

**SCIENCE EDUCATION AS A RECIPE FOR INCULCATING
SCIENTIFIC AND TECHNOLOGICAL LITERACY FOR SUSTAINABLE
DEVELOPMENT IN NIGERIA**

BY

**Dr Yakubu Peter Abuh¹., Nwaba Abraham Attah²., Atabor Moses Enemali³
& Obaje Gabriel Monday⁴**

^{1,2,3}Department of Physics, Kogi State College of Education Ankpa Kogi State

⁴Department of Chemistry, Kogi state College of Education Ankpa Kogi
State

Corresponding Author: pyabuh@gmail.com

Abstract

The study, science education as a recipe for inculcating scientific and technological literacy for sustainable development in Nigeria adopted quasi- experimental design and was guided by two research questions and two null hypotheses. The instrument tagged Science & Technology Literacy Level Test (STLLT) validated by four experts with reliability index of 0.82 was used to collect data from a sample of 200 out of the population of 309 students of Abubakar Tafawa Balewa University, Bauchi, KSCOE, Ankpa study centre using multistage sampling technique. Data collected were analyzed using mean, standard deviation, and ANCOVA to test the hypotheses. Results show significant difference in favour of students taught Science Education using inquiry based and Demonstration teaching strategies. The result also revealed that there is no significant difference based on the gender of the students. Based on the findings, recommendations were made that teachers should adopt the teaching strategy that is gender friendly among others.

Keywords: Science education, scientific and technological literacy, sustainable

Introduction

Science Education is a discipline that involves the transmission of scientific and technological concepts, methods of teaching and addressing scientific misconceptions held by learners. It is a tool for social transformation, and

acquisition of scientific skills for sustainable development. The reasons for teaching Science Education in schools are for the acquisition of scientific and technological knowledge, skills, development of rational and general science and technological literacy (Eze & Akubue, 2017). According to Arukotan (2017) Science Education being education through the study of science has been recognized the world over as a prerequisite for scientific and technological literacy level development to acquire relevant functional knowledge and scientific skills such as creativity, critical thinking, innovative etc that are associated with scientific process and technology.

One of the goals for Science Education in Nigeria as enshrined in the national policy of education of federal republic of Nigeria (2014) as amended is to develop scientific and technological literacy among citizens, in this vein, the aim of Science Education is to achieve unity in diversity in scientific and technological literacy. Daniel (2019) described scientific literacy as the recognition, understanding and the application of scientific principles and concept to real life situations, both at personal and societal levels. Whereas technological literacy involves the capability to make systematic application of scientific knowledge to practical task (Patrick, 2018). Okoro (2020) defined scientific and technological literacy (STL) as the individual's ability to utilize creatively science knowledge to solve every day problems, make informal decision and function well in the society. Scientific and technological literacy is the ability of an individual to live gainfully and conversantly in a science and technology world. Effective teaching of Science Education enhances the inculcation of scientific and technological literacy in our students and citizens at large. These enable the individuals to contribute and appreciate the value of science and technology in society. Problem solving, values and rational decision –making are integral part of scientific literacy and should form the integral part of Science Education curriculum (Liptonel, 2016). Hence the need for emphasis on skill development through the process of scientific inquiry, applied to numerous real life problems in service of self and the society.

Scientific and technological literacy provides the citizen the capability to examine technology for what it is as whole combining technical, organizational and cultural aspects, creating the “technological Micheu” which is a formative and dominant ingredient in today's global culture in which we all participate and in which we are educating our children for sustainable development (Casmir, 2016). The word sustainable development means putting in place an efficient Science Education

system which has an in built capacity of dictating the change situations and adapting constructively and productively to unchangeable situation in the present and in the future. Science Education is a science course designed for a student to gain an understanding of the role and function of science and technology in every day's life and the world he/she lives in (FME, 2016). Hence the need to teach Science Education using students' centered strategy, as it helps students acquire higher level of scientific and technological literacy for functional living in the technology driven society. Abuh (2022) opined that there is a need to teach Science Education in schools in the way and manner that will help the students develop higher level of scientific and technological skills for functional living in the society. This could enable students move from nominal level of STL to higher ones like functional or cultural literacy, structural literacy level and multidimensional level of literacy which is the ultimate. These enable students acquire manipulative skills to turn our world around for better living. To achieve this feat, effort must be geared towards using students centered teaching strategy, use of hands on activity method availability of qualified teachers and appropriate instructional materials, well equipped science laboratory and workshops and proper remuneration of teachers.

