ISSN: 2148-9955

International Journal of Research in Education and Science (IJRES)

www.ijres.net

Blended Learning and Problem-Based Learning Instructional Strategies as Determinants of Senior Secondary School Students' Achievement in Algebra

Omotayo Ojaleye[1], Adeneye O. A. Awofala[2]
[1]Crawford University
[2]University of Lagos

To cite this article:

Ojaleye, O. & Awofala, A.O.A. (2018). Blended learning and problem-based learning instructional strategies as determinants of senior secondary school students' achievement in algebra. *International Journal of Research in Education and Science (IJRES), 4*(2), 486-501. DOI:10.21890/ijres. 428286

IJRES International Journal of Research in Education and Science
Volume 4, Issue 2, Summer 2018 DOI:10.21890/ijres.428286

Blended Learning and Problem-Based Learning Instructional Strategies as Determinants of Senior Secondary School Students' Achievement in Algebra

Omotayo Ojaleye, Adeneye O. A. Awofala

Article Info

Article History

Received:
03 August 2017

Accepted:
11 January 2018

Keywords

Blended learning
Problem-based learning
Strategies
Achievement
Algebra

Abstract

The contribution of algebra to a shared understanding of the world and the society is vital to the development of science, technology and engineering. Thus, the teaching of algebra in schools must be maximised. This study examined the effects of blended learning (BL) and problem-based learning (PBL) instructional strategies on senior secondary school students' achievement in algebra in Lagos State in Southwest, Nigeria. Problem based learning is a learner-centred strategy hinged on problem solving heuristics in which learners are presented with ill structured problems and engaged the problems in a small collaboratory peer teaching to arrive at solutions to the problems. Blended learning is a learning strategy which supplements traditional face to face instruction congruent to the traditional lecture method (TLM) with a computer-based algebrator in which students were subscribed to a class e-mail list. Three research questions and three hypotheses were generated to guide the study. A quasi-experimental pre-test, post-test, non-equivalent control group design was adopted for this study. Multistage sampling techniques were applied to select sample of 388 students (204 boys and 184 girls) drawn from nine secondary schools in which intact classes were used. One research instrument, Algebra Achievement Test (AAT) was developed and the AAT was used for pretest and posttest. Analysis of covariance (ANCOVA) was used to test the hypotheses while the descriptive statistics of means and standard deviations were used to answer the research questions. All the hypotheses were tested at α=0.05 level of significance. Results showed that there was a statistically significant main effect of treatment on students' achievement in algebra. There was a statistically significant main effect of gender on students' achievement in algebra. There was no statistically significant interaction effect of treatment and gender on students' achievement in algebra. The findings of the study revealed that the students' achievement in algebra was enhanced when PBL and BL strategies were used than when TLM was used. Based on the findings of this study it was recommended that efforts should be made to integrate the philosophy of BL and PBL into the preservice teachers' curriculum at the teacher preparation institutions in Nigeria.

Introduction

The importance of algebra and its teaching was justified on its relevance to contemporary life. Its contribution to a shared understanding of the world and the society is vital to the development of science, technology and engineering. Thus, the teaching of algebra in schools must be maximised. Algebra provides power of operating with concepts at abstract level and applying those concepts in concrete terms. The understanding of many mathematical concepts is prerequisite to learning algebra. The quality of algebra teaching is normally measured by students' performance in tests and examinations. Algebra as a gatekeeper of mathematics is an area in which students have major problems and often show poor performance (Erbas, 2005; Kieran, 1981). The poor performance is not unconnected to errors committed by students while trying to solve problems on algebra. Students often commit both procedural and conceptual errors when solving problems on algebra. Procedural errors are connected with procedural knowledge and conceptual errors are associated with conceptual knowledge. ''Procedural knowledge refers to mastery of computational skills and knowledge of procedures for identifying mathematical components, algorithms, and definitions. … Conceptual knowledge refers to knowledge of the underlying structure of mathematics – the relationships and interconnections of ideas that

explain and give meaning to mathematical procedures'' (Eisenhart, Borko, Underhill., Brown, Jones, & Agard, 1993, p. 9). Many students fail to show success in algebra irrespective of gender.

Gender is often considered a common construct in the field of mathematics education and more often than not mathematics is regarded as a masculine domain. The relation between gender and achievement in mathematics and perhaps algebra also present a somewhat inconclusive finding (Awofala, 2017). Evidence suggests that there was a significant relationship between gender and achievement in mathematics (Akinsola & Awofala, 2009; Awofala, 2011; Awofala, 2010; Fatade, Nneji, Awofala, & Awofala, 2012; Ogunneye, 2003). Contrastingly, some researchers (Abakpa & Iji, 2011; Agommuoh & Nzewi, 2003; Arigbabu & Mji, 2004) had observed no significant effect of gender on students' achievement in mathematics thus concluding that gender differences in achievement/performance might be disappearing (Awofala, Arigbabu & Awofala, 2013).

Hydea and Mertzb (2009) revealed that girls have reached parity with boys in mathematics performance, including at high school where a gap existed in earlier decades and affirmed that girls are doing better than boys even for tasks that require complex problem solving. In addition, narrow gender gap in achievement has been observed in U.S.A (Perie, Moran & Luktus, 2005) and in Australia (Forgasz, Leder & Vale, 2000) but in Nigeria significant gender differences in achievement in mathematics exist in favour of males (Ogunkunle, 2007) in which nurture entrenches male dominance over the female gender (Bassey, Joshua & Asim, 2007). The issue of gender inequality in science, technology, and mathematics education (STME) is a global phenomenon and it is believed that bridging gender gap is one major way of achieving egalitarian societies and enhancing human development. Thus, there is the need to accord boys and girls exactly the same opportunities and challenges in the classrooms.

One vital component in teacher-student interaction is instructional strategy and that mathematics teachers feel more comfortable in using the traditional method in teaching algebra simply because it is more amenable to teaching large class size (Owoeye & Yara, 2011). Recent reforms proposed by National Council of Teachers of Mathematics (NCTM) standard emphasized the use of technology in teaching and learning of mathematics because technology is changing the world and daily life, yet the teaching of mathematics remained relatively unchanged and still relied on traditional lecture method (TLM) (Ifamuyiwa & Kehinde, 2011). The objective of mathematics education in global scene is to meet the critical need of the society. Thus, there is a need for teaching and learning strategies that accommodate new technology (Ajelabi, 2006; Odogwu, 2007; Udeani, 2006) within the context of active learning. Two of such learning strategies are Problem Based Learning (PBL) and Blended Learning (BL) for this study.

Problem-based learning is described as a learning environment where the problem drives the learning. In PBL, the learning begins with a problem to be solved in such a way that students need to gain new knowledge before they can solve it. Students interpret, gather new information, identify possible solution and method, develop problem solving skill, collaborate, discuss and compare ideas to come up with their conclusion. The PBL developed at McMaster University four decades ago (Barrows & Tamblyn, 1976, 1980), has grown as an interactive instructional strategy in medicine, engineering, and education (Edens, 2000; Edwards & Hammer, 2004; Eldredge, 2004; Fink *etal*., 2002; Jones, 2006; Şahin, 2009a; Selcuk & Şahin, 2008; Stonyer & Marshall, 2002). In addition, PBL has equally been used in physical science subjects like physics (Duch, 1996; Iroegbu, 1998; Raine & Collett, 2003; Şahin, 2007; Şahin, 2009b; Şahin & Yörek, 2009). It is evident that PBL has been researched into and very well documented as an effective strategy in enhancing students' learning outcomes in varied school subjects across many countries in Europe, America, Asia, and Africa (Albanese & Mitchell, 1993; Berkson, 1993; Colliver, 2000; Major & Palmer, 2001; Norman & Schmidt, 1992, 2000; Prince, 2004; Vernon & Blake, 1993) but its effectiveness in Nigeria is yet to be confirmed (Fatade, Arigbabu, Mogari & Awofala, 2014).

