Annals of Technology Education Practitioners Association of Nigeria
ATEPAN (June, 2023) 6(2), 8-17
ISSN: 2645-2839 (Print)
eISSN: 2645-2847 (Online)

EFFECTS OF THINK-PAIR-SHARE AND PROBLEM BASED LEARNING METHODS ON STUDENTS' ACHIEVEMENT IN BASIC SCIENCE AND TECHNOLOGY IN MINNA NIGER STATE

Bawa, S., Koroka M. U. S*, Maryam Mohammed Kolo., Racheal Kashi Nmadu, Musbawu, A. & Fatima Musa

Department of Science Education, School of Science and Technology, Federal University of Technology, Minna,

Corresponding E-mail: m.koroka@futminna.edu.ng (Tel: 08035965281_

Abstract: *The study employed a quasi-experimental research design. Specifically, the non-equivalent control group design was used. The study was carried out in Minna Metropolis. The population of the study consisted of all the 8,225 junior secondary school students in junior secondary schools in Minna Metropolis. Simple random sampling technique was used to select 240 students from 4 junior secondary schools in Minna. The instrument used for data collection in this study was a 40 item Basic Science and Technology Achievement Test (BSTAT). The Basic Science and Technology Achievement Test (BSTAT) was face and content validated by two experts in Department of Science Education, Federal University of Technology, Minna. Reliability test was obtained by analyzing the responses obtained from the trial testing among JSS II students from Junior Secondary School, Bosso which is outside the research area. This method was used to estimate the stability of the items since the same instrument was used for both the pretest and the posttest. An index of internal consistency of 0.82 was obtained using Kudder-Richardson formula 20 (K-R 20). The K-R 20 was applied since the items were dichotomously scored. The data collected were analyze using mean and standard deviation to answer the research questions and analysis of co-variance (ANCOVA) to test hypotheses at 0.05 level of significance. Findings from the results, revealed that moderate performance difference exist between the experimental and control group subjects. Male students had higher mean achievement compare to their female counterparts. There was a significant difference in the mean test scores of students taught with the three methods of teaching basic science and technology. From the findings, the study therefore recommend that teachers should avoid the continuous use of conventional lecture method in the teaching of basic science and technology and attention should be adequately paid to the female folds by advising teachers of basic science and technology to apply both the think-pair-share and problem based learning among others.*

Keywords: *Basic science and technology, think-pair-share, problem based learning, students*

Introduction

Education is an effort to develop the ability of individuals to live optimally as individuals or members of the society (Siagian & Surya, 2017). According to Eviyanti, *et al* (2017), the development of education in this era is inseparable from the desire of all stakeholders in education in order to improve the quality of teaching and learning in order to facilitate students' better academic performance. In Nigeria, Basic Science and Technology is one of the subjects a student must passed at junior secondary school before he/she can proceed to senior secondary school of learning. According to Adodo (2013) the purpose of basic science and technology is to expand our understanding of the natural world and to develop new tools, methods, and knowledge that can be applied to various aspects of human life. These two fields play essential roles in advancing society, fostering innovation, and improving our quality of life. The main objectives of teaching and learning of Basic Science and Technology in Nigeria schools as stipulated by NERDC (2012) is to develop learners interest in science and technology; acquire basic knowledge and skills in science and technology; apply scientific and technological knowledge and skills to meet contemporary societal needs; take advantage of the numerous career opportunities provided by science and technology; become prepared for further studies in science and technology; avoid drug abuse and related vices; and to be safety and security conscious. In order to achieve the objectives of Basic Science Technology, the thematic approach to content organization was adopted by NERDC for

the holistic presentation of scientific and technological concepts, knowledge and skills to learners for better achievement.

In order to improve academic achievement in the students when teaching basic science and technology, it is imperative for the teacher to give proper and adequate attention especially in the choice of methods(s) appropriate for the inculcation of knowledge, ideas and skills in students to facilitate a better understanding of the subject matter (Adah & Ameh, 2022). There are many methods a teacher may use in the course of his/her work. The teaching of basic science and technology at the junior secondary school is mostly handled using traditional and think-pair-shares as pointed out by Olaitan (2018). Think-pair-share and problem based learning were selected to test students academic achievement in basic science and technology. These two methods were selected based on the fact that they were activity and student-centred oriented.

