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Rethinking Learning Strategies in Basic Science, Technology and Mathematics Education (BSTM): the Efficacy of Problem-Based and Project-Based Learning in Junior Secondary Schools, Sokoto State, Nigeria

Dr. (Mrs.) R. Muhammad, Dr. M.A. Yusha'u and N.I. Lawal
Department of Science and Vocational Education, Faculty of Education and Extension Services Usmanu Danfodiyo University, Sokoto

Abstract: *The study was carried out to determine the effects of problem-based and project-based learning strategies on the academic performance of basic science, technology and mathematics students atbasic education level in Sokoto state. Three (3) specific objectives, three (3) research questions and three (3) null hypotheses were used as guide. 165JSS II basic education students from six (6) educational zones formed the sample of the study. A 30-item Achievement Test in Basic Science, Technology and Mathematics (BSTM) was used for data collection. Descriptive statistics and P-value at 0.05 were used for data analysis. The findings from the research revealed that, students exposed to both problem-based learning and project-based learning strategies performed better than students exposed to expository (Traditional)strategy. It was also found out that, the academic performance of BSTM students taught using problem-based strategy learning was better than that of those taught using project-based learning strategy. Consequently, it was recommended among other things that, to have a re-think, teachers should adopt a paradigm in terms of strategies by employing learning strategies(problem-based and project-based learning strategies) that will improve students' academic performance.*

Keywords: *Rethinking learning Strategies Problem-based and Project-based on basic science, technology and mathematics education*

I. Introduction

Engagement in meaningful learning is a universal theme advanced in literature on students' academic performance. Integration of instruction into real-world problem is a second emerging theme. The effect of teaching methods on students' performance is receiving considerable attention from educators and researchers worldwide. What students learn is greatly influenced by how they are taught (Abdulhamid, 2010). Teachers teachingScience, Technology and Mathematics (STM) in junior secondary schools have implemented a wide variety of learning strategies that fit different niches within the STM classroom. There has been drastic reduction in the standard of students' performance at all levels of education in Nigeria in the past decades(Emaikwu, 2012). The fall in the standard of education is traceable to many issues which are rooted in psychological and environmental factors. At junior secondary level, this fall in students' performance is incontrovertibly attributable to instructional strategies adopted by learners in schools (Tick, 2007).

Squeira (2012) stresses that learning through some methods are passive rather than active. Educators and researchers have repeatedly acknowledged the setback of teaching with a strict lecture format. Abdulhamid (2013) refers to lecture method as a teaching method that results in long periods of uninterrupted teacher-centered expository discourse which relegates students to the role of passive 'spectators' in the classroom. Daluba (2013) also describes lecture method as talk and chalk or textbook method.Peter,Nephat, and James, (2014) reported that, learning and understanding of school subjects have been frustrated by clumsy methods and instructional materials Teaching methods according to Hang (2006) are the approaches, ways and strategies that a teacher adopts in conducting his lesson to a successful end. Mamudu, and Uhumuarbi, (2009).also defines teaching methods as the way of teaching which involve a series of teacher directed activities that result into pupils' learning. Teaching methods comprise of principles and strategies used for instruction (Daluba, 2013). Teaching methods are the tools of the teacher for reaching the set goals and objectives.

Science has become the dominant world culture; it has also become the index of development among nations. Countries that have invested heavily in science and technology have achieved greatness, while those that have not done so are lagging behind. According to Mamudu, and Uhumuarbi, (2009) material well-being of the world is driven by science and technology, the rich countries of the world are the science and technology haves while the poor countries are the science and technology have not. That the differences in the scientific and technological infrastructure and in the popularization of science and technology in the two groups of countries are the most important causes of differences in the social, economic, political and cultural developments of the

two groups. It is against this backdrop this paper seeks to find out whether a re-thinking in the strategies used in teaching Science, Technology and Mathematics could yield result in students' academic performance.

