regression Slope For Tat

Tests of Between-Subjects Effects					
Dependent Variable: Post-TAT					
Source	Type III Sum of Squares	df	Mean Square	F-value	Sig.
Corrected Model	21310.865[a]	3	7103.622	811.266	.000
Intercept	183.292	1	183.292	20.933	.000
Group	107.670	1	107.670	12.296	.001
Pre-TAT	14825.584	1	14825.584	1693.150	.000
Group * Pre-TAT	10.188	1	10.188	1.163	.281
Error	3064.675	350	8.756		
Total	1266463.000	354			
Corrected Total	24375.540	353			
a. R Squared = .874 (Adjusted R Squared = .873)					

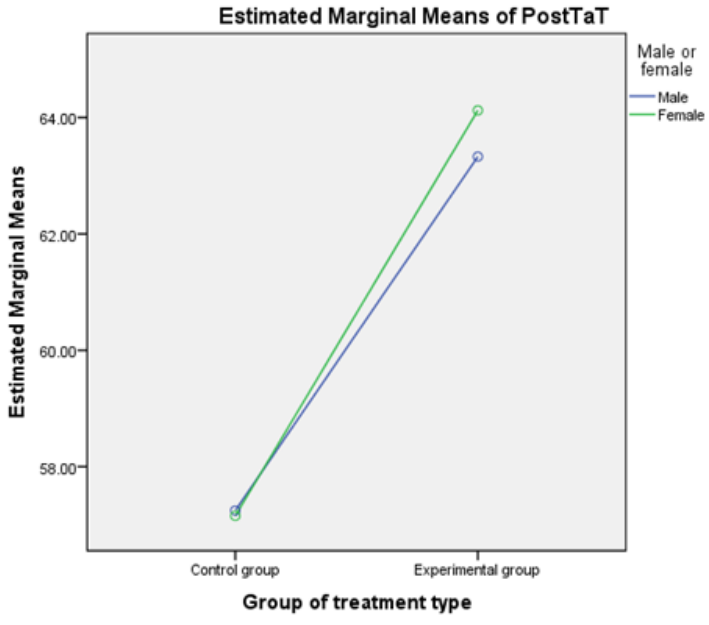

Figure 2: Graph Of Interaction Effect Of Teaching Method And Gender On Students'achievement In Trigonometry**.**