Think-pair-share is a cooperative discussion strategy developed by Frank Lyman and his colleagues in Maryland. It gets its name from the three stages of student action, with emphasis on what students are to be doing at each of those stages. Think-pair-share (TPS) is a collaborative learning strategy where students work together to solve a problem or answer a question about an assigned reading. This strategy requires students to think individually about a topic or answer to a question; and share ideas with classmates. Discussing with a partner maximizes participation, focuses attention and engages students in comprehending the reading material. TPS is a model of cooperative learning in pairs and give students more time to think, respond, and to help each other. As stated by Jumanta (2014), Think-Pair-Share is a simple technique with great advantages. Think-Pair-Share can improve students' ability to recall information and a student can also learn from other students and convey to each other ideas for discussion before being submitted to the class. Think-Pair-Share means giving time for students to think about answers to questions.

Students help each other to resolve the issue with the capabilities of each. Cooper *et al.* (2021) in a research carried out concluded that Think-Pair-Share enhance the problem solving and learning outcomes of students. Kaddoura (2013) also concluded from a different research that an increase in student learning outcomes are taught by implementing cooperative learning model Think-Pair-Share with card use plus and minus in the matter of addition and subtraction. Think-pair-share creates an active learning environment for students and provides benefits to learning in the classroom. Think-pair-share according to Sumarni (2016) is a cooperative learning model that is considered to arouse student interest in sciences and make students more active and socialize, encourage cooperation among students in learning the material, so that it can improve student learning outcomes.

Problem-based learning is known as an effective instruction technique capitalizing on the knowledge and expertise of two or more teachers in the same classroom (Argaw *et al.*, 2016). Argaw *et al.* (2016) opined that at the university level, it is often discussed and recommended in teacher preparation programs as a way both to utilize the professional understandings of two teachers as well as to meet the needs of diverse students in a classroom.

Problem-based learning involves two or more teachers teaching the same group of students. The group of students will benefit from the expert knowledge of different teachers, unlike the single teacher teaching technique where the students are left at the limited resources of an individual teacher. Single-teacher teaching is an instructional procedure whereby a teacher is responsible for teaching, directing and evaluating the learning of a group of students all through while problem-based learning is equally an instructional procedure whereby two or more teachers jointly share the responsibility of directing, teaching and evaluating the learning of a common group of students (Demirel & Dağyar, 2016).

Problem-based learning also involves a group of instructors working purposefully, regularly and cooperatively to help a group of students of any age to learn. Teachers together set goals for a course, design a scheme of work, teach students, and evaluate the results. They share insights,

argue with one another, and perhaps even challenge students to decide which approach is better. Teams can be single-discipline, interdisciplinary, or school-within-a-school teams that meet with a common set of students over an extended period of time. New teachers may be paired with veteran teachers. Innovations are encouraged, and modifications in class size, location, and time are permitted. In problem based learning method, the teacher still controls most of what goes on in the classroom, even though the students are working in groups, the students take full responsibility for learning together to boast their academic achievement. Adah and Ameh (2022) defined achievement as the learning outcomes which include knowledge, skills that are acquired and retained through course of study within and outside the classroom situation that can help to have a better academic achievement.

Achievement according to Adeyemi (2012) is the scholastic standing of a student at a given moment. It has to do with the successful accomplishment of goal(s). The purpose of testing an achievement is to help the teacher and the students evaluate and estimate the degree of success attained in learning a given concept. It is also useful in testing the retention of information and skill. It is equally appropriate in determining the efficiency of instruction. One of the issues at stake in education today is students' achievement measure in relation to teaching and the overall success of learning outcome, Use of think-pair-share and problem based learning method in teaching simple machine by basic science and technology teachers may make basic science and technology lesson objective stimulating and interesting to the students. From the foregoing, it become imperative to search for appropriate instructional approaches that would assist students to learn and in finding solution to their academic problems with ease. A number of teaching methods have been in use as earlier cited. Hence the researcher intends to determine and compare the effects of effects of think-pair-share and problem based learning methods on students' achievement in basic science and technology in Minna Niger State.