II. Conceptual Framework

Education and learning should serve particular socio-economic ends and be directed primarily at producingthe producers (Scientists, Technologists and Mathematicians). This underscores the need to improve the quality of Science, Technology and Mathematics teaching and learning. The standard of science technology and mathematics teaching should reflect the changing physical, social and economic needs of today.Modern Science, Technology and Mathematics learner should be role player, discoverer, technician, experimenter, designers, and self-directed learner. While the STM teacher of today should be a resource person, a stimulator, organizer, evaluator, innovators moderator and manager of learning (Daluba, 2013). To appropriately address the problem of this study, the researchers considered it necessary to proceed from a premise of conceptual clarification. Major concepts in this study that requires clarification are:

1. Expository (Lecture) or Traditional method
2. Problem-based learning strategy
3. Project-based learning strategy

1. **Expository (Lecture) or Traditional Teachingmethod:**

This is one of the oldest and most widely used teaching methods in junior secondary schools in Nigeria (Daluba, 2013).It is a kind of classroom interaction in which teacher talks and writes notes on the board while students listen and take down note of facts worth remembering. Lecture method is important in handling large classes and in imparting large body of factual information but it does not encourage creativity. In this method the teacher regards himself as chief source of knowledge which he imparts to the learners in doses like a doctor giving prescription of medicine to patient. This is not an effective way of getting learners to learn(Hang 2006).

2. **Problem-Based Learning Strategy (PBLS)**

Problem-based learning strategy {PBLS) is astrategy that challenges students to learn through engagement in a real problem. It is a format that simultaneously develops both problem solving strategies and disciplinary knowledge bases and skills by placing students in the active role of problem-solvers confronted with an ill-structured situation that simulates the kind of problems they are likely to face as future managers in complex organizations(Daluba, 2013).Problem-based learning is student-centered. PBL makes a fundamental shift-from a focus on teaching to a focus on learning. The process is aimed at using the power of authentic problem solving to engage students and enhance their learning and motivation. According to Adekoya and Olatoye, (2011)there are several unique aspects that define the PBL strategy:

- Learning takes place within the contexts of authentic tasks, issues, andproblems-based that is aligned with real-world concerns.
- In a PBL strategy, students and the instructor become co-learners, co-planners, co-producers, and co-evaluators as they design, implement, and continually refine their curricula.
- The PBL strategy is grounded in solid academic research on learning and on the best practices that promote it. This approach stimulates students to take responsibility for their own learning, since there are few lectures, no structured sequence of assigned readings, and so on.
- PBL strategy is unique in that it fosters collaboration among students, stresses the development of problemsolving skills within the context of professional practice, promotes effective reasoning and self-directed learning, and is aimed at increasing motivation for life-long learning.

Problem-based learning begins with the introduction of an ill-structured problem on which all learning is centered. The problem is one that students are likely to face as future professionals. Expertise is developed by engaging in progressive problem solving. Thus, problems drive the organization and dynamics of the course.Students, individually and collectively, assume major responsibility for their own learning and instruction. Most of the learning occurs in small groups rather than in lectures. The role of teacher, changes from "sage on stage" to a "guide by the side." The role of the teacher is more like that of a facilitator and coach of student learning, acting at times as a resource person, rather than as know ledge-holder and disseminator. Similarly, the role of individual, as a student, is more active, as he/she engaged as a problem-solver, decision-maker, and meaning-maker, rather than being merely a passive listener and note-taker.

3. **Project-Based LearningStrategy (PLS)**

Project-based learning refers to any programmatic or instructional approach that utilizes multifaceted projects as a central organizing strategy for educating students. When engaged in project-based learning, students will typically be assigned a project or series of projects that require them to use diverse skillssuch as researching, writing, interviewing, collaborating, or public speaking—to produce various work products, such as

