

Exploring the Effectiveness of Project-Based Learning Approach on Junior Secondary School Students' Academic Achievement in Descriptive Geometry in Katsina, Nigeria

Hamza Abubakar¹, Ahmed Madugu² And Muntari Idris³

^{1,2,3}department Of Mathematics, Isa Kaita College Of Education
P.M.B. 5007 Dutsin-Ma, Katsina, Nigeria



Abstract – This study examined the effectiveness of the project-based learning strategy on the academic achievement of junior secondary school students on descriptive geometry in dutsin-ma, Katsina State, Nigeria. The study utilized the pretest, posttest and post posttest quasi experimental design involving two groups tagged ‘experimental’ and ‘control’. The population of the study consists of all the public senior secondary school two (JSS2) students of the eleven (11) secondary schools in Dutsin-Ma Zonal Quality Assurance with a total population of 34312 students. The sample size was 120 students. The instrument for the collection of data was Descriptive geometry achievement test (DGAT). It was validated by experts in measurement and evaluation and mathematics education with a reliability index of 0.88. Inferential statistic ANCOVA was used to test the hypotheses formulated at 0.05 level of significance. The study found among other things that discovery method enhanced students’ achievement in the Descriptive geometry taught during the period of this study. Recommendations such as encouraging teachers to adopt this strategy in their mathematics classroom were made. Adequate conclusion was equally reached.

Keywords – Project-Based Learning; Descriptive Geometry; Achievement; Secondary Students.

I. INTRODUCTION

The student-centered active learning process within which the teacher is merely a guide is the focal point of contemporary education systems. Active learning is a learning process in which the learner takes the responsibility of his/her learning and he/she is given the opportunity to make decisions about various dimensions of the learning process and to perform self-regulation. In active learning process, learning is no longer a standard process, but it transforms into a personalized process. Here, the skills of problem-solving, critical thinking and learning to learn are developed. In this respect, it is important for students to be prepared for the future by facing real problems in their learning environment and producing appropriate solutions to

these problems. What is expected from education is to enable individuals to become effective problem solvers in their actual lives (Abubakar et al. 2015a). Pedagogy, the art of teaching and learning, was an age - long educational activity in the teaching and learning process and the teacher, whose responsibility is to deliver the message to the child, needs to have the most effective strategies and methods of passing on the knowledge to the child. For some time now, the best way to teach mathematics to students has been a serious concern to mathematics educators (Abubakar et al 2015b).

The present day teaching and learning of mathematics in Nigeria is far from being satisfactory (Adeyemo, 2010). The poor alarming results and recent debates on the falling standard off the achievement of students in mathematics

have triggered increasing attention for researchers, parents, and educational scholars in their quest for the way forward over the past two decades. The teaching and learning of mathematics have for now become a great concern for all and sundry in this country. Recent development in Nigeria has shown marginal decline in students' performance. The reports from the West African Examination Council chief examiners indicates that the general performance of the candidates in mathematics for the May/June 2015, 2016, 2017 and 2018 examinations did not differ significantly from those of the previous years (WAEC, 2015, 2016, 2017 & 2018). This performance was attributed to ineffective teaching and learning strategies in mathematics and sciences. This is because students' academic performance in mathematics and sciences will determine the production of scientific literate citizens and future scientist and technologist for national development. Olofin, et al. (2020) attributed the poor performance recorded by WASSCE over the years to poor teaching strategies employed by teachers. It is because of the embarrassment recorded over the years on students' poor achievement in mathematics made researchers to look for the best method to adopt. This has also informed why government in power is spending huge sums of money supporting researches, conferences, workshops and seminars to find the best possible initiatives to promote effective teaching and learning of mathematics to make it more enjoyable in Nigeria.

The teacher's way of teaching is also immensely affected by the theoretical perspectives of the teachers, especially the beliefs of the teachers about the subject. It is based on these therefore, that the effects of teachers' related factors on students' achievement in mathematics especially descriptive geometry has become imperative. Geometry is a key area in the curriculum of school mathematics. Its usefulness in everyday life is evident in the measurement and estimation areas. The West African Examinations Council (WAEC) Chief Examiners' Reports May/June (2015, 2016, 2017, 2018 and 2019) identified geometry as one of the branches of mathematics in which students have not been performing satisfactorily.