More so, the effectiveness of PBL in the educational classroom is somewhat fraught with mixed conclusions (Fatade, *etal*., 2014). For instance, Albanese & Mitchell (1993) concluded that problem-based instructional approaches were less effective in teaching basic science content (as measured by Part I of the National Board of Medical Examiners exam), whereas Vernon & Blake (1993) reported that PBL approaches were more effective in generating student interest, sustaining motivation, and preparing students for clinical interactions with patients. Mixed results had also been found in the studies by Moust etal (2005) and Prince (2004) in which the latter maintained that it is difficult to conclude if it is better or worse than traditional curricula, and that it is generally accepted that PBL produces positive student attitudes whereas the former concluded that PBL has a positive effect on the process of learning as well as on learning outcomes. While Major and Palmer (2001) observed that students in PBL courses reported greater satisfaction with their experiences than non-PBL students Beers (2005) demonstrated no advantage in the use of PBL over more traditional approaches. This

inconclusive finding concerning the effect of PBL on students' learning outcomes warrants further examination in this study.

Blended learning strategy is one strategy that combines face to face learning with online approach (New South Wales Department of Education and Training, 2002). It is combining face to face instruction with computer mediated instruction (Roh, 2003). Blended learning is a hybrid of traditional face to face and online learning instruction which occurs both in the classroom and online and where the online component becomes a natural extension of traditional classroom teaching (Rovai & Jordan, 2004). Graham (2006) defines the blended learning as the combining of the two different education models, traditional face to face learning and distance learning. Blended learning can also be defined as integrating face to face learning and electronic learning or distance learning, using difference learning theories, methodologies and techniques in the same place and supporting the learning with various online technologies during the learning process in the classroom (Singh, 2003).

The BL was achieved in this study by supplementing traditional face to face instruction congruent to the lecture method with a computer based algebrator in which students are subscribed to a class e-mail list. The algebrator is a software for solving most algebraic problems that are not word problem based at secondary school level. Ahmad, Shafie and Janier (2008) investigated the effect by blended learning strategies on teaching concept of integration using thirty engineering students. The study showed increased students' achievement and majority of the students (87.5%) indicated that blended learning helped them to learn topic better. In a study by Archee and Courney (2006) in which blended learning approach was used to teach statistics, findings revealed that the strategy showed improvement in students' performance than the traditional approach. While the search for an enduring, appropriate and effective method of teaching mathematics in general and algebra in particular is on-going, evidence suggests that PBL and BL are two minds-map, hands-on constructivist learner-centred strategies that have been widely used (Balarabe, 2006; Diaz & Strictland, 2009; Heinze, Procter & Scot, 2007; Ling, Elinda, Kelvin & Lee, 2009; Naidoo & Naidoo, 2007; Schoenfed, 2002) with overwhelming positive results. It is daunting to note that most of the studies on PBL and BL are outside the shores of Nigeria despite the positive effects of these strategies on students' learning outcomes. The implication of this is that little or nothing is known about the application of these strategies in teaching mathematics in Nigeria (Azu & Osinubi, 2011; Fatade, *etal*., 2014). The purpose of this study therefore, was to investigate the effects of problem-based learning and blended learning instructional strategies on senior secondary school students' achievement in algebra using gender as a moderator variable.

Research Questions

The study addressed the following research questions:

RQ1. What is the main effect of treatment (PBL, BL, and TLM) on students' achievement in algebra?
RQ2. What is the main effect of gender on students' achievement in algebra?
RQ3. What is the interaction effect of treatment and gender on students' achievement in algebra?

Null Hypotheses

This study put to test the following null hypotheses at α=0.05 level of significance.

H_{01}: There is no significant main effect of treatment on students' achievement in algebra.
H_{02}: There is no significant main effect of gender on students' achievement in algebra.
H_{03}:There is no significant interaction effect of treatment and gender on students' achievement in algebra.

Conceptual Framework of the Study

The conceptual framework below illustrated how the instructional strategy employed by the teacher in the form of PBL, BL, and TLM separately affects achievement in algebra through the gender.

Conceptual Framework

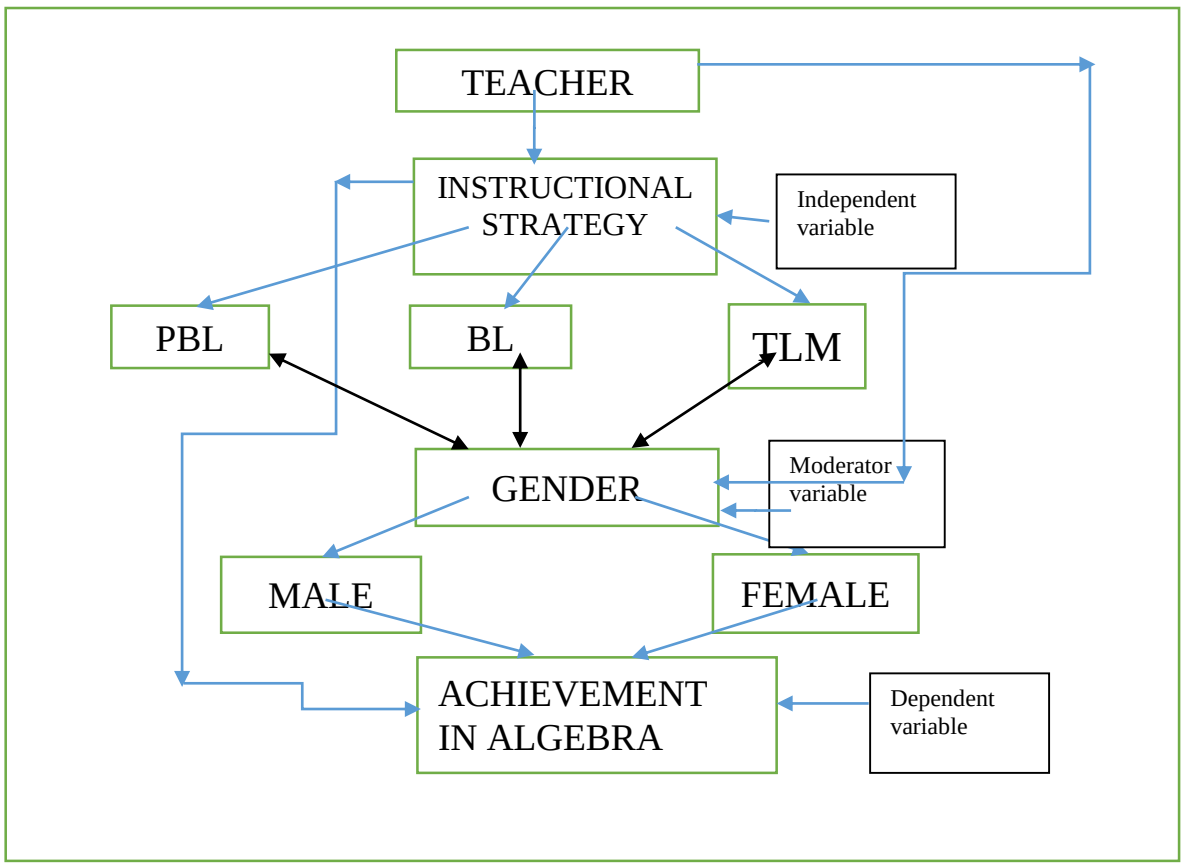

Figure 1. Conceptual framework for the study

Method

Research Design

The model of inquiry adopted for this study was a quantitative method (Creswell & Plano Clark, 2011) within the blueprint of quasi-experimental pretest, posttest non–equivalent control group design. The quasi-experimental design allows identification of variables (Blaxter *etal*., 1996) in the study. The quasi-independent variable-instructional strategy was manipulated at three levels (PBL, BL & TLM) while the quasi-moderator variable-gender was at two levels (Male and Female) and answering the research questions and testing the null hypotheses for the study required data that allowed assessment of the extent to which the PBL, BL and TLM influence students' achievement in algebra. This study relied on interval (scores on Algebra Achievement Test) data as the stronger form of quantification (Okpala, Onocha & Oyedeji, 1993). In this study, participants do not have control over which group (control or experimental) they belonged or of receiving or not receiving the treatment based on quasi-experimental design (Fatade, *etal*., 2014). One inherent advantage of this design is that it is typically easier to set up than true experimental designs (Shadish, *etal*., 2002) but lacks randomisation of subjects to treatment conditions. Using quasi-experimental design in the present study permitted the investigation of intact group in real classroom settings since it was unnecessary to randomly gather students for any intervention during the school hours so as not to create artificial conditions. Students in control and experimental groups partook in the study in their normal classroom conditions without any hitch.