research papers, scientific studies, public-policy proposals, multimedia presentations, video documentaries, art installations, or musical and theatrical performances, for example. Unlike many tests, homework, assignments, and other more traditional forms of academic coursework, the execution and completion of a project may take several weeks or months, or it may even unfold over the course of a semester or year.Closely related to the concept of authentic learning, project-based-learning experiences are often designed to address real-world problems and issues, which requires students to investigate and analyze their complexities, interconnections, and ambiguities (i.e., there may be no "right" or "wrong" answers in a project-based-learning assignment). For this reason, project-based learning may be called *inquiry-based learning* or *learning by doing*, since the learning process is integral to the knowledge and skills students acquire. Students also typically learn about topics or produce work that integrates multiple academic subjects and skill areas. For example, students may be assigned to complete a project on a local natural ecosystem and produce work that investigates its history, species diversity, and social, economic, and environmental implications for the community. In this case, even if the project is assigned in a science course, students may be required to read and write extensively (English); research local history using texts, news stories, archival photos, and public records (history and social studies); conduct and record first-hand scientific observations, including the analysis and tabulation of data (science and math); and develop a public-policy proposal for the conservation of the ecosystem (civics and government) that will be presented to the city council utilizing multimedia technologies and software applications (technology).

Statement of the Problem

Traditional educational practices, starting from primary to tertiary levels, tend to produce students who are often disenchanted and bored with their education. They are faced with a vast amount of information to memorize, much of which seems irrelevant to the world as it exists outside the school. Students often forget much of what they learned, and that which they remember cannot often be applied to the problems and tasks they later face in the business world. Traditional classrooms also do not prepare students to work with others in collaborative team situations.Research in educational psychology has found that traditional educational approaches (e.g., lectures) do not lead to a high rate of knowledge retention. Despite intense efforts on the part of both students and teachers, most material learned through lectures is soon forgotten, and natural problem solving abilities may actually be impaired. In fact, studies have shown that in 90 days students forget 90% of everything they have been told (Tick, (2007). Motivation in such traditional classroom environments is also usually low.Therefore, this study was set to investigate if the use of problem-based and project-based learning strategies of teaching and learningBasic science, Technology and Mathematics in junior secondary schools could yield better performance.

III. Objectives of the study

The objectives of this studyare:

4. To determine if there is a difference in the efficacy of using expository method and problem-based learning strategy
5. To determine if there is a difference in the efficacy of using expository method and project-based learning strategy
6. To determine if there is a difference in the efficacy of using problem-based learning strategy and project-based learning strategy

Research Questions

1. Is there any difference in effectiveness between expository (Traditional) method and problem-based learning strategy on the academic performance of students in basic science, technology and mathematics?
2. Is there any difference in effectiveness between expository (Traditional) method and Project-based learning strategy on the academic performance of students in basic science, technology and mathematics?
3. Is there any difference in effectiveness between problem-based learning strategy and Project-based learning strategy on the academic performance of students in basic science, technology and mathematics?

Null Hypotheses

In line with each of the research question, the following null hypotheses were formulated and tested at 5% level of significance ($p = 0.05$).

1. There isno significant difference in effectiveness betweenexpository (Traditional) Method of Teaching and problem-based learning strategy on the academic performance of Basic science, Technology and Mathematics students.
2. There is no significant difference in effectiveness between expository (Traditional) Method of Teaching and project-based learning strategy on the academic performance of Basic science, Technology and Mathematics students.

3. There is no significant difference in effectiveness between problem-based learning strategy and Project Based learning strategy on the academic performance of Basic science, Technology and Mathematics students.

IV. Methodology

Quasi experimental design was adopted for this study. This design was suitable for this research as it allowed the researchers to collect data on students' academic performance under the learning strategies (problem-based learning and project-based learning strategies).

V. Results

Analysis of data collected was done using various inferential statistics.

RQ1. Is there any difference in effectiveness between expository (Traditional) and problem-based learning strategy on the academic performance of students in basic science, technology and mathematics?

Table 1: Means and Standard Deviation of Post-test Scores of Students under Problem-based Learning Strategy (PSBLS) and Expository Method (TMT)

Group	N	Mean	Std. Dev.	Std. Error	Mean Diff
PSBLS	55	48.678	18.158	2.4480	28.048
TMT	55	20.630	10.460	1.4105	

(Field work 2015)

Result in table 1 indicated that, post-test performance of students taught using problem-based strategy was better than that of students taught using the expository(TMT) method. This therefore showed that, problem-based strategy was effective in teaching BSTM in junior secondary schools. The calculated mean for problem-based post-test was 48.7 while that of the control group post-test was 20.6. This revealed that, students performed better in problem-based method (PSBLS) than Expository method (TMT).

