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EFFECTS OF TRAINING BIOLOGY TEACHERS IN SCIENTIFIC THINKING SKILLS ON TEACHING BEHAVIOURS AND ACHIEVEMENT OF SENIOR SECONDARY TWO STUDENTS IN KANO, NIGERIA

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ABSTRACT

The study investigated the effects of training biology teachers in scientific thinking skills on teaching behaviours and achievement of senior secondary two students in Kano State, Nigeria. The study employed the non-randomized pre-test, post-test quasi-experimental control group design. A population of 4879 senior secondary school two students was drawn from 65 schools, and 48 biology teachers The sample for the study comprised 975 SS2 students, 30 from 30 schools and 30 teachers. Three research questions and three null hypotheses guided the study. Instruments used for data collection were Teachers Classroom Observation Checklist (TCOC) and Biology Achievement Test (BAT). The data were analyzed using Statistical Package for Social Sciences (SPSS) version 26.0. Research questions were answered using mean and standard deviation while hypotheses were tested using Analysis of Covariance (ANCOVA) at 0.05 level of significance. Findings of the study revealed that students taught using scientific thinking skills achieved higher in biology compared to those taught using lecture method. Furthermore, it was revealed that exposure of biology teachers to scientific thinking skills increased teachers' teaching behaviours more than those who were not exposed to scientific thinking skills training. It was concluded that training teachers in scientific thinking skills improved their teaching behaviours, as well as, students' achievement in biology. Based on the findings of the study, it was recommended that teachers should be trained in scientific thinking skills for improved pedagogical skills which will culminate in enhanced achievement. outcomes by students in biology.

Keywords: Achievement, Biology, Scientific thinking skills, Teaching behaviours.

INTRODUCTION

Education is the corner stone of both human and material progress because through it, individuals are equipped with lifelong skills and learning experiences that prepare them for happy, productive, and fruitful living. Mastery of life-long skills which include thinking skills is considered a basic requirement in this rapidly changing world. It is important for the educational system to develop young minds that are capable of thinking, weighing evidences, and analyzing them, and, also produce individuals who appreciate the place and value of knowledge and life-long learning that contribute meaningfully to the development of the society. This underscores the need to teach learners to think scientifically as is emphasized in the National Policy on Education (Federal Republic of Nigeria [FRN], 2014). Oher objectives stipulated in the policy are to help students at all levels of education develop to their fullest potentials intellectually, emotionally, physically, and aesthetically; prepare students to attain economic self-sufficiency and become useful members of the society, and; assist students to develop responsible character not only for participation in society but also for ensuring the survival and well-being of the society.

In an effort to achieve this objective, the National Policy on Education emphasizes that science subjects should be taught at all levels of education in Nigerian schools. Science subjects or disciplines include chemistry, physics and biology in senior secondary schools. The Policy further prescribes science teaching in secondary schools for the use of hands-on and minds-on, process-oriented activities to enable students participate actively in science tasks and become critically-minded, scientific, reflective thinkers and socially responsible citizens.

Biology is a natural science subject concerned with the study of life and living organisms in the environment (Nwagbo, 2014). It has practical aspects which develop students' competence in

skills of understanding concepts that are useful in solving day-to-day challenges of life. This competence is needed to meet the scientific and technological demands of the society (Adewale, Nzewuihe & Ogunsola, 2016). Biology is of vital importance to all science-related fields and environmental professions, such as, agricultural science, medicine, pharmacy, nursing, genetic engineering, and forensic science. These disciplines are critical for the nation's scientific, technological and economic development. For this reason, the Federal Government introduced the 60 :40 ratio in university admissions in favour of science-based courses. The essence is to prepare, improve and promote science-oriented citizens that are expected to manifest high level of achievement in science and science-related fields.

