# Acquisition of mathematical skills in trigonometrical concepts through project based learning in junior secondary schools in Calabar municipality of Cross River State, Nigeria.

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This paper focuses on the interactive development of junior secondary three (JS3) students' knowledge and performance in Pythagoras theorem using project-based learning skills (collaboration and critical thinking). The purpose therefore, is to acquaint the students with the necessary mathematical skills that enrich their knowledge of formation and solution of Pythagorean triple triangles. A non-equivalent pre-test post-test quasi-experimental design was used on a sample of 280 JS3 students from two private and two public schools to ascertain the knowledge level and cognitive achievement before and after exposing them to project-based learning strategy. Students were also interviewed. Special lesson plans were developed and the teachers were trained on the use of this strategy. Mean scores, standard deviations and dependent t-tests were used to analyse the data. It was discovered that students' performance was enhanced and they were able to construct and solve Pythagorean triple triangles easily and quickly. Recommendations were made based on these findings.

**Keywords: acquisition, mathematical skill, project-based learning, trigonometrical concepts.**

## Introduction

There has been a drastic reduction in the standard of performance by students at all levels of education in Nigeria in the past decades. This fall in standard of education is attributed to many factors, one of which is wrong method of teaching (Emaikwu and Nworgu, 2005; Onah, 2012). Emaikwu (2012) attributes the fall in standard of performance at secondary school level to pedagogical approaches adopted by teachers. The methods commonly used may not be effective as learners are passive listeners in the teaching and learning process. This leads to low achievement in both internal and external examinations. Researchers have made several efforts towards designing techniques for more effective teaching in mathematics.

At the moment, there are a number of innovative instructional techniques advocated which include constructivism (Ekon, 2013), project-based learning approach (Ekwueme, 2013), co-operative learning and problem solving approach (Ekwueme, 2006). Ekwueme, (2013) stated that these innovative strategies, especially project-based learning, not only help students learn and retain information but have a positive effect on the students' attitudes towards studying mathematics. Ekwueme (2006) stated that mathematics is more about seeing and doing than hearing since we can easily forget what we hear. She further stated that mathematics is made more real when students are fully involved in the activity of arriving at a conclusion.

She advocated project-based learning approach as an innovative approach that exposes students to collaboration and critical thinking.

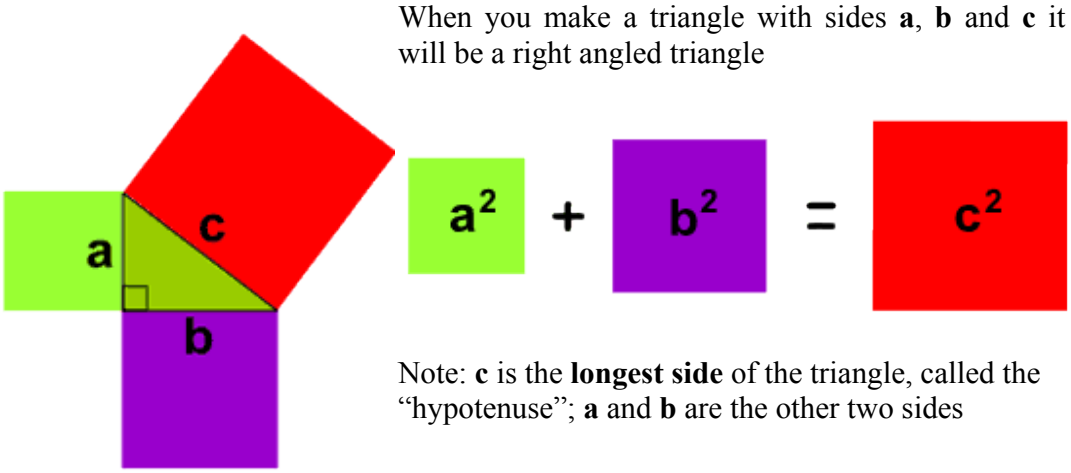
Project-based learning is an individual or group activity that goes on over a period of time, resulting in a product, presentation or performance. It is an effective method of teaching mathematics for inter-disciplinary transfer. Here, the teacher engages students actively in projects involving mathematical skills and knowledge. Learners are engaged in varied, meaningful practice, the type that can be fostered through real-life applications in order to gain skills required for competent and flexible performance on independent tasks. John (2000) described project-based learning as a model that organises learning around projects. He stated that there are instances where project work follows traditional instruction in such a way that the project serves to provide illustrations, examples, additional practice or practical applications for materials taught initially by other means. Meaningful applications of concepts rather than rote recall need to be practised until they become second nature.