Ho1. There is no significant difference in effectiveness between expository (Traditional) Method of Teaching and problem-based learning strategy on the academic performance of Basic science, Technology and Mathematics students.

Table 2 T-test for significant difference between mean of problem-based learning strategy (PBLS) and Expository(TMT) students

Group	N	Mean	SD	Df. T-cal	P-Value
PSBLS	55	48.678	18.158		0.000
TMT 55		20.636	10.460	1.089.922	

(Field work 2015)

The result of t-test analysis used to test null hypothesis one was presented in table 2. From the table, the t-calculated was 9.92 which is greater than the p-value0.000 at∞ =0.05 level of significance ($p \leq 0.05$). The analysis therefore showed that, problem-based learning strategy has significant effect on the academic performance of Basicscience students. Therefore, the null hypothesis which states that, problem-based learning strategy has no significant effect on the academic performance of science students was rejected.

RQ2. Is there any difference in effectiveness between expository (Traditional) method and Project-based learning strategy on the academic performance of students in basic science, technology and mathematics?

Table 3 mean and standard deviation of post-test scores of students under project-based learning strategy (PBLS) and expository (TMT) method

Group	N	Mean	Std. Dev.	Std. Error	Mean Diff
PBL	55	28.146	10.346	1.3949	
TMT	55	20.636	10.460	1.4105	7.51

(Field work 2015)

Table 3 showed the means and standard deviations of project-based post-test and control group post-test respectively. The means and standard deviation for project-based learning strategy post test scores are 28.14 and 10.34 and those of control group post test scores are 20.63 and 10.46 From table 3 therefore, it was clearly show that, students performed better in project-based learningstrategy than in expositorymethod (lecture method) this implies that, project-based learning strategy has an effect on students' academic performance.

Ho2. There is no significant difference in effectiveness between expository (Traditional) Method of Teaching and project-based learning strategy on the academic performance of Basic science, Technology and Mathematics students.

Table 4 T-test for significant difference between mean of Project-based learning strategy(PBLS) and Expository(TMT) method students

GroupN	Mean	SD	Df.	T-cal	P-Value
PBL 55	48.678	18.158	1.08	9.922	0.000
TMT 55	20.636	10.460			

(Field work 2015)

The t-test analysis used to test null hypothesis two as presented in table 4 revealed that, t-calculated 9.92 was greater than p-value 0.000 at $\infty = 0.05$ level of significance ($p \leq 0.05$). This implies that, the null hypothesis, which states that, project-based learning strategy has no significant effect on the academic performance of science students, was rejected. RQ3. Is there any difference in effectiveness between problem-based learning strategy and Project-based learning strategies on the academic performance of students in basic science, technology and mathematics?

Table 5: Means and standard deviations of student post test scores under problem-based learning (PSBLS)and project-based learning (PBLS)strategies

Group	N	Mean	Std. Dev.	Std. Error	Mean Diff
PSBLS	55	48.673	18.158	2.4448	
PBLS	55	28.146	10.345	1.3949	20.527

(*Field work 2015)*

Table 5represents the means and standard deviations of students' scores under both problem-based learning and project-based learning strategies.These were obtained after exposing students to the two learning strategies (problem-based learning and project-based learning strategies). The mean score and standard deviation of students exposed problem-based learning48.67 and 28.14which are greater than the mean score and standard deviation of students exposed to the discussion method 18.1 and 10.34. This therefore showed that, students performed better in problem-based learning than in project-based learning strategy.

Ho3. There is no significant difference in effectiveness between problem-based learning strategy and Project Based learning Strategyon the academic performance of Basic science, Technology and Mathematics students.