Despite the crucial role biology education plays in national development and its premium position among other subjects, students' achievement in biology in both local and public examinations have remained persistently poor. This is evident in the West African Examinations Council (WAEC) report in the two past decades which had consistently pointed to the under-achievement of students in WAEC results (Agbola & Oyemide, 2017.) In view of the spate of poor achievement of students in biology and considering the importance of subject in every facet of human endeavour, the federal and state governments have made efforts to enhance effective teaching and learning of science subjects, biology inclusive, in secondary schools in Nigeria, by providing science equipment and also sponsoring teachers in science conferences and workshops via federal government intervention agencies, like the Tertiary Education Trust Fund (TETFUND). However, students' achievement in biology in public examinations is still not commensurate with the efforts put in by the government and other stakeholders, like the Science Teachers' Association of Nigeria and Curriculum Organization of Nigeria in the area on mounting conferences and workshops on training of teachers in innovative and effective strategies of teaching science-related subjects. If the failure rate of students in biology is not addressed, the 60:40 ratio mandate by the government in admissions into Nigerian conventional universities will be realized. This, therefore, implies that it may not be possible for students to gain admission into universities and other higher institutions to pursue biology-related careers. This will further have a ripple effect on national development and the aspiration of Nigeria to stand among the 20 world's big economies.

In an attempt to change the fore-going narrative, researchers have made concerted efforts to unravel the causes of poor achievement in biology and to proffer possible solutions. Some of the factors identified by researchers include the use of ineffective teaching methods, incompetent teachers, teachers poor or non-application of thinking skills (Nbina, 2013), candidates' inability to interpret questions that required scientific thinking skills; failure to write and answer questions logically, systematically and convincingly (WAEC, 2019). According to Josiah (2020) teachers' use of lecture, demonstration, and discussion methods of teaching is the primary cause of poor achievement of students in biology, because the methods do not inspire students to learn and expose them to activities that require thinking but rather make them prone to rote learning and regurgitation of facts and principles.

Scientific thinking skills are application of methods or principles of scientific inquiry to reasoning or problem- solving situations. These skills are often referred as science process skills. They are basically the ability to apply 'scientific method' starting from identifying and formulating problems or questions, formulating hypotheses, designing experiments to collecting data and drawing conclusions. Scientific thinking skills are basic competences of problem-solving that lead students in the process of finding out facts by themselves instead of learning what other people have discovered. Scientific thinking skills enable students to make discoveries through asking the right questions, conducting investigations, collecting data, analyzing the data, evaluating ill-defined problems, drawing the right conclusions, making informed decisions and providing a variety of solutions to a particular problem (Asmitia & Crowley, 2014).

Developing scientific thinking skills, as emphasized in the National Policy on Education, suggests that thinking is central to scientific processes where meaningful learning and understanding of all science subjects is built upon. Therefore, developing scientific thinking skills in

students should be the core of teachers' classroom teaching behaviours. Teaching behaviours refer to ways teachers interact with students and different methods or strategies they use to present biology lessons to stimulate and develop students' scientific thinking skills and promote learning outcomes. Some aspects of teaching behaviours are asking thought-provoking questions, instructional clarity, instructional variety, communicating learning objectives and task-orientation. These teaching behaviours have been found to be significant in promoting scientific thinking skills. Studies have also shown that teachers' use lecture method of teaching cannot promote scientific thinking skills that would enhance effective learning (Abidoye 2017). It is in view of the fore-going that this study investigated the effects of training biology teachers in scientific thinking skills on teaching behaviours and achievement of senior secondary two students in Kano, Kano State, Nigeria.

Statement of the problem

The National Policy on Education, NPE (2009) clearly emphasizes that teaching and learning of biology as a science subject in senior secondary schools should be process-oriented and student-centered to promote students' understanding of biology concepts and applying the knowledge gained in solving problems (Akanji, 2015). This objective seems not to have been realized as results from Sambo and Eriba (2019) showed high rate of poor achievement of students in biology in the Senior Secondary Certificate Examinations.