The research design is symbolically illustrated below:

O_1	X_1	O_2	X_1 difference = $O_2 - O_1$ O_1 O_3 O_5 = pre-tests
O_3	X_2	O_4	X_2 difference = $O_4 - O_3$ O_2 O_4 O_6 = post-tests
O_5	C	O_6	C difference = $O_6 - O_5$

X_1, X_2 and C represent PBL treatment, BL treatment and TLM treatment respectively. The mean difference scores between O_1 and O_2, O_3 and O_4 and O_5 and O_6 were tested for statistical significance using the Analysis of Covariance (ANCOVA).

Population of the study: The target population for the study comprised private senior secondary school year two students in Lagos State in Southwest, Nigeria.

Sample and sampling technique-The multi stage sampling technique was used. First, simple random sampling was used to select educational Districts II and IV out of the six educational districts in Lagos State in Southwest, Nigeria. Second, purposive sampling was used to select schools to participate based on five (5) conditions: (a) schools that have qualified mathematics teachers (i.e graduates) who have been consistent with the school for at least three years. The three years minimum was the researchers' decision to ensure some degree of teachers' cognate experience; (b) schools that have been presenting candidate in external examinations such as SSCE and NECO for mathematics for four years. The minimum of four years was the researchers' decision to ascertain that the schools have been presenting candidates in mathematics at external examinations; (c) schools that have access to computers and the students are computer literate. This was necessary since one of the treatment conditions (blended learning strategy) requires both online and face to face interaction; (d) schools that have access to internet; and (e) schools should be private and coeducational. Base line study at the time of the present study revealed that public schools in Nigeria did not have enough computers and where computers were present they were not in good condition. This led to the idea of using private schools for the study since they had enough functional computers that could aid the implementation of blended learning aspect of the study. Based on the aforementioned criteria, 12 schools and 14 schools in education District II and education District IV respectively met the criteria. Thereafter, four and five schools were randomly selected from the education District II and education District IV respectively to make a total of nine schools. Three (3) schools each were randomly assigned as Experimental group one (E_1), Experimental group two (E_2), and Control group (C) through tossing of a coin. Each of the schools has one arm for mathematics and intact class was used for the study. A total of three hundred and eighty eight (388) consisting 204 males and 184 females senior secondary year two mathematics students were involved in the study.

Instrumentation

For the purpose of data collection, only one instrument was developed and used in the study.

Algebra Achievement Test (AAT)

The AAT is a multiple choice objective test with one key and four distracters. It has two sections A and B. Section A seeks personal information on the students with respect to gender and name of school. Section B consists of sixty (60) multiple choice objective test items. Each test item is followed by five answer options (A—E) from which the student was expected to select the correct alternative. Test contents covered the course content for the study in the three levels of cognitive domain of Remembering (knowledge), Understanding (comprehension & application), and Thinking (analysis, synthesis, & evaluation) (Okpala, Onocha & Oyedeji, 1993). The test item specification was shown in table 1 below

Table1. Achievement Test Item Specification

Content	Cognitive Levels			Total
	Remembering	Understanding	Thinking	
Factorisation	4	4	5	13
Quadratic equation	4	4	4	12
Rational fraction	3	4	4	11
Simultaneous equation	4	4	5	13
Graph	3	4	4	11
Total	18	20	22	60

The reliability coefficient has been calculated using Kuder-Richardson formula 21 with a sample group of 40 students from one senior secondary school not part of the study schools in education District II of Lagos State, Nigeria. The reliability value for AAT was computed as 0.82.

Procedure for Data Collection

The study covered a period of 12 weeks. Prior to the commencement of teaching in the experimental and control schools, participants were pretested on the AAT. The importance of the pre-treatment was to find out the background knowledge of the participants in both the experimental and control schools before entering into the experiment/instruction. The attention of the regular mathematics graduate teachers in the control schools was sought after the managements of the schools had given approvals for the study to be conducted in the schools. The details of the study were neither made known to them nor fully discussed with the school managements as the study was presented to the teachers and the managements as if the exercise was meant for their schools alone. The essence of this was to prevent any form of bias and influence on the part of the teachers in the course of their teaching.

The participating teachers in the control schools unlike their counterparts at the six experimental schools were not trained on either the PBL or BL approach but the researchers paid unscheduled visits to the three control schools during the school hours and this afforded them the opportunity to observe the teachers while teaching. Thus, no attempts were made to discuss the classroom interaction patterns that prevailed between the teachers and the students in the classrooms. The participating teachers in the control schools taught the students with the traditional lecture method following the already prepared instructional plan within the context of the contents selected for the study. The teachers covered the topics related to factorisation, quadratic equation, rational fraction, simultaneous equations, and graph.

The instructional lesson plan in the control schools was different from the one enacted in the experimental schools in the area of presentation. The presentation in the control schools followed the routine traditional activities in which the traditional mathematics instruction involved lessons with lecture and questioning methods to teach the concepts related to factorisation, quadratic equation, rational fractions, simultaneous equations, and graph. The participants in the control schools studied the approved mathematics textbooks on their own before the class hour. The teachers in the control schools structured the entire class as a unit, wrote notes on the chalkboard about definitions of concepts related to factorisation, quadratic equation, rational fraction, simultaneous equations, and graph. The control schools teachers worked examples on the chalkboard about factorisation, quadratic equation, rational fractions, simultaneous equations, and graph, and, after their explanations, participants discussed the concepts and examples with teacher-directed questions. For the majority of instructional time in all the control schools, participants received instruction and engaged in discussions stemming from the teachers' explanations and questions. In short, teaching in the control schools was largely teacher-dominated and learning confined to the classroom. The classroom instruction in the control classes was two periods of 80 minutes each per week in the morning on Mondays and afternoon on Wednesdays. The morning and afternoon periods on these two days were uniform across the schools in the two education districts of the study.

The researchers sought the consent of the managements of the PBL schools and approvals were given to conduct the study in the schools. The nature and purpose of the research were then explained to the three mathematics teachers who showed willingness and readiness to participate in the study. The highlight of the weekly activities that would be carried out and the extent of their involvement were discussed with them. The mathematics teachers were given comprehensive orientation on the principle behind the PBL as an instructional strategy and content areas for the study discussed. They were free to ask questions and offer suggestions on how best this modern approach could successfully be implemented in the three schools. The teachers were trained for a period of two hours per week for two weeks on the use of PBL after which they were assessed through micro teaching exercise in the preparation of the PBL lesson. Each of the trained mathematics teachers led the teaching of the participants in their respective schools using the PBL instructional strategy in order to ensure fidelity of treatment and intactness of the PBL classes.