Geometry is a branch of mathematics which deals with the study of different shapes or figures and their properties (Fabiyyi, 2017). Geometry could be a plane or solid shape and their properties. The plane shape is a geometrical object with length and width/ breadth or base and height/ altitude. Plane shapes are also called 2-dimensional shapes such as square, rectangle, circle, polygon, triangle, and so on. A solid shape is a geometrical object with length, breadth and height or

base area and height. Solid shapes are also called 3-dimensional shapes such as a cone, pyramid, sphere, cylinder, prism, cube, and cuboid and (Salman, 2009). Geometry plays a significant role in primary and secondary schools mathematics curricula in Nigeria and other countries. It provides a rich source of visualization for understanding arithmetical, algebraic, and statistical concepts (Battista, 1999). Also, Pittalis et al. (2010) expressed that geometry provides a complete appreciation of the world we live in. Geometry appears naturally in the structure of the solar system, a geological formation, rocks and crystals, plants and flowers, and even in animals. It is also a major part of the synthetic world such as art, architecture, cars, machines, and virtually everything humans create. In the same vein, studies revealed that geometry is applicable and relevant to employment in everyday live, other subjects in the curriculum such as science, arts, and technology. Also, geometry is used to develop students' spatial awareness, intuition, visualizations and to solve practical problems Chiphambo et al (2020). Despite the importance, nevertheless, students continue to hate and dislike geometric concepts and thus attain poor external examination (Bello et al. 2017). The problems and difficulties experienced are traceable to insufficient knowledge of design rubrics, measurement and identification of descriptive shapes and figures (WAEC Report 2016-2018). The general concern of every mathematics educators is to improve the achievement of students in mathematics. One of the topics that need students' attention is geometry because of its importance in our everyday lives such as in building technology and in construction industries. In the effort to improve students' achievement in mathematics, researchers have suggested various new teaching methods. It is very important to prefer the right and effective educational approaches for students. One of the effective teaching approaches is project based learning because students use problem solving methods, their cognitive and psychomotor skills in this approach.

Project-based learning strategy is a method of teaching where the students arrive at "new" knowledge as a result of their own observations (Obodo, 2004). It provides for activities which permit self-direction, exploration, the nurturing and satisfying of curiosity on the parts of students. Some scholars see it as avenues to discover new truths, new rules, new generalizations, new principles, new methods and techniques of learning and tackling life problems for themselves. Tarmizi, et al.(2012), examined the effects of PBL on educational statistics course. Six PBL modules, which consisted of scenarios and guided questions, were

used during a 10-week teaching. Comparing students' performances based on two tests showed that there was a significant difference between the mean performance of the PBL group and that of the conventional group – indicating PBL efficacy. Holmes, et al. (2016) investigated the benefits of project-based learning (PBL) on secondary-mathematics students' academic skill development and motivated strategies for learning (i.e., cognitive, social, and motivational). The focus of this study was academic skill development (algebra- and geometry-assessment scores) and other factors related to secondary mathematics learning, with comparable traditional high schoolers serving as the control group. Results showed that at-risk and minority students benefited greatly from PBL in learning mathematics. The academic performance gap was present, but its width diminished significantly. Compared to their public school counterparts, PBL students were more intrinsically motivated, showed significantly higher critical thinking skills, and appreciated peer learning. Han et al. (2015) investigate whether participating in science, technology, engineering, and mathematics (STEM) project-based learning (PBL) activities effected students who had varied performance levels and to what extent students' individual factors influenced their mathematics achievement. STEM PBL instruction influenced student achievement in mathematics by both student demographic backgrounds and performance levels. Low performing students showed statistically significantly higher growth rates on mathematics scores than high and middle performing students over the 3 years. Results of the present study implied that STEM PBLs in schools benefitted low performing students to a greater extent and decreased the achievement gap. Solihatin et al. (2019) study the effect of Brain-Based Learning and Project Based Learning strategies on the results of mathematics learning in students of visual learning styles in the Basic Mathematics. The results showed that the learning outcomes of students from the visual learning style group were taught the strategy of Brain-Based Learning higher than Project-Based Learning. Chen et al. (2019) performed a meta-analysis to synthesize existing research that compared the effects of project-based learning and those of traditional instruction on student academic achievement. Forty-six effect sizes (comparisons) extracted from 30 eligible journal articles published from 1998 to 2017 were analyzed, representing 12,585 students from 189 schools in nine countries. The results indicated that project-based learning has a medium to large positive effect on students' academic achievement compared with traditional instruction. Craig et al. (2019). This article reports a study of the effectiveness of