Empirical evidences and personal observation as a biology teacher in senior secondary schools in Kano State have shown that biology teachers in Nigerian secondary schools still use predominately lecture, demonstration and discussion methods in which the teacher dominates the teaching process and students do little or no thinking-oriented activities. This practice is at variance with the recommendation of the National Policy on Education (NPE, 2014) that science teaching and learning must be done using hands-on and minds-on, process-oriented and student-centered approaches. The consequences of not given the teaching and learning of biology and other science subjects their deserved attention, unimaginable. There would a shortage of personnel in science-related jobs and professions, which would draw the nation backward in development of science and technology. This situation therefore, calls for a paradigm shift calls in teaching methodologies that could address students' continuous under achievement in these subjects. One way to achieve this in biology instruction, for instance, is through integrating innovative learner-centered instructional strategies, such as, computer jigsaw strategy, scaffolding strategy and scientific thinking skills strategy into strategies for biology instruction. This implies that biology teachers have to be trained on scientific thinking skills to improve their classroom teaching behaviours and students' achievement in biology. Hence, the need for this study.

Purpose of the study

The purpose of this study was to determine the effects of training biology teachers' in scientific thinking skills on teaching behaviours, and achievement of senior secondary two students' in Kano, Nigeria. The following research questions and hypotheses guided the study:

Research questions

1. What are biology teachers' pre-test and post-test lesson clarity mean scores in experimental and control groups?
2. What are biology teachers' pre-test and post-test mean scores on communicating of lesson objectives in experimental and control groups
3. What are students' pre-test and post-test biology achievement mean scores in experimental and control groups?

Hypotheses

The following hypotheses were tested at 0.05 level of significance:

1. There is no significant difference between the post-test instructional clarity mean scores of biology teachers exposed to scientific thinking skills training and those not exposed to the training.
2. There is no significant difference between the post-test mean scores of biology teachers exposed to scientific thinking skills training on communicating lesson objectives and those not exposed to the training.
3. There is no significant difference between biology post-test achievement mean scores of students exposed to scientific thinking skills training and those not exposed to the training.

Method and Procedure

The study adopted the non-randomized pre-test, post-test quasi-experimental control group design research design. The study was conducted in secondary schools in Nassarawa Local Government Area of Kano State. The population for the study comprised all the senior secondary class two (SS2) biology students and their teachers in Nassarawa Local Government Area. The number of the students in these schools that offered biology was 4789 with 48 senior secondary school two biology teachers. Only schools with at least two streams taking biology were selected for the study. A total 975 SS2 students and 30 teachers drawn from 30 schools were used as sample for the study. The teachers were drawn using purposive sampling technique. The assignment of the sampled students in their intact classes to experimental and control groups was done randomly using a simple ballot system. The experimental group for students had 515 students while control group had 460 students. The experimental and control groups for teachers had 15 teachers, respectively. The teachers and students were used in their intact classes.

The instruments used for collection of data were, a Teachers Classroom Observation Checklist (TCOC) and Biology Achievement Test (BAT). The TCOC was used to observe lessons in biology to provide data for the teachers and students' activities during instructional processes. The TCOC observational schedule was a structural observational checklist that contained statements relating to teacher classroom teaching behaviour that involved, maintained and enhanced students' thinking in the classroom. It contained 38 observational items with four-point rating scale of very often, often, sometimes and never, with numerical values of 4, 3, 2, and1 ascribed to them. The BAT was used to assess students' achievement in Biology and mastery of contents taught during the teaching-learning exercise. The BAT was used as both pre-test and post-test. The versions for post-test were re-arranged. The BAT contained 40 multiple-choice test items and three essay questions. The TCOC and BAT were validated by two experts in the Department of Science and Technology Education, and one expert in Research Method and Evaluation Unit, both in the Faculty of Education, University of Jos. The reliability indices of BAT and TCOC were established through trial testing of the instruments on a group of biology teachers and SS2 students not used in the study. The internal consistencies of TCOC and BAT were determined using Cronbach alpha method and Kuder Richardson formula 21, as 0.97, and 0.88, respectively.