Before the commencement of actual implementation of PBL in the experimental schools, one of the researchers in collaboration with each of the three participating mathematics graduate teachers grouped the participants in their respective schools heterogeneously based on their performances at the senior secondary school (SSS) year 1 final examination. Each PBL class was named PBL Community Group (PBLCG) and the sitting arrangement was reconstituted in a semi-circular form that made it possible for teachers to walk across the groups and the participants facing the chalkboard. Just like the control schools, two periods of eighty minutes each were allocated to the teaching of mathematics in a week. The periods were usually in the morning on Monday and afternoon on Wednesday as dictated by the government policy. Thus, the researchers had no control on the placement of mathematics in the afternoon on Wednesday on the school timetable.

The rigidity of the timetable in the PBL schools did not allow the researchers to create more instructional time in the teaching of the contents in the PBL classes and more importantly, the school authorities in compliance with the State Government's directives did not allow any extension of classroom activities beyond the closing time of 2 p.m. This precluded any intruder in the PBL classes that could have created an unusual atmosphere. Each of the participating mathematics teachers in their respective schools led discussions in the mathematics classes using PBL in a scaffolding manner to suit the already prepared instructional lesson plan. The instructional plan consisted of Introduction, Objectives, Content, Presentation, Evaluation, and Conclusion. In the PBL classes, the PBL group process adopted consisted of five phases (Fatade, 2012; Fatade, *etal*., 2014) namely: (i) identify the problem; (ii) make assumptions; (iii) formulate a model; (iv) use the model; and (v) evaluate the model.

In the first contact period of the fourth week in the PBL classes, participants were given orientation on the PBL and its associated problem-solving processes. This was followed by a diagnostic test on factorisation in which participants were to determine the correctness of the given quadratic equation: $6x^2 - 5xy - 6y^2 = (3x - 2y)(2x + 3y)$? Participants were left to ponder on the given task individually and in groups following the identified problem-solving processes while the mathematics teacher in each PBL class acted as a facilitator. One member each from the groups was selected by the teacher in each PBL class to make presentations on the chalkboard while other members of the PBL community group critiqued the presentations and this triggered off dialogue in the classroom. Thus, mixed feelings ensued among members of the PBL community group as some were in favour that the equality holds for the equation, some were against this stand and obtained $(3x + 2y)(2x - 3y)$ as the solution while others were indifferent. In reaching agreement among the three opposing groups, the teacher interjected by calling the participants attention to expand the value on the right hand side of the quadratic equation and see whether it corresponds to the value on the left hand side. This made the three opposing groups to recline on their decisions and agreed that the equality did not hold and stemming from the teacher's questions, a member of the class stated that the equality did not hold because the factors of the product of first and last terms did not produce the middle term. The entire class concurred with the final submission while another member of the class gave a brisk overview of the factorisation. Similar procedure was adopted in each of the PBL classes in teaching topics related to rational fractions, simultaneous equations, and graph for the eight weeks of the study. In each of the topics taught participants in each of the PBL classes were given ill-structured tasks as homework that demanded their visiting the libraries, and surfing the net in preparation for presentation in the next contact period.

Just like the control and PBL schools, the researchers sought the consent of the managements of the BL schools and approvals were given to conduct the study in the schools. The nature and purpose of the research were then explained to the three mathematics teachers who were computer literate and who showed willingness and readiness to participate in the study. The mathematics teachers were to be computer literate because the BL enacted in this study involved the use of computer. The highlight of the weekly activities that would be carried out and the extent of their involvement were discussed with them.

The mathematics teachers were then given comprehensive orientation on the principle behind the BL as an instructional strategy that involves online and face to face interaction and content areas for the study discussed. They were free to ask questions and offer suggestions on how best this modern approach could successfully be implemented in the three schools. The teachers were trained for a period of two hours per week for two weeks on the use of BL after which they were assessed through micro teaching exercise in the preparation of the BL lesson. Each of the trained mathematics teachers led the teaching of the participants in their respective schools using the BL instructional strategy in order to ensure fidelity of treatment and intactness of the BL classes. The BL involved three phases namely: pre-computer session - in which word problem was broken down and translated into algebraic symbols; computer session – in which the algebrator software was used to solve algebraic problem; and post-computer session- in which participants were evaluated through assignment given online and submission to be made via class email using yahoo mail. It should be noted that before the actual implementation of the BL in the experimental schools, each of the participating mathematics teachers in collaboration with the researchers in their respective schools ensured that the participants in their schools had email addresses and the class email was made known to them.

In addition, the researchers ensured that the algebrator software was installed on each of the available computers in each school and participants were taught on how to use the algebrator by their respective teachers. Teaching in each of the BL classes was done in the morning on Monday and in the afternoon on Wednesday for two periods of eighty minutes each. In the case where the algebraic problem did not involve word problem, each of the mathematics teachers in their respective classes made the participants to use the algebrator to solve the

problem. In the case of algebraic word problem, the mathematics teacher in face-to-face lecture method transformed the word problem into an algebraic expression and then used the algebrator to complete the process of getting the solution. This process was enacted in each of the BL classes for teaching concepts relating to factorisation, quadratic equation, simultaneous equation, rational fractions, and graph. The treatment conditions were concluded in both the PBL, BL and TLM schools in the eleventh week and the twelfth week was used for administration of AAT as posttest. It should be noted that a re-organised version of the pretest was used as posttest in order to prevent hallo effect which could result from over familiarisation with the pretest. Table 2 showed the summary of the fieldwork activities for a period of twelve weeks.

Table 2. Field work Activities

Week	**Activities**
1st , 2nd	Selection and training of research assistants on the administration of instruments, selection of schools, categorization of schools into experimental and control groups, random selection of intact classes. Selection, sensitization, and training of participating teachers.
3rd	Administration of AAT as pre-test on both the experimental and control groups.
4th, 5th,6th ,7th,,8th, 9th,10th,11th	Implementation of training packages in experimental and control schools i.e teaching in the experimental and control schools using lesson plans on PBL, BL, and TLM in respective schools. In BL group, participants were exposed to the algebrator and traditional face to face lecture supplemented with email. The topics considered include factorization, quadratic equation, rational fraction, simultaneous equation, and graph.
12th	Administration of AAT as post-test on both the experimental and control groups.

Data Analysis

The quantitative data collected using AAT were analysed using the descriptive statistical tool of means and standard deviations, which are important precursor to conducting inferential statistical test of analysis of covariance (ANCOVA). This study tested differences in participants' achievement in algebra before and after treatment conditions in both the experimental and control classes and no attempt was made to test relationships. Thus, this foreclosed the adoption of correlation statistic. The ANCOVA statistic was adopted in the study partly because three groups were involved and more importantly, the statistic is considered more robust when comparing differences of three group means which involve the use of covariates. The ANCOVA was used to partial out the initial differences among the three groups and it was also considered appropriate in this study to test the null hypothesis that bothers on interaction effect which the t-test statistic cannot do. This study also foreclosed the adoption of analysis of variance (ANOVA) since pretest score was involved. An alpha (α) level of 0.05 was used for all statistical tests.

Results

Research Question One: What is the main effect of treatment (PBL, BL, and Traditional Lecture method) on students' achievement in algebra?