Statement of the Problem

The teaching of basic science and technology requires appropriate instructional methods, as their proper application is essential for facilitating the achievement of the set objectives. The experience of the teacher and his adoption of appropriate methodology in teaching greatly help in promoting his effectiveness and consequently students' academic achievement (Adah & Ameh, 2022; Idoko, 2021). From records, it has been observed that students' achievement in basic science and technology in Basic Education Certificate Education (BECE) has not been very good. It has been declining for a number of years. For instance, the percentage ordinary passes and total failures for 2020, 2021 and 2022 years were 50.5%, 53.5% and 58.0% respectively. The performance of students has not been impressive, (National Examination Council (NECO), (2022) respective Chief Examiners' Report showed a decline in students academic achievement in basic science and technology. The decline could be traceable to basic science and technology teachers' method of teaching the subject. Onimisi (2020) and Ibitoye (2017) suggested that to improve on students' academic achievement in sciences like basic science and technology, the need for demonstrable, appropriate, skill and practically oriented methods like think-pair-share and problem based learning approach are advocated. Based on the foregoing, the problem of this study therefore is: could the think-pair-share and problem based learning approach enhance students' achievement in basic science and technology in junior secondary schools in Minna, Niger State?

Purpose of the Study

1. Determine the relative achievement scores of students taught with think-pair-share, problem based leaning and conventional lecture methods.
2. Determine the academic achievement scores of male and female students in basic science and technology when taught with think-pair-share, problem based leaning and conventional lecture methods.

Research Questions

1. What is the students' mean achievement scores in Basic Science and Technology when taught with think-pair-share, problem based leaning and conventional lecture methods?

2. What is the academic achievement scores of male and female students taught Basic Science and Technology with think-pair-share, problem based leaning and conventional lecture methods?

Hypotheses

The following null hypotheses were formulated and tested at 0.05 level of significance.

H_{O1}: There is no significant difference in the mean achievement scores among the students taught with the think-pair-share, problem based leaning and conventional lecture methods of teaching basic science and technology.

H_{O2}: There is no significant difference in the mean achievement scores of male and female students taught with think-pair-share, problem based leaning and conventional lecture methods of teaching basic science and technology.

Methodology

The study employed a quasi-experimental research design. The study was carried out in Minna, Niger State. The population of the study consisted of all the 8,225 junior secondary school students in junior secondary schools in Minna. Simple random sampling technique was used to select 240 students from 4 junior secondary schools in Minna. The instrument used for data collection in this study was a 40 item Basic Science and Technology Achievement Test (BSTAT) drawn from the five identified difficult topics/areas in the curriculum for junior secondary school two (JSSII). The Basic Science and Technology Achievement Test (BSTAT) was face and content validated by two experts in Department of Science Education, Federal University of Technology, Minna. Reliability test was obtained by analyzing the responses obtained from the trial testing among JSS II students from Junior Secondary School, Bosso which is outside the research area. This method was used to estimate the stability of the items since the same instrument was used for both the pretest and the posttest. An index of internal consistency of 0.82 was obtained using Kudder-Richardson formula 20 (K-R 20). The K-R 20 was applied since the items were dichotomously scored. The data collected were analyze using mean and standard deviation to answer the research questions and analysis of co-variance (ANCOVA) to test hypotheses at 0.05 level of significance.

Results

Table 1: Relative students' mean achievement scores in basic science and technology taught with think-pair-share, problem based leaning and conventional lecture methods

Group	N	Pretest		Posttest		Mean gain difference
		X	SD	X	SD	
Think-pair-share	90	47.77	4.48	66.57	7.75	18.82
Problem based learning	86	47.09	3.93	72.27	7.54	25.18
Conventional lecture method	64	46.33	4.30	61.47	6.25	15.14

N= Number of subjects, $\bar{x}$ = Mean, SD = Standard deviation

Table 1 shows that prior to the use of think-pair-share and problem based leaning (Experimental methods 1 and 2) in the teaching of basic science and technology by teachers in the experimental group, their mean score were 47.77; 47.09 while their standard deviations were 4.48 and 3.93 respectively. The mean score of the experimental group two (X = 47.77) is slightly higher than that of the experimental group one (X = 47.09). The control group has a pre-test mean score of 46.33 the standard deviation of 4.30 in the BSTAT and this is lower than that of experimental groups. The standard deviations of 4.48 and 3.93 respectively for the experimental groups as against 4.30 for the control group showed that the range of scores between the experimental and control group was very narrow. But after the treatment which was teaching the students in both groups, the posttest mean scores for the experimental students improved appreciably from 47.77 to 66.57 for think-pair-share method and 47.09 to 72.27 for problem based learning while their standard

deviation show a decrease from 7.75 for think-pair-share to 7.54 for problem based learning thereby showing a high level of narrowness of the test scores. But for the control group, it was an improvement from a mean score of 46.33 to 61.47 and an increase in standard deviation of 4.30 to 6.05. But when compared with the experimental groups, it was low. This shows that there is a slight closeness in the test scores. The table also shows that the mean gain difference was 25.18 in problem based learning method followed by 18.82 for think-pair-share and 15.14 in conventional lecture method. This implies that subjects taught with problem based learning performed best in the achievement test followed by those of think-pair-share method and least by those taught with conventional lecture method. A moderate performance difference exist between the experimental and control group subjects.