Thirty research assistants (biology teachers in the schools selected for the study) in the experimental and control groups were exposed to pre-test by the researcher in classroom teaching behaviours. After administration of the pre-test, fifteen research assistants in the experimental group were trained by the researchers in scientific thinking skills of observing, experimenting, inferring, predicting outcomes, communicating, inductive and deductive reasoning by integrating these skills into the biology content, the unit of life, for four weeks, while the control group was taught the same content of unit of life for the same period of time using lecture method. The exercise lasted for four weeks. Post-test TCOC was administered to the teachers in both experimental and control group. Having completed the training of research assistants for the experimental group, all the teachers returned to their respective schools for their normal classroom setting to teach 'unit of life'. Students in the experimental group were taught scientific skills of observing, designing experiment, inferring, inducting deducting, predicting outcome and communicating thoughts by teachers trained in scientific thinking skills. Prior to administration of

treatment, BAT was administered as pre-test to both students in the experimental and control groups. Students in the experimental group were exposed to scientific thinking skills of observing, experimenting, classifying, comparing, contrasting and predicting outcomes by integrating these skills in the topics, 'unit of life'. The control group was taught also the same topics 'unit of life' using lecture method. The teaching of both experimental and control groups lasted for 12 weeks. After the training exercise both experimental and control groups were exposed to a post-test in Biology Achievement Test (BAT) to determine the effects of the training on students' achievement in biology.

Data collected from biology teachers and students were analyzed, respectively, using Statistical Package for Social Sciences (SPSS) version 26.0. Research questions were answered using mean and standard deviation while hypotheses were tested using Analysis of Covariance (ANCOVA) at 0.05 level of significance.

Results

Results of the study are presented on tables on the bases of research questions and hypotheses.

Research Question 1

What are the biology teachers' pretest and post-test instructional clarity mean scores in the experimental and control groups?

Table 1
Pret-test and post-test Instructional Clarity Mean Scores of Biology Teachers in the Experimental and Control Groups

Test		Before		After			
	N	Mean	SD	mean	SD	Mean Gain	X-difference
Experimental	15	13.13	1.77	28.40	3.44	15.27	16.02
Control	15	13.00	2.00	12.07	2.37	-0.93	

Table 1 reveals the pre-test and post-test lesson clarity mean scores in the experimental and control groups. The result shows a pretest mean score of 13.13 for experimental group and a mean score of 28.40 for post-test. Also, the pre-test mean score for control group was 13.00 and a post-test mean score of 12.07, indicating that there was an improvement in the lesson clarity means score of Biology teachers in the experimental group. It means that exposure to scientific thinking skills training improved lesson clarity behaviour of Biology teachers.

Research Question 2

What are the biology teachers' pre-test and post-test mean scores on communicating of lesson objectives in the experimental and control groups?

Table 2
Biology Teachers Pre and Post-test Mean Scores on Communicating of Lesson Objectives in the Experimental and Control Groups

Test		Before		After			
	N	Mean	SD	Mean	SD	Mean Gain	X diff.
Experimental	15	10.33	1.88	22.27	2.82	11.94	12.03
Control	15	11.07	1.98	10.98	2.55	-0.09	

Table 2 reveals the biology teachers' pre and post-test mean scores on communicating of lesson objectives in the experimental and control groups. The result shows a pretest mean score of 10.33 for experimental group and a mean score of 22.27 for post-test. Also, the pre-test mean score for control group is 11.07 and a post-test mean score of 2.55, indicating that there was improvement in the mean score of teachers on communicating of lesson objectives after exposure to scientific

thinking skills training. Since the experimental group had a higher mean score (22.27) than the control group (10.98) in the posttest, with a mean difference of 12.03, it means that exposure to scientific thinking skills can improve teachers' behaviour on communicating of lesson objectives.

Research Question 3

What are the students' Pre and Post-test Biology Achievement mean scores in the experimental and control groups?

Table 3

Pre-test and Post-test Biology Mean Scores of Students in the Experimental and Control Groups

Test		Before		After			
	N	Mean	SD	Mean	SD	Mean Gain	X-difference
Experimental	515	42.30	10.78	71.80	12.79	29.5	27.98
Control	460	40.81	11.28	42.33	9.16	1.52	

Table 3 reveals the biology Students' pre and post-test achievement mean scores in the experimental and control groups. The result shows a pretest mean score of 42.30 for experimental group and a mean score of 71.80 for post-test. Also, the pre-test mean score for control group is 40.81 and a post-test mean score of 42.33, indicating that there was improvement in the achievement mean score of students taught by teachers exposed to scientific thinking skills training.

Hypothesis 1

There is no significant difference between the post-test lesson clarity mean scores of biology teachers exposed to scientific thinking skills training and those not exposed to training.