Table 3. Result of statistical analysis of posttest and pretest algebra achievement

Treatment	posttest		pretest		N	Mean	% mean
	$\bar{x}$	SD	$\bar{x}$	SD		difference	difference
PBL	24.25	9.34	15.51	7.44	96	8.74	56.35
BL	34.36	8.46	16.38	7.75	176	17.98	109.77
TLM	17.47	5.10	14.94	7.23	116	2.53	16.93

The mean of the posttest scores in Table 3 above for the Blended Learning (BL) group *($\bar{x}$ = 34.36, SD=8.46)* was higher than the mean of the Problem-Based Learning (PBL) group *($\bar{x}$ =24.25, SD=9.34)* while the mean of

the Problem-Based Learning (PBL) group *($\bar{x}$ =24.25, SD=9.34)* was higher than the mean of the Traditional Lecture Method (TLM) group *($\bar{x}$ =17.47, SD=5.09).* In addition, participants exposed to the BL strategy had the highest mean difference of 17.98 whereas the PBL and TLM groups had mean difference of 8.74 and 2.53 respectively. These results connote that the students in the BL group recorded high difference in algebra achievement than their counterparts in the PBL and TLM groups. This is in line with the submission that the learner-centred instructional strategies might improve the attitudes of students toward mathematics (Awofala, *etal*., 2013) and in the present study achievement in algebra.

Research Question Two: What is the main effect of gender on students' achievement in algebra?

Table 4. Result of statistical analysis of posttest and pretest algebra achievement based on gender

Gender	posttest		pretest		N	Mean	% mean
	$\bar{x}$	SD	$\bar{x}$	SD		difference	difference
Male	23.12	8.32	15.53	7.71	204	7.58	48.80
Female	21.33	8.51	15.95	7.32	184	5.38	33.73

Table 4 above showed the results of statistical analysis of posttest algebra scores based on gender. The mean of the posttest algebra scores for the male students *($\bar{x}$ =23.12, SD=8.32)* was higher than the mean of their female counterparts *($\bar{x}$ =21.33, SD=8.51).* In addition, the male students had the highest mean difference of 7.58 whereas the female counterparts had a mean difference of 5.38.This result meant that female students recorded lower difference in algebra achievement than their male counterparts. This result seemed to buttress the fact that gender inequity in mathematics education might not be over yet (Awofala, *etal*., 2013) but a trend in favour of males.

Research Question Three: What is the interaction effect of treatment and gender on students' achievement in algebra?

Table 5. Result of statistical analysis of posttest and pretest algebra achievement based on treatment and gender

Treatment	Gender	posttest		pretest		N	Mean	% Mean
		$\bar{x}$	SD	$\bar{x}$	SD		difference	difference
PBL	Male	26.24	9.30	15.62	7.87	50	10.62	67.99
	Female	22.09	8.98	15.39	6.96	46	6.70	43.53
BL	Male	24.95	8.00	16.63	7.82	92	8.32	50.03
	Female	23.73	8.95	16.10	7.71	84	7.63	47.39
TLM	Male	17.90	5.00	13.85	7.22	62	4.05	29.24
	Female	16.96	5.21	16.18	7.10	54	0.78	4.82

Table 5 above showed the results of statistical analysis of posttest algebra scores based on treatment and gender. In the traditional method group, the male students recorded higher posttest algebra mean score ($\bar{x}$ =17.90, SD=5.00) than their female counterparts ($\bar{x}$ =16.96, SD=5.21). In addition, in both the PBL and BL groups male students obtained higher posttest algebra mean score ($\bar{x}$ =26.24, SD=9.30; $\bar{x}$ =24.95, SD=8.00) than their female counterparts ($\bar{x}$ =22.09, SD=8.98; $\bar{x}$ =23.73, SD=8.95) respectively. More so, in both the PBL, BL and TLM groups, male students obtained the highest mean difference of 10.62 (67.99%), 8.32(50.03%), and 4.05(29.24%) respectively whereas female students in the PBL, BL, and TLM groups had mean difference of 6.70 (43.53%), 7.63 (47.39%), and 0.78 (4.82%) respectively. These results connote that in the teacher-centred strategy (i.e. TLM) group male students seemed to display higher achievement in algebra than their female counterparts. More so, in the student-centred strategy (i.e. PBL & BL) groups male students recorded higher algebra achievement scores than their female counterparts.

Null Hypothesis One: There is no significant main effect of treatment (PBL, BL, and TLM) on students' achievement in algebra

An analysis of the posttest achievement scores of the students in the two experimental and one control groups using the Analysis of Covariance as contained in Table 6 below showed that the difference in means among the three groups was statistically significant ($F_{(2,387)}$=30.112, p=0.000, η^2_p=0.136). The significant result at a level of

p<0.05 meant that there was a less than 5% chance that the result was just due to randomness. The flip side of this was that there was a 95% chance that the difference in posttest achievement scores among the three groups was a real difference and not just due to chance. As observed in Table 6 below, the two-tailed p value was 0.000 meaning that random sampling from identical populations would lead to a difference smaller than was observed in 100% of experiments and larger than was observed in 0% of experiments. The partial eta squared (η_p^2) which is the proportion of the effect + error variance that is attributable to the effect (Awofala, Fatade & Udeani, 2015) was just .136 in this study, which means that the factor treatment by itself accounted for only 13.6% of the overall (effect+error) variability in the senior secondary school students' achievement in algebra score. This result suggested a large effect for treatment (Cohen, 1988). Thus, the null hypothesis one was rejected and we upheld that there was a significant main effect of treatment on students' achievement in algebra.

Table 6. Summary of Analysis of Covariance of Achievement in Algebra Scores by Treatment and Gender

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	η_p^2
Corrected Model	4885.062[a]	6	814.77	13.641	.000	.177
Intercept	26923.365	1	26923.365	451.091	.000	.542
Covariates	555.569	1	555.569	9.308	.002	.024
Treatment (T)	3594.465	2	1797.232	30.112	.000*	.136
Gender (G)	434.030	1	434.030	7.272	.007*	.019
Treatment×Gender	153.261	2	76.631	1.284	.278	.007
Error	22739.979	381	59.685			
Total	220110.000	388				
Corrected Total	27625.041	387				

[a]R Squared = .177 (Adjusted R Squared = .164) * Significant at p <0.05

The results from post-hoc analysis (Table 7) indicated that the mean algebra achievement scores of the students taught with the BL strategy were significantly higher than those taught with the traditional method. The mean algebra achievement scores of students taught with the PBL were significantly higher than those taught with the traditional method. However, main source of observed significant difference was due to the significant difference between the BL and TLM groups and between the PBL and TLM groups. The difference between mean posttest algebra scores of students in the BL and PBL groups was statistically not significant. Therefore, the PBL strategy was the most efficient of the treatment conditions and the direction of decreasing effect of instructional strategy on algebra achievement was TLM<BL<PBL

Table 7. Bonferroni Comparison of Treatment Groups' Mean Score on Algebra

(I) Treatment	(J) Treatment	Mean Difference (I-J)	Std.Error	Sig[a]	95% CI for difference Lower Bound	Upper Bound
PBL	BL	-.035	.982	1.000	-2.397	2.327
	TLM	6.652*	1.068	.000	4.085	9.220
BL	PBL	.035	.982	1.000	-2.327	2.397
	TLM	6.687*	.928	.000	4.455	8.920
TLM	PBL	-6.652*	1.068	.000	-9.220	-4.085
	BL	-6.687*	.928	.000	-8.920	-4.455

*Based on estimated marginal means [a]Adjustment for multiple comparisons: Bonferroni

Null Hypothesis Two: There is no significant main effect of gender on students' achievement in algebra.

Analysis of the posttest algebra scores of male and female students using the Analysis of Covariance as contained in Table 6 above showed that the difference in means between the male and female students was statistically significant ($F_{(1,387)}$=7.27, p=0.007, η^2_p=0.019). The significant result at a level of *p<0.05* meant that there was a less than 5% chance that the result was just due to randomness. The flip side of this was that there was a 95% chance that the difference in post-test achievement scores among the three groups was a real difference and not just due to chance. As observed in Table 4.2 above, the two-tailed p value was 0.007 meaning that random sampling from identical populations would lead to a difference smaller than was observed in 99.3% of experiments and larger than was observed in 0.7% of experiments. The partial eta squared (η_p^2) which is the

proportion of the effect + error variance that is attributable to the effect (Awofala, *etal*., 2015) was just .019 in this study, which means that the factor gender by itself accounted for only 1.9% of the overall (effect+error) variability in the senior secondary school students' achievement in algebra score. This result suggested a small effect for gender (Cohen, 1988). Thus, the null hypothesis one was rejected and we upheld that there was a significant main effect of gender on students' achievement in algebra.