Table 2: Analysis of covariance of the mean achievement scores of students taught basic science and technology with different methods

Source of Variance	Sum of Squares	df	Mean Square	F	Sig. level at 0.05
TPS & CLM	14181.089	1	14181.089	273.73	S
PBL & CLM	30099.812	1	30099.812	580.99	S
TPS & PBL	3184.62	1	3184.62	61.47	S
TPS, PBL & CLM (Group)	14155.740	2	7077.87	136.62	S
Group (Methods)	9760.770	2	4880.385	133.992	S
Pretest	187.029	1	187.029	3.61	NS
Error	37094.151	716	51.807		
Total	**228903.282**	**719**			

* TPS –Think-pair-share *PBL -Problem based learning * CLM - Conventional lecture method

In Table 2, the calculated F-ratio in each row is compared with the table F-ratio at 0.05 level of significance to find out if the hypothesis is accepted or not. The calculated F-ratio between TPS (experimental method 1) and CLM (control) was found to be 273.73 and the table F value df 1, 716 at 0.05 level of significance was 24.4. Since the calculated F-ratio was greater than table F value at df 1, 716 at 0.05 level of significance, the stated null hypothesis is therefore rejected meaning there was a significant difference between the mean achievement score of students taught with think-pair-share method and conventional lecture method. Students taught with think-pair-share method recorded higher test mean scores than those taught with conventional lecture method.

In the cases of PBL and CLM, the calculated F-ratio was 580.99 and the table F value at df 1 and 716 at 0.05 level of significance was 24.4. This shows that there was a significant difference between the performance of students taught with PBL and CLM as F-ratio calculated was greater than table F value at df 1, 716 at 0.05 level of significance thus making the null hypothesis formulated to be rejected. This therefore shows that students taught with PBL performed higher than those taught with the CLM. Comparing the two experimental methods (TPS & PBL), the calculated F-ratio was 61.47 and the table F value at df 1, 716 at 0.05 level of significance was 24.4 showing that a significance difference existed between the performances of students with the two experimental methods. Between the three (3) methods (TPS, PBL and CLM), there was a significant difference in the impact of the three methods since the calculated F-ratio of 136.62 was greater than the table F value of 19.41 at df 2, 716 at 0.05 level of significance. On the whole, the null hypothesis formulated was therefore rejected and the alternative that there was a significant difference in the mean test scores of students taught with the three methods of teaching basic science and technology was therefore accepted. This shows that students perform highest with PBL higher with TPS and lowest with CLM.

Table 3: Mean academic achievement scores of male and female students taught basic science and technology with the experimental and the conventional lecture methods

Group	Gender	N	Pretest		Posttest		Mean gain difference
			X	SD	X	SD	
Think-Pair-Share	Male	126	47.52	4.52	70.30	5.36	22.78
	Female	114	48.04	4.35	62.44	7.98	14.40
Problem Based Learning	Male	133	46.32	3.66	75.80	5.34	29.48
	Female	107	48.05	4.07	67.88	7.59	19.83
Conventional lecture method	Male	128	45.55	3.58	64.37	4.27	18.82
	Female	112	47.23	4.87	58.17	6.53	10.94