Table 4

ANCOVA Result on the Difference between the Post-test Lesson Clarity Mean Scores in the Experimental and Control Groups

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	2040.883[a]	2	1020.441	134.739	.000	.909
Intercept	81.865	1	81.865	10.809	.003	.286
Pre-test	40.049	1	40.049	5.288	.029	.164
Group	1977.543	1	1977.543	261.114	.000	.906
Error	204.484	27	7.573			
Total	14527.000	30				
Corrected Total	2245.367	29				

a. R Squared = .909 (Adjusted R Squared = .902)

Table 4 reveals the ANCOVA result on the difference between the post-test instructional clarity mean scores of biology teachers exposed to scientific thinking skills training and those who are not. Exposed to the training. From Table 4, $F(1,27) = 261.11$, $P < 0.05$, $p < 0.05$, partial $\eta 2 = .906$, the p value of 0.000 is less than 0.05 level of significance with an effect size of 91%. The null hypothesis was rejected, indicating that there was a significant effect of scientific thinking skills training on instructional clarity behaviour of teachers.

Hypothesis 2

There is no significant difference between the post-test mean scores of biology teachers exposed to scientific thinking skills on communicating lesson objectives and those not exposed to training.

Table 5
ANCOVA Result on the Difference between the Post-test Communicating Lesson Objectives Mean Scores of the Experimental and Control Groups

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	996.418[a]	2	498.209	79.698	.000	.855
Intercept	98.801	1	98.801	15.805	.000	.369
Pre-test	33.084	1	33.084	5.292	.029	.164
Group	996.298	1	996.298	159.377	.000	.855
Error	168.782	27	6.251			
Total	9432.000	30				
Corrected Total	1165.200	29				

a. R Squared = .855 (Adjusted R Squared = .844)

Table 5 reveals the ANCOVA result on the difference between the post-test communicating lesson objectives mean scores of biology teachers exposed to scientific thinking skills training and those who were not. From Table 5, $F(1,27) = 159.38$, $P < 0.05$, $p < 0.05$, partial $\eta 2 = .855$, since the p value of 0.000 is less than 0.05 level of significance with an effect size of 86%, the null hypothesis was rejected, indicating that there was a significant effect of scientific thinking skills training on Biology teachers communicating lesson objectives.

Ho 3: There is no significant difference between post-test mean achievement scores of biology students exposed to scientific thinking skills training and those were not.

Table 6
ANCOVA Result on the Difference between the post-test Mean Scores of the Experimental and Control Groups

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	251786.773[a]	2	125893.387	1494.979	.000	.755
Intercept	68141.656	1	68141.656	809.179	.000	.454
Pre-test	40767.760	1	40767.760	484.115	.000	.332
Group	197728.585	1	197728.585	2348.019	.000	.707
Error	81852.919	972	84.211			
Total	3601371.000	975				
Corrected Total	333639.692	974				

a. R Squared = .755 (Adjusted R Squared = .754)

Table 6 reveals the ANCOVA result on the difference between the post-test mean scores of biology students exposed to scientific thinking skills training and those who are not. From Table 6, $F(1,972) = 2348.01$, $P < 0.05$, $p < 0.05$, partial $\eta 2 = .707$, since the p value of 0.000 is less than 0.05 level of significance with an effect size of 71%, the null hypothesis was rejected, indicating that there was a significant effect of scientific thinking skills training on students achievement.

DISCUSSION

Data on Table 1 show that the SS 2 biology teachers exposed to scientific thinking skills training had more improved achievement on instructional clarity teacher behaviour than the SS 2 biology teachers in the control group who were exposed to lecture method. The improvement in the mean achievement in favour of the experimental group could be that scientific thinking skills training facilitated teachers thinking abilities to design; organize and present information that stimulated students' interest and made learning interactive, engaging and student-centered. It could also be attributed to the fact that the teachers developed skillful lesson plan that foster thinking skills in their teaching and helped students to develop more effective way to use their minds. This implies

that scientific thinking skills training can improve instructional clarity teacher behaviour. This finding agrees with Usmad (2015) who indicated that acquisition of scientific thinking skills addresses complex issues in lesson plan such as use of language with accuracy, organization of thought and clarity of presentation which is approximately twice as strong as impact on affective learning.