PBL on high school students' performance on state mandated standardized mathematics and science achievement measures. This study addresses both of these concerns and found that students taught through PBL, as a group, matched performance of conventionally taught students on mathematics. These results align with literature on the effects of PBL and deepen our understanding of these effects by providing a controlled study with random assignments to the PBL experience. Asri, et al. (2017) study the different levels of junior high school students' academic procrastination in learning mathematics by applying a project-based learning strategy and a conventional learning strategy. The result shows an interaction effect of project-based learning and self-regulated learning strategies on academic procrastination of junior high school students in learning mathematics. Also Busari (2016) proposed a problem solving strategy for effective teaching and learning. To achieve maximum success, students must therefore be guided by the psychological characteristics of how people learn..

There is little work known about the use of the project-based learning strategy in the education system in Nigeria, particularly in Descriptive geometry. Furthermore, in Nigeria there are very few empirical research on the use of the discovery technique in mathematics. Thus, the impact of the project-based learning strategy on the academic achievement of Junior Secondary school students in Descriptive Geometry in Nigeria needs to be explored empirically.

II. STATEMENT OF THE PROBLEM

The consistent poor achievement of students in mathematics has been of concern to mathematics educators, mathematicians and the general public. Despite the importance attached to mathematics and most especially geometry and the sums of money spent by government organizing workshops, seminars and on instructional materials to schools, students' achievement has not been encouraging.

The traditional methods often used in teaching topics in mathematics such as Descriptive Geometry in Junior schools in Nigeria, where teachers spend most of their class time watching, listening, copying and actually receiving passively from teachers, do not help to bring about a meaningful grasp of the concept of mathematics.. The summary of the West African Examination Council (WAEC) chief examiners' report (2014-2019) indicated that students fail to attempt questions relating to geometry. Those who do haphazardly

attempted it. Ogunleye (2010) reported that out of all the topics at the senior secondary school curriculum, geometry has the highest percentage of students' failure. This ugly trend in students' avoidance and consisted failure necessitated the choice of geometry for the study. Many factors among which are the poor achievement have been attributed ; inadequate teachers' content knowledge of geometry, poor teaching methods, lack of instructional materials, students' misconception and misinterpretation of questions and non adoption of limitless power of technology. Based on these, the researcher feels motivated to investigate effect discovery learning approach has on geometrical achievement among Junior secondary school students as compared to traditional teaching method.

III. OBJECTIVES OF THE STUDY

The study is designed to achieve the following objectives:

1. To investigate the effects of project-based learning strategy on students' performance in geometry.
2. To examine the efficacy of project-based learning strategy on students' attitudes toward geometry.

IV. RESEARCH QUESTIONS

1. What are the influences of project-based learning on the academic performance of Junior Secondary school students in geometry?
2. What are the effects of project-based learning strategy on students' attitude toward geometry?

V. RESEARCH HYPOTHESES

Ho₁: There is no significant difference between the mean performance scores of those taught geometry using project-based learning strategy and those taught with the conventional lecture method.

Ho₂: There is no significant difference between the mean attitude scores of those taught geometry using the project-based learning strategy and those taught with the conventional lecture method.

VI. METHODOLOGY

The design of this study employed quasi-experimental design. Specifically, pretest, posttest was used. For the purpose of establishing the effect of independent variables, the groups that experimented the treatment is compared with the group without any treatment. This is because the group will not have a random selection of students. Secondary school classes exist as intact and it would be difficult for the

school authorities to allow the classes to be dismantled for the case of research purposes.

Experimental and control were assigned to two groups at random. Intact classes of male and female students were sampled randomly to form the study subjects. The two groups were pretested before treatment to determine equivalence in all relevant aspects particularly in descriptive geometrical concepts. The experimental group was exposed to descriptive geometrical concept using project-based learning approach while conventional method was exposed to control group. After, a posttest was administered to the groups to observe if there is any significant difference in students' achievement between the groups.

A. Population And Sample

The population of the study consists of all the public Junior secondary school two (JSS2) students of the eleven (11) Junior secondary schools in Dutsin-Ma Zonal Quality assurance with a total population of (25314) students registered in 2016 – 2017 academic.