N= Number of subjects, x = Mean, SD = Standard deviation

Table 3 shows that the pretest mean scores of students taught with the three methods of teaching i.e. think-pair-share (Experimental method 1), problem based learning (Experimental method 2) and conventional lecture method (Control) were found to be 47.52, 46.32 and 45.55 for male and 48.04, 48.05 and 47.23 for female respectively; while the post-test result shows 70.30, 75.80 and 63.37 for male and 62.44, 67.88 and 58.17 for female respectively. These results show there is a difference between the students pre-test and post-test scores in each method of teaching. The difference is highest with the problem based learning, followed by the think-pair-share and lowest with the conventional lecture method. The mean gain scores of the male students are 29.48 for problem based learning, 22.98 for the think-pair-share and 18.32 for the conventional lecture method; for the female students the mean gain scores are 14.40, 19.83 and 10.94 in each method respectively. The results further shows that the difference in post-test mean scores is highest among male students taught with problem based learning followed by those taught with think-pair-share and least by those taught with conventional lecture method. Also for female students it was highest with problem based learning followed by the think-pair-share and the conventional lecture method respectively. In the case of variability of test scores, the standard deviation obtain in each case shows a minimal spread of scores. In the case of variability of test scores, the standard deviation obtained in each case showed a minimal spread of scores. It was also noticed that there was a little increase in the posttest mean scores for female students taught with think-pair-share, problem based learning and conventional lecture methods.

Table 4: Analysis of covariance of mean achievement scores of group of students taught basic science and technology with different methods based on gender

Source of Variance	Sum of Squares	df	Mean Square	F	Sig. level at 0.05
TPS & CLM	2123.724	1	2123.724	36.31	S
PBL & CLM	3344.832	1	3344.832	52.19	S
TPS & PBL	3492.083	1	3492.083	57.70	S
TPS, PBL & CLM (Group)	14962.063	2	7481.0315	129.9	S
Group (Method)	12936.775	2	6468.388	171.06	S
M and F	3823.438	1	3823.438	65.37	S
Group * Sex	128.263	2	64.131	1.696	NS
Intercept	20208.460	2	10104.23	172.75	S
Pretest	974.742	1	974.742	16.66	NS
Error	41879.556	716	58.491		
Total	**100567.668**	**719**			

* TPS - Think-pair-share * PBL - Problem based learning * CLM - Conventional lecture method
* F – Female * M- Male

Table 4 above shows that the calculated F-ratio between the two experimental methods (TPS and PBL) was found to be 36.31 and the table F value at df 1, 716 at 0.05 level of significance was 24.4. The calculated F-ratio was greater than the table F value of 24.4. It therefore means that the hypothesis of no significant difference between the performance of students taught basic science and technology with the TPS and those taught with the PBL was rejected. The students taught with the PBL therefore performed higher than those taught with TPS.

As for the TPS and CLM, the calculated F-ratio was 59.19 and the table F- value at df 1, 716 at 0.05 level of significance was 24.4. Thus making the null hypothesis formulated to be rejected. This then shows that there was a significant difference between the performance of students taught basic science and technology with the TPS and the CLM with the TPS group scoring higher than the CLM group. Also between the PBL and the CLM, the calculated F-ratio was 59.70 and the table F value at df 1, 716 at 0.05 level of significance was 24.4 making the null hypothesis to be rejected. These therefore means that a significant difference exist between the performance of students taught basic science and technology with the PBL and those with the CLM. The performance of students taught with the PBL was therefore higher than those taught with the CLM. Comparing the three methods (TPS, PBL and CLM) the calculated F-ratio of 129.90 was greater than the table F value at df 2 and 716 at 0.05 level of significance was 19.41. The calculated F-ratio was greater than the table F value therefore the hypotheses of no significant difference between the performance of students taught basic science and technology with the three methods was therefore rejected. Again with gender, the calculated F-ratio of 65.37 at table F value at df 1 and 716 at 0.05 level of significance was 24.4. Again with gender, since the calculated F-ratio was greater than the table F value, the null hypotheses formulated was therefore rejected. It therefore implied that male students performed higher than their female counterpart in the BSTAT tasks.

Discussion

The students that were taught with the think-pair-share and the problem based learnings were found to have high achievement in the BSTAT than their counterparts in the control group that were taught with the conventional lecture method of teaching. This finding is in agreement with some earlier findings of Idoko and Oladimeji (2022) and Alio (2017). These researchers observed that the students in the experimental group who were allowed to interact and allowed to carryout activities in group performed better than those in the control group who were passive listeners in their basic science and technology classes. The think-pair-share and the problem based learnings used in this study were activity oriented and encourage students-teachers, students-students and students-material interactions.

Students in the experimental group who recorded high achievement scores, were taught with the use of more activity oriented teaching methods. The activity nature of the teaching methods makes the students to provide relevant answers to the BSTAT questions than their counterparts in the control group, that were not exposed to the activity-based method. This agrees with Musa (2017) who stated that adoption of good and thought provoking teaching methods, under a conducive learning environment, facilitate better learning and mastery of the learnt materials by students.