Null Hypothesis Three: There is no significant interaction effect of treatment and gender on students' achievement in algebra.

An analysis of the posttest algebra scores of the interaction of treatment (PBL, BL & TLM) and gender (male & female) using the Analysis of Covariance as contained in Table 6 above showed that the interaction effect of treatment and gender was statistically not significant ($F_{(1,387)}$=1.284, p=0.278, η^2_p=0.007). Thus, the null hypothesis three was not rejected and we upheld that there was no significant interaction effect of treatment and gender on students' achievement in algebra.

Discussion

Results pertaining to the research questions and null hypotheses were fully discussed and previous results/findings used to corroborate the present study results.

Main Effect of Treatment (PBL, BL, and Traditional Lecture method) on Students' Achievement in Algebra

At the onset, attention was paid to the selection of nine schools with comparable characteristics in terms of achievement in mathematics, age, language, etc. so that the three groups that emerged from these schools would enter the instruction/experiment on relatively comparable strength. This was to ensure that if any observable significant difference was seen in the mean post-test scores of the three groups on the AAT then such difference would not be attributed to chance but the effect of the intervention. This set the stage for the discussion of results in respect of the above research question one and null hypothesis one analysed in the preceding section of the present study.

The results showed significant main effect of treatment on students' achievement in algebra and that the 13.6% of the variance in students' achievement in algebra could be explained by treatment. The results indicated that students' achievement in algebra was greatly improved when they were exposed to the teaching strategies of blended learning and problem-based learning when compared with the traditional lecture method. This finding supported earlier findings (Awofala, 2017b; Awofala, *etal*., 2013; Akay & Boz, 2010; Akinsola & Awofala, 2009 Awofala, Fatade & Olaoluwa, 2013; Awofala, Balogun & Olagunju, 2011; Nicolaou & Philippou, 2004; Akinsola & Tella, 2003; Awofala, 2011) which associated improved content learning to learner-centred teaching strategies.

This was further substantiated considering the fact that the learner-centred teaching strategies alleviated misunderstandings about the nature of mathematics (Akay & Boz, 2010), and in this study, the strategies of blended learning and problem-based learning had positive impact on students' acquisition of domain specific knowledge of algebra when compared with the traditional teaching method. The traditional teaching method had not only been criticized for emphasizing teacher activity at the expense of pupil involvement (Awofala, *etal*., 2013; Ige, 2001) but that it had a negative effect on students' achievement in mathematics (Akay & Boz, 2010).

Blended learning was found to be effective in promoting achievement in algebra in this study because the strategy enabled learners to blend their experiences in face-to-face teaching with online learning. The online experience seemed to have further concretised students' understanding of algebra in face-to-face teaching. The finding that students who were exposed to the PBL performed better in algebra corroborated the views of PBL proponents that the strategy was effective in enhancing students' achievement and self-regulated learning (Sungur & Tekkaya, 2006; Wheijin, 2005). Fatade (2012) found that PBL students, among others, achieved better in further mathematics in Nigeria. Similarly, Gordon, Rogers, Comfort, Gavula and McGee (2001) found that PBL students valued the student-centred nature of PBL, including information seeking, high levels of challenge, group work, and personal relevance of the material.

Main Effect of Gender on Students' Achievement in Algebra

The results showed significant main effect of gender on students' achievement in algebra and that the 1.9% of the variance in students' achievement in algebra could be explained by gender. The significant main effect of gender on students' achievement in algebra in this study was in line with the results of previous studies (Awofala, 2008; Erinosho, 1997). These studies reported significant main effect of gender on students' achievement/performance in mathematics. The present finding failed to support the work of researchers who believed that gender stereotyping was declining in the Nigerian educational system (Fatade, Nneji, Awofala, & Awofala, 2012; Arigbabu & Mji, 2004). The present result was in support of the work of researchers who had established gender differences in achievement in mathematics (Awofala, 2008; Awofala, 2017a). The result of the present study suggests the existence of differential experiences of boys and girls within and outside the classroom (Awofala, *etal*., 2013) and that gender differences in achievement in mathematics might not have all disappeared. The present finding suggested that gender differences in algebra might not have totally disappeared in Nigeria.

Interaction Effect of Treatment and Gender on Students' Achievement in Algebra

The study result showed that there was no significant interaction effect of treatment and gender on students' achievement in algebra. The no significant interaction effect of treatment and gender recorded in this study showed that gender seemed not to interact with instruction to produce results, meaning that the treatment conditions did not discriminate across gender in this study. This finding was in agreement with the finding of some researchers (Awofala, *etal*., 2013; Anoh, 2014; Awofala & Nneji, 2011) who had found non-significant interaction effect of treatment and gender on students' learning outcome in mathematics and science. This result indicated that in the traditional lecture method group, the male students held higher achievement in algebra than their female counterparts whereas in BL group male and female students held comparable achievement in algebra. In the PBL group, male students recorded higher achievement in algebra than their female counterparts. These results meant that in the teacher-centred strategy (i.e. TLM) group both male and female did not record comparable achievement in algebra whereas in the students-centred strategy (i.e. BL) group, both male and female students recorded comparable achievement in algebra. Thus, blended learning strategy could be used to close the gap of gender disparity in achievement in algebra. Thus, it could be said that the gender variable was not treatment sensitive on achievement in algebra in this study.

Conclusion

This study has shown the effectiveness of the BL and PBL in promoting students' achievement in algebra. It is therefore recommended that these strategies be put to use in the teaching and learning of mathematics. The non-significant interaction effect of treatment and gender recorded in this study implied that PBL and BL strategies could be used to advance learning and close the gap of gender disparity in the learning of mathematics. These learners' centred strategies could be used as a basis for individualizing instruction for both male and female students (Awofala, *etal*., 2013). However, it was recommended that efforts should be made to integrate the philosophy of PBL and BL into the preservice teachers' curriculum at the teacher-preparation institutions in Nigeria.

Acknowledgement

The authors thank the teachers and the students that made themselves available for the study.

References

Abakpa, B. O. & Iji, C. O. (2011). Effect of mastery learning approach on senior secondary students' achievement in geometry. *Journal of the Science Teachers' Association of Nigeria, 46*(1), 165-176.

Agommuoh, P. C. & Nzewi, U. M. (2003). Effects of videotaped instruction on secondary school students' achievement in physics. *Journal of the Science Teachers' Association of Nigeria 38*(1&2), 88-93.

Ahmad, W. F. W., Shafie, A. B., & Janier, J. B. (2008). Students' perceptions towards blended learning in teaching and learning mathematics: application of integration. Retrieved January 23, 2013 from http://atcm.mathandtech.org/EP2008/papers_full/2412008_15274.pdf.

Ajelabi, A. (2006) Computer in humanities in Owhotu (ed) *An Introduction to Information in Education Technologies***,** Sibon Books Ltd Lagos, pp. 87-91.

Akay, H. & Boz, N. (2010). The effect of Problem Posing Oriented Analyses11Course on Attitude Toward Mathematics Self- Efficacy of Elementary Prospective Mathematics Teachers. *Australian Journal of Teacher Education, 35,* 60- 75**.**

Akinsola, M. K. & Awofala, A. O. A. (2009). Effects of personalization of instruction on students' achievement and self-efficacy in mathematics word Problems .*International Journal of Mathematical Education in Science and Technology, 40*(3), 389 – 404**.**

Akinsola, M. K., & Tella, A. (2003). Effectiveness of individualistic and cooperative teaching strategies in learning geometry and problem solving in Mathematics among junior secondary schools in Nigeria. *Personality Study and Group Behaviour, 23*, 95-105.