The sample size for the study was 120 senior secondary class two (JSS2) students. This is in line with central limit theorem of Tuckman (1988) and Sambo (2008) which recommends a minimum of 30 (students) sample size viable for experimental study. Based on the nature of this studies, the selection of the sample was based on three stage sampling techniques. Two senior secondary schools based on type (public) and gender composition (male and female) were selected using a purposeful sampling technique. For assigning the sampled schools to the experimental and control group, a simple random sampling was used. And finally, stratified sampling was used to assign the experimental group to 60 students.

B. Research Instrument

Descriptive Geometry Achievement Test (DGT) served as instrument for data collection. It consists of 30 items covering topics related to descriptive geometry: surface area, total surface area and volumes of cubes and cuboids, total surface area and volume of cylinder, cone, sphere, hemisphere and pyramids taught during the period of study. Three experts in the field of measurement, evaluation and mathematics education validated the instrument. It has a 0.88 reliability index set using test-re-test method. The study took six weeks to complete.

C. Experimental Procedures

Pre-test was given to two groups, experimental and control groups, followed by six weeks of experimental treatment, while at the same time teaching conventional method to the control group. Within the six weeks, students in experimental group were taught Descriptive geometry using the method of discovery where students were subjected to problems and were permitted to explore the alternatives on their own with the teacher serving as the referee. The control group was subjected to the method of reading. Using the chalk board as instructional materials, the researcher addressed the subject matter to the students. At the end of the assignment.

Immediately after treatment, the post - test was administered and another post-post test was performed after two weeks to determine their retention capacity. Analysis of Covariance (ANCOVA) was thereafter used. The teaching strategy was used as the independent variables while gender was used as the intervening variables using pretest scores as covariates. ANCOVA statistics controls the initial differences between experimental and control groups and also determines the direction of significance differences.

VII. ANALYSIS OF THE RESULTS

The data gathered through the achievement tests and attitude scales would be analyzed by using Statistical Package for Social Sciences 17.0. The descriptive statistics; mean, and standard deviation were used for answering the research questions while t-test was used in testing the null hypotheses.

A. Results Analysis

In answering the research questions, the data collected were analyzed using descriptive statistics of means and standard deviations. While in analyzing the null hypotheses, the data collected were analyzed using inferential statistics of t-test and one way ANOVA at p-value ≤ 0.05 . The details of the analyses were in tables;

B. Research Question One

What are the differences between the mean academic performance scores of students taught geometry using project-based teaching method those taught using conventional teaching method among junior secondary schools in Katsina state? To answer this question, a descriptive statistic using means and standard deviations were carried out. The result is presented in Table 4.

Table 4: Mean and Standard Deviation between the Project-Based Teaching Method and Conventional Teaching Method.

		Pretest			posttest		
Group	N	Mean	SD	Mean difference	Mean	SD	Mean difference
Experimental	90	9.68	30.23	-0.03	14.19	24.04	4.30
Control	90	9.71	29.11		9.89	11.88	
Total	180						

The result in table 4 revealed that the mean performance score of the experimental group was 14.19 (SD = 24.04) and that of the control group was 9.89 (SD = 11.88). The mean performance score difference between the groups was 4.30 in favour of the experimental group. The pretest performance scores were 9.68 (SD = 30.23) and 9.71 (SD = 29.11) for the experimental and control groups respectively. The mean difference of the scores was -0.03 in favour of the control group. This showed that there was a difference between the mean performance scores of those taught using project-based teaching strategy and those taught with conventional

teaching method after treatment in favour of project-based teaching method.

C. Null Hypothesis One

There is no significant difference between the mean performance scores of those taught geometry using project-based learning strategy and those taught using conventional teaching method among junior secondary school students in Katsina state. To test this hypothesis t-test statistics was employed, and the result is presented in table 5;

Table 5: T-test Analysis of Mean Performance Scores of Experimental and Control Groups.

Group	N	Mean	S.D	Df	t-cal.	P-val.
Experimental	90	14.19	24.04	178	6.81	0.0001
Control	90	9.89	11.88			

$p \leq 0.05$

The result in Table 5 shows that t-cal is 6.81 and p-value is 0.0001 which is significant at $p \leq 0.05$. This indicated that the null hypothesis one is rejected. Hence, there is significant difference in the mean performance scores of those taught geometry using project-based teaching strategy and those taught using conventional teaching method among junior secondary school students in Katsina state in favour of the experimental group.

D. Research Question Two

What is the effect of project-based learning strategy on students' attitude toward geometry?