The results of hypothesis one revealed that the mean achievement scores of the different groups of students taught with the different teaching methods – TPS, PBL and CLM differed significantly. The test scores recorded by students depend greatly on the teaching methods employed by the basic science and technology teachers. This therefore agrees with Mundi (2016) when he found out that the performance recorded by students in basic science and technology lessons is solely dependent on the attractive and stimulating nature of the method(s) employed by the teachers of basic science and technology.

The results showed that male and female students taught under the experimental group (TPS and PBL) performed better than those in the control group (CLM). Male students taught basic science and technology with PBL (X = 73.80); TPS (X = 70.30) and CLM (X = 64.37) performed better in

the ASAT than female students taught the same subject with GPSM (X = 67.58); TPS (X = 62.44) and CLM (X = 58.17). Comparing the three methods, male students performed higher than their female counterparts; the PBL group had the highest mean scores. This is in agreement with the studies conducted by Nworgu and Nworgu (2018); Man and Lynn (2020); Daluba and Audu (2021). These researchers observed that difference existed between the performance of male and female students in the science and other science related courses like basic science and technology.

Result of hypotheses 2 revealed that there was a significant difference effect between male and female students mean achievement scores in science and other related science subjects. The differential effect arises from the different teaching methods employed by the teachers. This finding agrees with those of Flower and Osborne (2018), Ajewole (2019), Nzewi & Osisioma (2021) When they found out that different teaching methods exert different impact on the students academic achievement.

Conclusion

From the foregoing findings, and discussion it could be concluded that: Most students taught with think-pair-share and problem based learning performed excellently well in the achievement test items, when compared with those taught with conventional lecture method, Students taught basic science and technology using problem based learning and think-pair-share performed better than those taught with the conventional lecture method. Generally, students taught with the use of problem based learning performed better than those taught with think-pair-share and conventional lecture methods. The students taught basic science and technology with problem based learning also performed better than those taught with think-pair-share while those taught with think-pair-share was higher than those taught with the conventional lecture method. Male students from single sex male schools performed better than those students from single sex female and co-educational schools when taught with problem based learning. Male students from single sex male schools performed better than those students from single sex female and co-educational schools when taught with think-pair-share and they also performed better than those students from single sex female and co-educational schools when taught with conventional lecture method. Generally, problem based learning appeared more effective in promoting students mean achievement scores in basic science and technology than think-pair-share and conventional lecture methods.

Recommendations

Based on the findings and conclusion of this present study, the following recommendations were made:

1. Teachers, therefore, should avoid the continuous use of conventional lecture method in the teaching of basic science and technology.
2. Teachers to aggressively adopt think-pair-share and problem based learning this method in basic science and technology in all classes at the junior secondary school level with the intention to promote students performance.
3. Attention should be adequately paid to the female folds by advising teachers of basic science and technology to apply both the think-pair-share and problem based learning. This is because the result of the study have shown a significant difference in their mean achievement scores in favour of males.

References

Adah, O. C. & Ameh O. S. (2022). Determination of Agricultural Teaching Methods on Students' Achievement in Secondary Schools. A care study of Olamaboro Local Government Area of Niger State. *Teacher Education Journal (TEJ)* 12 (2) 41-47.

Adeyemi, T. O. (2012). Predicting student's performance in junior secondary certificate Examination in Ondo State, Nigeria. *Humanity and social sciences journal* 3(1); 26-36.

Adodo, S. O. (2013). Effect of mind-mapping as a self-regulated learning strategy on students' achievement in basic science and technology. *Mediterranean Journal of Social Sciences*, *4*(6), 163.

Ajewole, G. O. (2019). Effects of Guided Discovery and Expository Instructional Methods on Students Transfer of Learning. *Journal of Science Teachers' Association of Nigeria (JSTAN)* 26 (2) 59-66.

Alio, B. C. (2017). Polya's problem solving strategy in secondary school students' achievement and interest in Mathematics. *An unpublished Ph. D. Thesis*. Faculty of Education, Nsukka: University of Nigeria.

Argaw, A. S., Haile, B. B., Ayalew, B. T., & Kuma, S. G. (2016). The effect of problem based learning (PBL) instruction on students' motivation and problem solving skills of physics. *Eurasia Journal of Mathematics, Science and Technology Education*, *13*(3), 857-871.