Albanese, M.A. & Mitchell, S. (1993). Problem-based learning: a review of the literature on its outcomes and implementation issues. *Academic Medicine, 68*, 52-81.

Anoh, J. N. (2014). Enhancing senior secondary school students' learning outcomes in biology using PCK instructional Ph.D Thesis, University of Lagos.

Archee, R. & Gurney, M. (2006).*Flash me now: Using Blended learning to teach SPSS to Undergraduate***.** The IADIS Virtual Multi Conference on Computer Science and InformationSystems.

Arigbabu, A. A. & Mji, A. (2004). Is gender a factor on mathematics performance among Nigerian pre-service teachers? *Sex Roles: A Journal of Research, 51*(II), 749- 753.

Awofala, A. O. A. (2010). *Impact of personalised instruction on senior secondary school learning outcomes in mathematics word problems.* Unpublished Ph.D Thesis. University of Ibadan.

Awofala, A. O. A., Fatade, A. O. & Olaoluwa, S. A. (2013).Improving students' interest in solving mathematics word problems through personalization of instruction, *Indian Streams Research Journal, 3*(1), 1-11.

Awofala, A. O. A.,Arigbabu, A. A. & Awofala, A. A.(2013). Effects of framing and team assisted individualised instructional strategies on senior secondary school students' attitudes toward mathematics. *Acta Didactica Napocensia, 6*(1), 1 – 22.

Awofala, A.O.A. & Nneji, L. M. (2011) Effects of framing and team assisted individualized instructional strategies on students' achievement in mathematics. *Journal of the Science Teachers Association of Nigeria, 46*(2), 60-71.

Awofala, A.O.A. (2008). Women and the learning of mathematics. *African Journal of Historical Sciences in Education, 3*(1), 195 – 213.

Awofala, A.O.A. (2011). Effect of concept mapping strategy on students' achievement in junior secondary school mathematics. *International Journal of Mathematics Trends & Technology, 2*(3), 11-16.

Awofala, A.O.A. (2017a). Assessing senior secondary school students' mathematical proficiency as related to gender and performance in mathematics in Nigeria. *International Journal of Research in Education and Science (IJRES), 3*(2), 488-502.

Awofala, A. O. A. (2017b). Effect of personalisation of instruction on students' anxiety in mathematical word problems in Nigeria. *Bulgarian Journal of Science and Education Policy (BJSEP), 11*(1), 83-120.

Awofala, A.O.A., Balogun, T. A. & Olagunju M. A. (2011). Effects of Three Modes of Personalisation on Students' Achievement in Mathematical Word Problems in Nigeria. *International Journal for Mathematics Teaching and Learning* (Online) Available, http://www.cimt.plymouth.ac.uk/journal/awofala.pdf, pp. 1–25.

Awofala, A.O.A., Fatade, A. O., & Udeani, U. N. (2015). Nigerian preservice science, technology and mathematics teachers' computer self-efficacy: An exploration based on gender, age, and discipline of study. *International Journal of Education in Mathematics, Science and Technology*, *3*(2), 101-119.

Azu, O. O. & Osinubi, A. A. (2011). A survey of problem-based learning and traditional method of teaching anatomy to 200 level Pharmacy students of the University of Lagos Nigeria-African. *Journal of Pharmacy and Pharmacology, 5*(2), 219-224**.**

Balarabe, U. (2006). The effects of blended e-learning on mathematics and computer attitude in the calculus and algebra. *The Montana Mathematics Enthusiastic, 3*(2), 176-183.

Barrows, H. S. & Tamblyn, R. M. (1976). An evaluation of problem-based learning in small groups utilizing a simulated patient. *J. Med. Educ., 51*, 52-54.

Barrows, H. S. & Tamblyn, R. M. (1980). *Problem-based learning: an approach to medical education*. New York: Springer.

Bassey, S.W., Joshua, M.T., & Asim, A.E. (2007). *Gender differences and mathematics achievement of rural senior secondary students in Cross River State, Nigeria*. Retrieved from http://web.gnowledge.org/episteme3/pro_pdfs/09-bassvjoshua-asim.pdf.

Beers, G. (2005). The effect of teaching method on objective test scores: problem based learning versus lecture. *J. Nursing Educ., 44*, 305-309.

Berkson, J. (1993). Problem-based learning: have the expectations been met. *Academic Medicine, 10,* 79-88.

Blaxter, I., Hughes, C. & Tight, M. (1996). *How to research.* Burkingham: Open University Press.

Cohen, J. (1988). *Statistical power analysis for the behavioural sciences (2. Auflage)*. Hillsdale, NJ: Erlbaum.

Colliver, J.A. (2000). Effectiveness of problem-based learning curricula: research and theory. *Academic Medicine, 75*, 259-266.

Diaz, V., & Strickland, J. (2009). EDUCAUSE learning initiatives, Unit 7: Implementing blended learning. *http://net.educause.edu/ir/library/pdf/ELI80077.pdf*

Duch, B. (1996). Problem-based learning in physics: the power of students teaching students. *J. College Science Teaching, 26*, 529-541.

Edens, K. (2000). Preparing problem solvers for the 21st century through problem based learning. *College Teaching, 48*(2), 55-60.

Edwards, S. & Hammer, M. (2004). Teacher education and problem-based learning: Exploring the issues and identifying the benefits. *International Education Research Conference of the Australian Association for Research in Education*. Melbourne.

Eisenhart, M., Borko, H., Underhill., R., Brown, C., Jones, D., & Agard, P. (1993). Conceptual knowledge fall through the cracks: Complexities of learning to teach mathematics for understanding. *Journal for Research in Mathematics Education, 24*(1), 8–40. http://dx.doi.org/10.2307/749384.

Eldredge, J.D. (2004). The librarian as tutor/facilitator in a problem-based learning (PBL) curriculum. *Reference Services Review, 30*, 355-358.

Erbas,A.K.(2005).Coklugösterimlerleproblemcözmeveteknolojininrolü(Problemsolvingwithmultiplerrepresentationsandtheroleoftechnology).*TheTurkishOnlineJournalofEducationalTechnolog,4(4***).**RetrievedFebruary21,2007,fromhttp://www.tojet.net/articles/4412.htm

Erinosho, S. Y. (1997). Female participation in science: An analysis of secondary school science curriculum materials in Nigeria. *Abridged Research Report* No. 2, 44.

Fatade, A. O. (2012). *Investigating the effectiveness of problem-based learning in the further mathematics classrooms* (Doctoral dissertation, University of South Africa).

Fatade, A. O., Arigbabu, A. A. Mogari, D., Awofala, A.O.A. (2014). Investigating senior secondary school students' beliefs about further mathematics in a problem-based learning context. *Bulgarian Journal of Science and Education Policy (BJSEP),* 8(1), 5-46.

Fatade, A. O., Nneji, L. M., Awofala, A. O. A., & Awofala, A. A. (2012). Mode of entry and gender as determinants of Nigerian pre-service teachers' performance in degree mathematics and science courses, *International Journal of Mathematics Trends and Technology*,3(3), 103 – 109.

Fink, F. K., Enemark, S. & Moesby, E. (2002). Centre for problem-based learning (UCPBL) at Aalborg University. *6th Baltic Region Seminar on Engineering Education*. Wismar.

Forgasz, H. J., Leder, G. C., & Vale, C. (2000) Gender and mathematics: Changing perspectives. In K. Owens & J.A. Mousley (Eds.). *Research in mathematics education in Australasia 1996-1999*. Turramurra, NSW: Mathematics education research group of Australasia inc.