Project-based learning varies from classroom to classroom, with the teacher in the role of facilitator rather than leader. A high level of intrinsic motivation and active engagement are essential to the success of a problem-based learning lesson. Students are actively engaged in doing things rather than in learning about something. Project-based learning is one of the best teaching strategies for engaging students in realistic learning activities. This is because it engages the minds of the students and they think critically. It is an individual or group activity. In project-based learning, students go through an extended process of inquiry in response to a complex question, problem or challenge. Rigorous projects are carefully planned; managed and assessed to help students learn key academic content and practise 21st century skills such as collaboration, communications and critical thinking.

In mathematics, Pythagoras' theorem is mostly taught as the formula $a2 + b2 = c2$, where $a$, $b$, and $c$ are the lengths of the sides in a right angled triangle. Finding a missing length is taught as a procedure to be learnt. In a problem-based learning approach that incorporates the formation of Pythagorean triples, there are possibilities for developing mathematical understanding.

A **Pythagorean triple** consists of three positive integers $a$, $b$, and $c$, such that $a2 + b2 = c2$. Such a triple can be written as ($a$, $b$, $c$), and a well-known example is (3, 4, 5).

Figure 1: Pythagoras' theorem (http://www.mathisfun.com/index.htm)



### *Purpose of study*

The purpose of the study is to acquaint the students with the necessary mathematical skills that will help them master, solve and form Pythagorean triple triangles with ease. Specifically the study seeks to:

(i) Acquaint the junior secondary school three students with the mathematical skills of constructing Pythagorean triple triangle with ease.
(ii) Solve related problems in Pythagoras' theorem using any of the stated patterns.
(iii) Create an opportunity for collaboration and critical thinking in students.

## Methodology

A quasi-experimental design was used for the study. The study covered four secondary schools (two private and two public) with a sample of two hundred and eighty students. A simple random sampling technique was used to select the four schools from the forty-five secondary schools in Calabar Municipality of Cross River State, Nigeria. A class that has been taught Pythagoras' theorem conventionally was selected for the intervention in each of the selected schools.

The two instruments used for data collection were a Mathematics Skills Acquisition Test (MSAT) and a Preference Teaching Strategy Interview (PTSI). These were used to measure students' mathematical skill acquisition (before and after the project based learning intervention) and their preference for teaching approach, respectively. The MSAT was in two sections: Section A consists of questions on skill acquisition based on constructing Pythagorean triple triangles, while section B consists of problem solving using Pythagoras' theorem and patterns in Pythagorean triples.

Students worked in small groups on different methods of constructing Pythagorean triple triangles. Each group used a different method. A representative of each group made a presentation of the group's work. Students were interviewed individually about their preference for either a conventional or project-based learning approach. Their responses to each of the methods were recorded. Four mathematics teachers from the selected schools were trained to use the project-based learning approach to teaching Pythagorean triples.

## Experimental Procedure

### *Training programme for teachers*

The four teachers were trained on how to use the project-based learning approach to construct and solve Pythagorean triple triangles. The training exercise lasted for two days. The researchers highlighted the need for better instructional methods to improve students' academic performance in mathematics, and how project-based learning could help. They introduced the Pythagorean triple triangles lesson, and the different methods that could be used in their formation. The training included micro-teaching by the teachers.

### *Research questions*

1. What is the students' general assessment of the project-based learning approach?
2. What is the mean difference in performance of students in pre-test and post-test scores?

### *Research hypothesis*

There is no significant effect of the project-based learning approach on academic performance of JS3 students in solving Pythagorean triple triangles.

### Data analysis

Data were analysed using percentages, mean difference and dependent t-test analysis as presented in the tables below.