To answer this question, a descriptive statistics using means and were carried out. The result is presented in Table 6.

Table 6: Frequency Counts and Mean Results on Students' Attitudes Towards Learning Geometry

S/N	Items	SA	A	U	DA	SDA	MEAN (X)	Decision
1	Geometry has been my worst area in mathematics	6	8	23	30	23	2.20	Accepted
2	I am not the type to do well in geometry	4	6	23	41	15	2.34	Accepted
3	I am usually at ease when learning geometry	23	17	23	13	14	3.21	Accepted
4	I think I could handle more difficult concepts in geometry	24	23	22	9	2	3.44	Accepted
5	I learn new concepts in geometry easily when taught with this method	33	23	22	9	2	3.96	Accepted
6	I understand lesson on geometry better when taught with this method	32	22	26	7	3	3.82	Accepted
7	My teacher have made me feel I have the ability to go on in geometry	31	24	21	12	2	3.75	Accepted
8	I am now comfortable when learning geometry using this method.	30	21	32	5	2	3.76	Accepted
9	I am more conversant with geometrical shapes	35	17	21	13	3	3.76	Accepted
10	I can now differentiate between two and three dimensional objects	35	22	19	10	4	3.85	Accepted
11	I can now use different methods to solve problem on polygon.	27	21	27	12	3	3.60	Accepted
12	I can apply Pythagoras theorem to solve practical problem.	41	19	18	10	2	3.98	Accepted
13	I developed my skills in solving problems on geometry	37	24	18	10	1	3.91	Accepted

Table 6 shows that items 3,4,5,6,7,8,9,10,11,12 and 13 have means ranging from 3.21 to 3.98 while items 1 and 2 have means of 2.20 and 2.34 respectively. The results indicated that student taught geometry using project-based teaching method have positive attitude toward learning geometry.

Table7: T-test Analysis of Geometry Attitude questionnaire of The Experimental and Control Groups.

Group	N	Mean	S.D	Df	t-cal.	P-val.
Experimental	90	3.47	26.04	178	5.46	0.0012
Control	90	2.59	21.68			

Table 7 shows the mean of attitude questionnaire of the experimental and control groups to be 3.47 and 2.59 respectively. The spread of scores around the mean for the above comparison group was 26.04 and 21.68 respectively. T-test was used to determine whether there is a significant difference between the of attitude questionnaire of experimental and control groups. The table showed that t-calculated is 5.46 while p-value is 0.0012 at 5% level of significant. Since p-value is less than 0.05, then the null hypothesis is rejected, which means there is significant difference between the mean of attitude questionnaire of experimental group and that of the control group in favour of the experimental group.

VIII. DISCUSSION

This study examined the effects of projects-based learning strategy on performance and attitude in geometry among junior secondary school students in Katsina State, Nigeria. Result from the study in table 5 revealed students taught geometry using project-based learning strategy performed better than those taught using lecture method. The result is in line with that for Bilgin et al (2015), Ozdemir et al. (2006) and Koparan et al, (2014) who investigated the effects of project-based learning in mathematics on fifth grade students' learning outcomes. In the study, both qualitative and quantitative research methods were used. According to the findings, the project-based learning approach affected the academic success of students.

Result in table 7 revealed that students taught geometry using project-based learning strategy have positive attitude towards geometry better than those taught using lecture method. This result is corresponds with the finding of Kaldi et al, (2011) and Erdem (2012) whose study on the effects of students' attitude and strategies on based on project-based learning. It was observed that project-based learning had on positive effect on students' attitudes and self-efficacy. The

Ho₂: There is no significant difference between the mean attitude scores of those taught geometry using the project-based learning strategy and those taught with the conventional lecture method.

result obtained from this study is also confirmed by other research studies in which the Project-based learning strategy is compared with conventional method from point of academic achievement (Bugaje et al, 2015; Tseng et al.,2013; Shin ,2018; Çakici et al. ,2013; and Beier et al. ,2019). In another hand, the finding of this study is contrary with the finding of Holmes et al. 2016; Ayaz et al. 2015and Helle et al (2006) in their study on the effects of project-based learning approach on learning process and learners' attitudes in mathematics. In the research, experimental method was used. It was found that there was no significant difference between pre-and post-test results of attitude scale on control and experimental groups.