The findings of the result in Table 2 showed that teachers in the experimental group had a higher mean score (22.27) than the control group (10.98) in the post-test, with a mean difference of 12.03 which was an indication that scientific thinking skills training can enhanced biology teachers behaviour on communicating of lesson objectives. This finding is in line with (Eupena, 2013) who affirmed that communicating clearly lesson objectives to students' prior lesson was associated with student learning outcome. On the contrary, Usmand (2015) discovered that communicating lesson objectives to students up front made them to devalue and ignore meaningful aspects of a lesson.

Data in Table 3 revealed that SS 2 biology students exposed to scientific thinking skills had more improved academic achievement in biology than the students in the control group taught using lecture method. The finding of the study could be ascribed to the fact that students in the experimental group were able to master the selected scientific thinking skills (observing, experimenting, inferring, predicting outcomes and others) better than the control group. This is because scientific thinking skills help the students to carry out experimental investigations, and verification of biology concepts. The finding in line with Akubuilo (2013) who indicated that students taught using scientific thinking skills performed better than their counterpart. The finding also agrees with the ones of Aktamis and Omer (2010) who observed that scientific thinking skills increased students' academic achievement and scientific creativities.

The result in Table 4 revealed that teachers exposed to scientific thinking skills training performed significantly better than their colleague who were not exposed to scientific thinking skills training on instructional clarity. This finding agrees with the view of Mahmood (2017) who posited that level of competency in content development in science classroom require the development of logical and scientific thinking skills. The finding is also in line with Bird (2020) that scientific thinking skills are counted as the best predator of the academic performance of learners. Results in Table 5 indicated significant effect of scientific thinking skills training on Biology teachers on communicating lesson objectives. This implied that treatment was effective on biology teachers exposed to scientific thinking skills training on communicating lesson objective in the classroom. This confirmed the position of Nkwo, Akinbola and Ikitde (2019) who affirmed that prior knowledge of lesson objectives statistically facilitates achievement on difficult concepts in physics.

Results in Table 6 showed that students taught biology after exposure to scientific thinking skills training (experimental group) achieved better than their colleagues who were not exposed to scientific thinking skills training (control group). These finding is in agreement with the findings of Allzam (2013) on the investigation of scientific thinking skills in science education in the development of academic achievement in biology, revealed that students taught biology using scientific thinking skills achieve significantly better than those taught using lecture method.

CONCLUSION

Based on the findings of the study, it was concluded that adequate training in teaching for thinking is required for biology teachers through a well- structured thinking programme that incorporates various teaching strategies to promote students' thinking in the classroom. Also teachers should consider teaching behaviours that invoke, maintain, and enhance students thinking in the classrooms as a tool for effective learning and learning.

RECOMMENDATIONS

Based on the findings of the study, it was recommended that biology teachers should:

1. incorporate the scientific thinking skills strategy in teaching biology in senior secondary school level to enhance students' achievement in the subject.

2. be trained adequately on how to integrate scientific thinking skills in their regular teaching content in biology classrooms.

REFERENCES

Adedoye, M. A. (2017). Innovations and curriculum development of basic education in Nigeria. Policy priorities and challenges of practice and implementation. *Journal of International Studies*, *2*(3), 12-14.

Adewale, A. M., Nzewuihe, G., & Ogunsola, F. (2016). *Academic performance in biology at secondary school certificate examination (SSCE) and the influence factors among students in Owerri Municipal of Imo State.* Retrieved fromwww.iiardpub.org.

Agbaje, A. F., and Alake, U.M. (2014) influence of gender family background and motivation on students achievements in basic technology in Lagos. International journal of social sciences, 6(3), 35-41.

Ajaja, P. O., & Evavwoke, U. O. (2013). Teachers' characteristics and science teachers' classroom behaviour: Evidence from science classroom survey. U.S- *China Education Review*, *3*(1), 36-53.