Table 6 t-test analysis of the significant difference between the academic performance of students under problem-based learning strategy (PSBLS) and project-based learning strategy(PBLS)

Group	N	Mean	SD	Df.	T-cal	P-Value
PSBLS	55	48.673	18.158			0.000
PBL	55	28.146	10.345	1.08	7.285	

(Field work 2015)

Table 6presents t-test analysis of the difference between the academic performance of agricultural science students taught using problem-based learning strategy and those taught using project-based learning. The table showed that, t-cal7.285 is greater than P-value0.000 at $\infty = 0.05$ level of significance ($P \leq 0.05$). This implies that, there is a significant difference between the performance of basic science students taught using problem-based learning strategy and those taught using project-based learning. Therefore, the null hypothesis which states that, there is no significant difference between the academic performance of sciences students taught using problem-based learning strategy and those taught using project-based learning has been rejected.

VI. Discussion of Findings

The study revealed that, problem-based learning strategy has significant effect on the academic performance of BSTM students in junior secondary schools. This was revealed by the findings in table1 in which the mean score for students exposed to problem-based learning strategy48.67 was greater than the mean score for students exposed to the traditional lecture method 20.63. The result of t-test analysis on table 2 also revealed that problem-based learning strategy has significant influence on the academic performance of science students in junior secondary schools. This was because; t-calculated 9.92on table 6 was greater than the p-value (0.000) at $\infty = 0.05$ level of significance ($P \leq 0.05$). This finding agrees with Ahmed, (2002) and Omorere, (2011) who found that, problem-based learning strategy enhance teaching and learning of BSTM and promote students' performance.Table 3 showed a mean score of students exposed to project-based strategy28.14 to be greater than the mean score of student exposed to expository or traditional lecture method 20.63. The t-calculated 9.92 on table 4 was also greater than the p-value0.000 at $\infty = 0.05$ level of significance ($P \leq 0.05$). This therefore revealed that, project-based learningstrategy has a significant effect on the academic performance of BSTM students. This also agreed with the findings of other researchers. Adekoya et al, (2011) found that, project-based learning strategy has a significant effect on the academic performance of BSTM students. Ebrahimi, (2006) and Edinyang (2012) also opined that project-based learning strategyis very effective in teaching BSTM science and can be used to enhance students' performance. This work also agrees with the work conducted by Abdulhamid (2013) who found that, project-based learningstrategy is very effective in teaching and learning BSTM and can promote students' academic performance.Table 5 showed the means score and standard deviation of students exposed to problem-based

learning strategy and those exposed to project-based learning strategy. The table reveled that, students in problem-based learning strategy performed better than those in the project-based learning strategy. This is because, the mean score of students exposed to problem-based learning strategy48.67 was greater than the mean score of students exposed to project-based learning strategy28.14. The t-test analysis in table 6 showed a significant difference between the performance of BSTM students exposed to problem-based learning strategy and those exposed to the project-based learningstrategy. T-calculated was (7.28) while p-value was0.000)at 5% level of significance ($P \leq 0.05$), which meanthat, there was a significant difference between the two strategies. This implies that, problem-based learning strategywas more effective in teaching and learning BSTM in junior secondary schools than project-based learning strategy. This finding is in line with the findings of others researchers. Oghenevwede, (2010) foundproblem-based learningstrategy as the best method for teachingBSTM in junior secondary schools. This was supported by Jada, (2002) and Omotere (2011) who maintained that problem-based learningstrategy is a better strategy for teaching STM in junior secondary schools and that lead to active participation by the learners.

VII. Conclusion

Based on the findings of the study, the following conclusions were drawn:-

1. Problem-based and project-based learningstrategies are very effective in teaching science, technology and mathematics in junior secondary schools and can enhance students' academic performance.
2. Problem-based strategy is more effective than project-basedstrategy in teaching science, technology and mathematics in junior secondary schools.
3. Both Problem-based and project-based learning strategies can be used concurrently to facilitate effective teaching and learning and enhance better performance by the learners.

VIII. Recommendations

Based on the findings and conclusions of the study, the following recommendations were made;

1. There is need for curriculum planners to emphasize the importance of using Problem-based and project-based learning strategies when teachingBasic sciences, Technology and Mathematics by the teachers in junior secondary schools.
2. Teachers in junior secondary schools should be encouraged to use problem-based learning strategy in teaching science as it was found to be more effective than project-based learning strategy.
3. There is need for the federal and state ministries of education to equip schools with adequate facilities and equipmentneeded for effective Problem-based and project-based learning strategies.

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