IX. RECOMMENDATION

1. Based on the findings and conclusion of the study, the following recommendations are made:
2. Teachers of mathematics should be encouraged to integrate the project-based learning strategy in the teaching and learning processes at all levels of post primary school.
3. Parent teacher's association and non-governmental organizations should be assisting secondary schools with facilities that to be used in project-based learning.
4. School managers should allocate enough time /period for mathematics in their schools in so as to have good opportunity to carry out activities related to project-based method.
5. The Federal and State Ministries of education in collaboration with other bodies such as Mathematical Association of Nigeria (MAN) and National Mathematics Society (NMS) should organize seminar/workshop for teachers so as to update their knowledge on the use of project-based learning strategy to improve teaching and learning in Nigeria.

6. Teachers Training Institutions should also make the use of project-based learning strategy as part of their teacher education curriculum.

X. CONCLUSION

This study has established that project-based learning strategy is an effective instructional strategy that can be used to improve students' performance in mathematics at secondary school level. The strategy also improves students' attitude toward learning geometry. From the findings of this study, the researchers have come to a realization that students obtain better results when taught mathematics with Project-based learning strategy. Also, that teaching students using this approach enhances their ability to discover and solve problems on their own through the guidance of their teacher, thereby increasing the students' abilities in self-discovery and scientific method of problem solving.

CONFLICT OF INTEREST

There are no competing interests. All the authors contributed significantly to writing this article.

ACKNOWLEDGEMENTS

This research is supported by the Isa Kaita College of Education under Tertiary Education Trust Fund Research Grant Scheme

REFERENCES

- [1] Abubakar, H., Idris, M., & Madugu, A. (2015b). The Effect Of Further Mathematics On Secondary School Students' achievement In Mathematics, Biology, Chemistry And Physics In Katsina State, Nigeria. *International Journal of Scientific & Engineering Research*, Volume 6, Issue 4, April-2015 2011ISSN 2229-5518
- [2] Abubakar, H., Rabi, A., Usman, H., & Yahaya, M. (2015a). The Impact Of Physical Exercise On Junior Secondary
- [3] Adeyemo, S. A. (2010). Teaching/learning physics in Nigerian secondary school: The curriculum transformation, issues, problems and prospects. *International Journal of Educational Research and Technology*, 1(1), 99-111.
- [4] Asri, D. N., Setyosari, P., Hitipeuw, I., & Chusniyah, T. (2017). The influence of project-based learning strategy and self-regulated learning on academic procrastination of junior high school students' mathematics learning. *American Journal of Educational Research*, 5(1), 88-96.
- [5] Ayaz, M. F., & Söylemez, M. (2015). The Effect of the Project-Based Learning Approach on the Academic Achievements of the Students in Science Classes in Turkey: A Meta-Analysis Study. *Education & Science/Egitim Ve Bilim*, 40(178).
- [6] Beier, M. E., Kim, M. H., Saterbak, A., Leautaud, V., Bishnoi, S., & Gilberto, J. M. (2019). The effect of authentic project-based learning on attitudes and career aspirations in STEM. *Journal of Research in Science Teaching*, 56(1), 3-23.
- [7] Bello, N., Abdullahi, T. (2017). Effects of Mastering Learning Approach on senior secondary school students' performance in Geometry in Gusau Metropolis, Nigeria. *Proceedings of August 2017 54th Annual National Conference of Mathematical Association of Nigeria*.
- [8] Bilgin, I., Karakuyu, Y., & Ay, Y. (2015). The effects of project based learning on undergraduate students' achievement and self-efficacy beliefs towards science teaching. *Eurasia Journal of Mathematics, Science and Technology Education*, 11(3), 469-477.
- [9] Bugaje, M. A., & Abubakar, H. (2015). The Effects of Activity-Based Instructional Approach on the Academic Performance of Student in Integrated Science Education in Katsina State College of Education Nigeria.
- [10] Busari, R. I. (2016). Effects of constructivist approach on junior secondary school students' Achievement in geometry. *Journal of Higher Education*, 57(3), 260-264.
- [11] Çakici, Y., & Turkmen, N. (2013). An investigation of the effect of project-based learning approach on children's achievement and attitude in science. *The online journal of science and technology*, 3(2), 9-17.
- [12] Chen, C. H., & Yang, Y. C. (2019). Revisiting the effects of project-based learning on students' academic achievement: A meta-analysis investigating moderators. *Educational Research Review*, 26, 71
- [13] Chiphambo, S. M., & Feza, N. N. (2020). Polygon Pieces: Tools To Address Students' alternative Conceptions And Misunderstandings When Learning Of Geometry. *International Journal*, 76(7/1).
- [14] Craig, T. T., & Marshall, J. (2019). Effect of project-based learning on high school students' state-mandated, standardized math and science exam performance.