### *Research question 1*

What is the students' general assessment of the project-based learning approach?
The students' responses to the interview questions are shown in table 1.

Table 1:Response of Students on Preference and Assessment for Teaching Method

| Teaching method | Frequency of students' response | |
|---|---|---|
| | Private (n=100) | Public (n=180) |
| Conventional approach | 30 (30%) | 32 (17.8) |
| Project-based approach | 70 (70%) | 148 (82.2%) |

From table 1, more of the students in both Private and Public schools indicated a preference for the project-based learning approach with 70% and 82.2% respectively. They preferred this approach because it exposed them to the real meaning of Pythagorean triple triangles and easy solution of right angle triangle problems without memorisation of the theorem.

### *Research question 2*

What is the mean difference in performance of students in pre-test and post-test scores? Their mean scores and standard deviations were calculated as shown in table 2.

Table 2: Mean scores and standard deviation of the pre-test and post-test

| | N | X | SD |
|---|---|---|---|
| Pre- test | 280 | 40.03 | 9.54 |
| Post-test | 280 | 71.61 | 17.99 |

From table 2, the mean and standard deviation scores in pre- and post-tests were 40.03 and 9.54; 71.61 and 17.99 respectively. This implies that students performed better in their post-test after experiencing project-based learning than in

their pre-test as can be observed from their mean scores of 71.61 and 40.03. However the variation in the results was greater. To find out if the observed difference in mean was statistically significant, the corresponding hypothesis was therefore tested.

### *Hypothesis*

There is no significant effect of the Project –Based Learning Approach on academic performance of JS3 students in solving Pythagorean triple triangles.

The scores of the pre-test and post-test were used to calculate the mean, standard deviation and dependent t-test as shown in table 3.

Table 3: Dependent t-test analysis for pre- and post-test scores on MSAT

| | N | X | SD | Df | t-Cal | t- table | Dec |
|---|---|---|---|---|---|---|---|
| Pre-test hypothesis rejected | 280 | 40.03 | 17.99 | 558 | 100.9 | 1.645 | Null |
| Post-test | 280 | 71.61 | 9.54 | | | | |

.05 Significance level

Since the calculated t-value of 100.9 is greater than the critical t-value of 1.645 at an alpha level of 0.05 with 558 degree of freedom (Df), the null hypothesis of no significant difference was rejected and the alternate hypothesis upheld. This showed that there was a statistically significant effect of the project-based learning approach on academic performance of JS3 students in solving Pythagorean triple triangles.

## Discussion

The findings revealed that there was a statistically significant difference in the mean scores of the students' pre-test and post-test. The high mean score of 71.61 after exposing students to the problem based learning approach is an indication that the experience helped the students to acquire mathematical skills required for real understanding of Pythagorean triple triangles.

The active involvement of the students caused them to interact with one another, work in groups and construct Pythagorean Triples individually. This finding is in line with Ekwueme (2013) who observed that the problem-based learning approach enhances students' performance in mathematics. In the individual interviews most students expressed a preference for the problem-based learning approach over a conventional approach when constructing Pythagorean triple triangles. They felt more confident about using a variety of strategies for constructing Pythagorean triple triangles.

## Recommendations

Based on the findings of this study, the following recommendations have been made.

1. The research indicated that majority of the students preferred the project-based learning approach to a conventional approach. Mathematics teachers should try to use this approach.
2. Regular seminars and workshops should be organised for mathematics teachers to acquaint them with innovative teaching techniques to improve their effectiveness in the classroom.

3. Mathematics teachers should be exposed to innovative methods of teaching through in-service training programmes organised and delivered by appropriately qualified personnel.
4. Teachers should make lessons that will challenge students to be actively involved by choosing tasks that will provoke their curiosity and interest in mathematics.
5. Teachers should give students opportunities to express themselves in a variety of ways.
6. Teachers could adopt the problem-based learning approach used in this study to secure better understanding of solving Pythagorean triple triangles and greater achievement in mathematics.

## Suggestion for further studies

Based on the findings of this study, further studies should be carried out in other places and subjects to investigate the efficacy of the problem-based learning approach.

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