Gordon, P. R., Rogers, A. M., Comfort, M., Gavula, N., & McGee, B. P. (2001). A taste of problem-based learning increases achievement of urban minority middle-school students. *Educational Horizons,*79, 171-175.

Graham, C. (2006). Blended learning systems. Definitions, current trends and future directions. In C.Bonk & C. Graham (Eds.), *The handbook of blended learning: Global perspectives, local designs*. San Francisco: John Wiley and Sons.

Heinze, R, Procter, C. & Scot, B. (2007). Use of conversation theory to underpin blended learning *International Journal of Teaching and Case Studies*, 49(1/2). 108-120.

Hydea, J. S. & Mertzb, J. E. (2009). *Gender, culture, and mathematics performance.* Retrieved from http: / /tctvideo. madison.com/uw/gender.

Ifamuyiwa, A. S. & Kehinde, M. A. (2011). Teacher knowledge of and response to curriculum reforms in mathematics in Nigeria. In O.S Abonyi, Reforms in STEM Education.52nd Annual Conference of Science Teacher Association of Nigeria pp(321-329)

Ige, T. A. (2001). Concept mapping and problem-solving teaching strategies as determinants of achievement in secondary school ecology. *Ibadan Journal of Educational Studies,1*(1),290-301.

Iroegbu, T.O. (1998). Problem-based learning, numerical ability and gender as determinants of achievement in line graphing skills in senior secondary physics. *PhD Thesis*. Ibadan, University of Ibadan.

Jones, R.W. (2006). Problem-based learning: description, advantages, disadvantages, scenarios and facilitation. *Anaesthesia & Intensive Care, 34*, 485-488.

Kieran, C. (1981). Concepts associated with the equality symbol. *Educational Studies in Mathematics,12,* 317-326

Ling, S.E, Elinda, L.A., Kelvin, G.T.H, & Lee, B. Y. (2009). *Teaching mathematics using blended learning model. A case Study in University of Technology* Sarawak, Paper delivered at conference on Scientific Education and Social Research.

Major, C. & Palmer, B. (2001). Assessing the effectiveness of problem-based learning in higher education: lessons from the literature. *Academic Exchange Quarterly, 5*, 4-9.

Moust, J. H. C., Van Berkel, H. J. M. & Schmidt, H. G. (2005). Signs of erosion: reflections on three decades of problem-based learning at Maastricht University. *Higher Education, 50*, 665-583.

Naidoo, K. & Naidoo, R. (2007). First year student understanding of elementary concept in differential calculus in a computer laboratory teaching environment. *Journal of College Teaching and Learning,* 4(a), 55-69.

New South Wales Department of Education and Training, (2002), Learning technologies,blendedlearning,*http://www.schools.nsw.edu.au/learning/yrk12focusareas/learntech/blended/index.php*

Nicolaou, A. A., & Philippou, G. N. (2004). Efficacy beliefs, ability in problem posing, and mathematics achievement, *Proceedings of the 3rd International Biennial SELF Research Conference Berlin, Self-Concept, Motivation and Identity: Where to go from here?*4 – 7 July, 2004.

Norman, G.R. & Schmidt, H.G. (1992). The psychological basis of problem based learning: a review of the evidence. *Academic Medicine, 67*, 557-565.

Norman, G.R. & Schmidt, H.G. (2000). Effectiveness of problem-based learning curricula: theory, practice and paper darts. *Medical Education, 34*, 721-728.

Odogwu H. N. (2007). Integration of information and communication (ICT) in the preservice training of teachers in the 21st century. *International Journal Of Multicultural Education.1*(1), 141-151.

Ogunkunle, L.A. (2007). Effects of gender on mathematics achievement of students in constructivist and non-constructivists groups in secondary school. *ABACUS, Journal of Mathematical Association of Nigeria, 32*(1), 41-50.

Ogunneye, W. (2003). Students' understanding of the concept of gradient in physics. A case study of physics students from Tai Solarin College of Education, Ijebu-Ode. *Journal of the Science Teachers' Association of Nigeria, 38*(1&2), 100-106.

Okpala, P. N., Onocha, C. O. & Oyedeji, O. A. (1993). *Measurement and evaluation in education. Stirling-*Horden Publishers (Nig.) Ltd. .103-128.

Owoeye, J. S &Yara, P. O. (2011). Class size and academic achievement of secondary school in Ekiti state, Nigeria. *Asian Social Science,* 7 (6), 184-189.

Perie, M., Moran, R., & Lutkus, A.D. (2005). *NAEP 2004 trends in academic progress three decades of student performance in reading and Mathematics.* Washington D. C. National Center for Education Statistics.

Prince, M. (2004). Does active learning work: a review of the research. *J. Eng. Educ., 93*, 223-231.

Raine, D. & Collett, J. (2003). Problem-based learning in astrophysics. *Eur. J. Phys., 24*, S41-S46.

Roh, K.H. (2003).Problem-based learning mathematics *http:www.ericdigests.org/2004/.math.hm.*

Rovai, A.P & Jordan, H.M., (2004). Blended learning and sense of community: A comparative analysis with traditional and fully online graduate courses', *International Review of Research in Open and Distance Learning, August* 2004, ISSN: 1492-3831.

Şahin, M (2009b). Exploring university students' expectations and beliefs about physics and physics learning in a problem-based learning context. *Eurasia Journal Mathematics, Science & Technology Education, 5*, 321-333.

Sahin, M. & Yörek, N. (2009). A comparison of problem based learning and traditional lecture students' expectations and course grades in an introductory physics classroom. *Scientific Research &Essays, 4*, 753-762.

Şahin, M. (2007). The importance of efficiency in active learning. *Journal of Turkish Science Education, 4*(2), 61-74.

Şahin, M. (2009a). Correlations of students' grades, expectations, epistemo-logical beliefs and demographics in a problem-based introductory physics course. *International Journal of Environmental & Science Education, 4*, 169-184.

Schoenfeld, A. H. (2002). Making mathematics work for all children: Issues of standards, testing, and equity. *Educational Researcher*, 31(1), 13-25.

Selcuk, G. S. & Şahin, M. (2008). Problem-based learning and teacher education. *Buca Eğitim Fakültesi Dergisi, 24*, 12-19 [In Turkish].

Shadish, W.R., Cook, T.D. & Campbell, D.T. (2002). *Experimental and qua-si-experimental designs for generalised causal inference.* New York: Houghton Mifflin Company.

Singh, H. (2003). Building effective blended learning program. *Educational Technology, 43*(6), 51-54.

Stonyer, H. & Marshall, A. (2002). Moving to problem-based learning in the NZ engineering workplace. *J. Workplace Learning, 14*(5), 190-197.

Sungur, S., & Tekkaya, C. (2006). Effects of problem-based learning and traditional instruction on self-regulated learning. *The Journal of Educational Research, 99*(5), 307-320.

Udeani, U. (2006). Gender and information and communication in education in Owhotu(ed). *An Introduction to Information Technologies in Education,* Sibon Books, Limited, Lagos, pp. 203-204.

Vernon, D.T.A. & Blake, R.L. (1993). Does problem-based learning work: a meta-analysis of evaluative research. *Academic Medicine, 68*, 550-563.

Wheijen, C. (2005). Impact of constructivist teaching on student beliefs about teaching and learning in introductory physics. *Canadian Journal of Science, Mathematics and Technology Education, 5*(1), 95 – 109.

Author Information

Omotayo Ojaleye
Crawford University
Department of Mathematics
Nigeria
Contact e-mail: *ojaleyetayo@yahoo.com*

Adeneye O. A. Awofala
University of Lagos
Faculty of Education
Department of Science and Technology Education
Nigeria