- Journal of Research in Science Teaching*, 56(10), 1461-1488.
- [15] Erdem, E. (2012). Examination of the effects of project based learning approach on students' attitudes towards chemistry and test anxiety. *World Applied Sciences Journal*, 17(6), 764-769.
- [16] Fabiyi, T. R. (2017). Geometry concepts in mathematics perceived difficult to learn by senior secondary school students in Ekiti State Nigeria. *IOSR Journal of Research & Method in Education (IOS-JRME)*, 7, 83.
- [17] Han, S., Capraro, R., & Capraro, M. M. (2015). How science, technology, engineering, and mathematics (STEM) project-based learning (PBL) affects high, middle, and low achievers differently: The impact of student factors on achievement. *International Journal of Science and Mathematics Education*, 13(5), 1089-1113.
- [18] Helle, L., Tynjälä, P., & Olkinuora, E. (2006). Project-based learning in post-secondary education—theory, practice and rubber sling shots. *Higher education*, 51(2), 287-314.
- [19] Holmes, V. L., & Hwang, Y. (2016). Exploring the effects of project-based learning in secondary mathematics education. *The Journal of Educational Research*, 109(5), 449-463.
- [20] Holmes, V. L., & Hwang, Y. (2016). Exploring the effects of project-based learning in secondary mathematics education. *The Journal of Educational Research*, 109(5), 449-463.
- [21] Kaldi, S., Filippatou, D., & Govaris, C. (2011). Project-based learning in primary schools: Effects on pupils' learning and attitudes. *Education 3–13*, 39(1), 35-47.
- [22] Koparan, T., & Güven, B. (2014). The Effect on the 8th Grade Students' Attitude towards Statistics of Project Based Learning. *European Journal of Educational Research*, 3(2), 73-85.
- [23] Obodo, G.C. (2004). Principles and Practice of mathematics Education in Nigeria, Enugu. Floxtone press.
- [24] Olofin, S. O., & Kolawole, E. B. (2020). Effect Of Kolawole's Problem-Solving Teaching Strategy On The Academic Performance Of Secondary School Students In Mathematics In Nigeria. *Advances in Social Sciences Research Journal*, 7(2), 68-77.
- [25] Ozdemir, E. (2006). An investigation on the effects of project-based learning on students' achievement in and attitude towards geometry. *Unpublished Master's Thesis. Middle East Technical University Graduate School of Natural and Applied Sciences, Ankara.*
- [26] Pittalis, M., & Christou, C. (2010). Types of reasoning in 3D geometry thinking and their relation with spatial ability. *Educational Studies in mathematics*, 75(2), 191-212.
- [27] Salman, N., & Yvinec, M. (2009, June). High resolution surface reconstruction from overlapping multiple-views. In *Proceedings of the twenty-fifth annual symposium on Computational geometry* (pp. 104-105).
- [28] School Students Performance In Mathematics: Implication For Scientific And Technological Advancement In Nigeria. *International Journal of Technology Enhancements and Emerging Engineering Research*, 3, 57-61.
- [29] Shin, M. H. (2018). Effects of Project-based Learning on Students' Motivation and Self-efficacy. *English Teaching*, 73(1).
- [30] Solihatin, E., & Syahril, Z. (2019). The Effects of Brain-Based Learning and Project-Based Learning Strategies on Student Group Mathematics Learning Outcomes Student Visual Learning Styles. *Pedagogical Research*, 4(4).
- [31] Tarmizi, R. A., & Bayat, S. (2012). Collaborative problem-based learning in mathematics: A cognitive load perspective. *Procedia-Social and Behavioral Sciences*, 32, 344-350.
- [32] Tseng, K. H., Chang, C. C., Lou, S. J., & Chen, W. P. (2013). Attitudes towards science, technology, engineering and mathematics (STEM) in a project-based learning (PjBL) environment. *International Journal of Technology and Design Education*, 23(1), 87-102.
- [33] West African Examination Council (2016-2019). Chief examiners' reports. Yaba, Lagos. Amao press limited.