Akanij, C. A. (2015). *Enhancing teaching andlearning biology through the use of video clips in selected senior secondary schools in Lagos State*. A paper presented at the science teachers association of Nigeria (STAN) Lagos State chapter held in July, 2015.

Aklamis, H., & Omer, E. (2010). The effects of science process skills education on scientific thinking, creativity and scientific attitude and academic achievement in science. *Asia-Pacific Forum on science learning and teaching,* 9(5), 18-25.

Akubilo, D.U. (2014). The effects of problem solving: international strategy on students' achievement and retention in biology with respect to location in Enugu State. *Journal of Science Teachers' Association of Nigeria* (STAN), 24 (1&2), 94-100.

Ashdown, D. M., Bernard, M. (2012). Can explicit instruction in social and emotional learning skills benefit the social-emotional development, well-being and academic achievement of young children? *Early Childhood Educational Journal*, 39, 397-405.

Asmtia, A. A., and Crowley, R. (2014). The science hypothesis formulation ability of gifted ninth-grade students, journal of education psychology, 82(4), 838-848.

Brown, D.H. (2011). *Teaching by principle: An interactive approach to language pedagogy.* White Plains: NY Pearson Education Longman.

Borich, C. D. (2014). Effective teaching method fifth edition. New Jerssey: Pearson Merilli Prentice Hal.l

Costa, A. (2007). Teaching for thinking, of, and about thinking. In A. Costa (Eds.). Developing minds: *A resource book for teaching thinking* (3rd edition). *354-359*

Eupena, R. (2013). Teacher communication behaviour: It's impact to students Attitude in learning of science. *International Peer Review Journal,* 3, 2012. Retrieved from http://dx.doi.org/10.7718/ijss.v3i/.35

Federal Republic of Nigeria [FRN] (2014). Nigeria education research and development Council. NEDRC. Abuja.

Federal Republic of Nigeria [FRN] (2009). Senior secondary education curriculum for SS1-3, Abuja. *Nigeria Education Research and Development Council*.

Josiah, M. M. (2020), *Effects of jigsaw cooperative learning strategy on students' motivation and achievement in senior secondary school physics in Jos metropolis, Nigeria.* Unpublished PhD Thesis, University of Jos.

Muhaood, B. A. (2017). Effects of science process skills approach and lecture method on academic achievement of pre-service chemistry teachers in Kaduna, Nigeria. *ATBU Journal of Science, Technology and Education*,4(2), 2016.

Nbina, J. B. (2013). Analysis of poor performance of senior secondary school students' in chemistry. *African Research Review International Multidisciplinary Journal Ethiopia,* 6(4)34-334. http://dx,doi.org/10.414/atrrev.v 6i4.22

Nkwo, N. I., Abimbola, A. O., & Ikitde, G. A. (2019). Effects of prior knowledge on students achievement in selected difficult concepts in Nigeria senior secondary school physics. African Research Review, 2(1).

Nwagbo, C.R. (2014). *Effects of two teaching methods on achievement and attitude of biology students of different scientific literacy.*Unpublished Ph.D dissertation. University of Nigeria, Nsukka.

Sambo, S. M. S. & Ebira (2019). Effects of using the obstetric education model in developing deductive thinking and achievement in chemistry among first –years secondary students in Makkah. *International Journal of Early childhood SpecialEducation* (*INT.JECSE*), 12(2020), 35-48. DOI:10.9756/INT-JECSE/V/212.201054

Stapleton, L. (2014). What students really need: instructional strategies that enhance higher oder thinking skills (HOST) among unimas under graduates. Inernational journal of business and society, 18(4), 661-668. http://www.ibbs.unimas.my/images/ repository/ PDF/vol18-s4-paper2.pd.

Stahl, R. T. (2017). Using think-pair behaviour to promote students' information processing learning and on-task participation: Tempe, AZ: Arizona State University.

Usmand, A. C. (2015). Effects of cognitive and modeling techniques of counseling on students' study behaviours and achievement. Unpublished Ph.D Dissertation Department of Education, Ebonyi State University.

WAEC Chief Examiner (2006-2019). *Low enrolment of girls for science subject and achievement in the physics and other sciences*. WAEC (2011) Chief Examiners' Report Pubilcation of WAEC Lagos.