Cooper, K. M., Schinske, J. N., & Tanner, K. D. (2021). Reconsidering the share of a think–pair–share: Emerging limitations, alternatives, and opportunities for research. *CBE—Life Sciences Education*, *20*(1), fe1.

Daluba, N. E. and Audu, T. A. (2021). Comparing the Academic performances of Sandwich and Regular Students in Science, Technology and Mathematics Education (STME). Implications for standards. Sandwich/Part Time Programme and Science, Technology and Mathematics Education in Nigeria (Omonu J. B.; Audu, T. A. & Agashi, P. P. eds). Ankpa: A Publication of the School of Sciences, Niger State College of Education, pp 47-52.

Demirel, M., & Dağyar, M. (2016). Effects of problem-based learning on attitude: A meta-analysis study. *EURASIA Journal of Mathematics, Science and Technology Education*, *12*(8), 2115-2137.

Eviyanti, C. Y., Surya, E., Syahputra, E., & Simbolon, M. (2017). Improving the students' mathematical problem solving ability by applying problem based learning model in VII grade at SMPN 1 Banda Aceh Indonesia. *International Journal of Novel Research in Education and Learning*, *4*(2), 138-144.

Flowers, J. & Osborne, F. W. (2018). The Problem solving and subject Matter approaches to teaching vocational basic science and technology. Effects on Students achievement and retention. *The Journal of the American Association of Teacher Education in Basic science and technology*. 29 (1) 20, 26, and 52.

Ibitoye, S. J. (2017). The Role of Basic science and technology in the Development of our National Economy. *Journal of Vocational and Technical Educators (JOVOTED)* 1 (1) 23-28.

Idoko, C. U. (2021). Teachers Educational Qualification and Students' Achievement in Senior Secondary School Examination. *Teacher Education Journal (TEJ)* 2 (9) 77-79.

Idoko, C. U. and Oladimeji, A. J. (2022). Agricultural Improvement and Development through Education. An Overview. *Teacher Education Journal* 2 (1) 35-40.

Jumanta, H. (2014). Model dan metode pembelajaran kreatif dan berkarakter. *Bogor: Ghalia Indonesia*.

Kaddoura, M. (2013). Think pair share: A teaching learning strategy to enhance students' critical thinking. *Educational Research Quarterly*, *36*(4), 3-24.

Mundi, N. E. (2016). The State of Students' academic achievement in secondary school basic science and technology in Niger State. *Teacher Education Journal (TEJ) 12 (1) 14-19.*

Musa, S. A. A. (2017). The Effect of Lecture Method on Students' Achievement in Physics in Secondary Schools in Niger State. *Journal of Vocational and Technical Educators (JOVOTED) 1 (1) 12-17.*

National Examination Council (NECO), (2022). Basic Education Certificate Examination (BECE) chief examiner's report.

Nigerian Educational Research and Development Council, (2012). 9-year basic education curriculum: Basic Science for Upper Basic Education 7-9: NERDC PLC.

Nworgu, B. G. & Nworgu, I. N. (2018). Problem-centred Laboratory-Investigative Approach to Science Practical in Secondary Schools – Pilot Study Biology. *Journal of Creativity in Teaching for the Acquisition and Dissemination of Effective Learning (CITADEL).* Enugu: A publication of University Professional Educator (UPE) 2 (5) 155-167.

Nzewi, U. M. & Osisioma, N. (2021). The relationship between formal reasoning ability, acquisition of process skills and science achievements. *Journal of Science Teachers' Association of Nigeria. 29 (1 & 2) 41 – 45.*

Olaitan, S. O. (2018). *Agricultural Education in the Tropics – Methodology for Teaching Basic science and technology.* London: Macmillan Publishers.

Onimisi, J. A. (2020). Impact of type of teacher training on students' achievement and attitude towards Integrated Science. *An Unpublished Ph. D. Thesis,* Nsukka: University of Nigeria.

Siagian, M., & Surya, E. (2017). The influence of three stage fishbowl decision strategy on students' mathematical problem solving ability. *International Journal of Sciences: Basic and Applied Research (IJSBAR), 34*(1), 8-15.

Sumarni, S. (2016). Think Pair Share effect of understanding the concept and achievement. In *Proceeding of the International Conference on teacher Training and Education* (Vol. 2, No. 1, pp. 783-787).