Students' centered instructional strategy is a strategy that engages students investigating real world situations that they choose within a broad thematic framework. Students' centered teaching strategies that place the locus of central and acquisition of knowledge on the learners who are encouraged to generate self-relevant knowledge through critical inter active and collaborative inquires (Cholewinsky, 2019). Constructivist instruction has a number of student' centered instructional approaches and they are; concept mapping, think-pair-share, problem based learning, scaffolding, inquiry based instruction, cognitive conflict and conceptual change strategies (Mark & Denga, 2014). Teaching strategies are methods of instruction used by the teacher to help students to learn and to apply their knowledge to achieve the academic goals. This can be achieved through active interaction between the teachers and students as in the form of collaborative or cooperative and guided inquiry, among others in classroom setting. Hence in this paper, the research focused more on inquiry based teaching method which is student centered and demonstration teaching method which is teacher centered approach to investigate the best teaching approach in Science Education classroom that can help students acquire higher level of scientific and technological literacy among learners for sustainable development. Inquiry based instructional method according to

Musliua (2015) has been described as a method of teaching that involves probing, finding out, questioning, thinking, analyzing, synthesizing, discovering and evaluating given task.

A variety of studies investigated the effectiveness of inquiry instructional method as it enhanced the student acquisition of scientific and technological literacy (Mushau, 2015). Udu (2017) conducted a study on the effect of inquiry and lecture methods on students' academic achievement in Biology in senior secondary school using SS2 students, the results of the finding revealed that inquiry instructional strategy proved more effective than the lecture method in enhancing students' academic achievement similarly Omeize (2018) compared inquiry conventional teaching methods on senior secondary one (SS1) chemistry students and the results showed that inquiry teaching method favoured the student more than the student taught with conventional methods in the same vein students carried out by Ogundele (2014), Unoru (2015) and Uba (2016) respectively using inquiry instructional strategy and traditional lecture method on students acquisition of scientific literacy skills on senior secondary schools. Results of the studies revealed that students taught with inquiry instructional strategy acquire more scientific literacy skills as indicated by the higher mean achievement scores than those taught using traditional lecture method that can enhance sustainable development. Thus in this study the researchers compare inquiry teaching method with demonstration teaching strategy so as to determine the teaching that could best enhance students acquisition of scientific and technological literacy skills for sustainable development. Thus, this study compared inquiry teaching method with demonstration teaching strategy so as to determine the teaching strategy that could best enhance students' acquisition of scientific and technological literacy skills for sustainable development in Nigeria.

The demonstration method is a teaching learning process which is carried out systematically. This method is structured in such a way that ideas are normally communicated with the aid of visuals such as flip charts, posters, power point, etc (Smith, 2014). In demonstration method the teacher is expected to provide students with experiences of real events, phenomena, and processes, helping them to learn and improve or raise students' achievement, interest, and motivation levels. However previous researchers who have experimented on the use of demonstration method in Science Education revealed that it improves students' achievement in

physics and other science subjects (Ugwunyi, Nwankwo & Ugwoke, 2016. Okotube, 2020). It is an attention inducer and a powerful motivator in science and technology lesson delivery (Ogbodo, Ogirua & Ozedu, 2019). It enhances retention of science knowledge, leading to scientific and technological literacy (Domini, (2017), it improves science knowledge leading to scientific and technological literacy (Dominic, (2017) it improves science students interest and retention (Njoku & Attah, 2019). On the other hand none of the reviewed literature investigated the use of inquiry instructional strategy and demonstration method to enhance students' acquisition of higher level of scientific and technological literacy for sustainable development which is the gap the current study filled up. Also of important to this study is the contribution of gender of students' acquisition of scientific and technological literacy. Gender describes the personality traits, attitude, behaviours, value relative power, influence, roles and expectation (femininity and masculinity) that society ascribes to the two sexes on a differential basis. The gender gap in science and technology education in favour of males is a widely known phenomenon, that science subjects like physics, chemistry, mathematics are associated with Masculine gender (Eze, 2015) previous studies for example lietaenet and fraime (2015) showed that students acquisition of scientific and technological literacy is gender based. Abuh (2023) showed student acquisition of science and technological literacy is based on gender and that males acquire higher level of scientific and technological literacy than the famine gender. Ebe (2013) showed that students' acquisition of scientific and technological literacy is skewed to the males. However the study Obi (2019) showed that students acquisition of scientific and technological literacy is not gender based but teachers teaching strategies and style. In view of the differences in research findings, the present study is hinged. Thus the purpose of the study is to investigate the teaching of science education as a recipe for inculcating scientific and technological literacy among Nigerian citizenry for sustainable development. Specifically the study tends to:

- 1 find out the effect of Science Education teaching on students' level of scientific and technological literacy for sustainable development
- 2 determine the influence of gender on students' level of scientific and technological literacy possessed in science education

Based on the purpose of the study, the following research questions were also posed to guide the study:

1. What is the effect of science education teaching on students' level of scientific and technological literacy for sustainable development?
2. What is the influence of gender on students' level of scientific and technological literacy possessed in Science Education

Hypotheses

The following hypotheses were formulated to guide the study;

1. The level of scientific and technological literacy possessed by science education students is not significant
2. The level of scientific and technological literacy possessed by science education students based on gender is not significant.

Methodology

The research design adopted for this study was a quasi-experimental, specifically pre-test and post-test non-equivalent control group design. The design was considered appropriate for the study because intact classes were used and were randomly assigned to both treatment and control groups. The experimental and control groups were pre-tested before treatment and post-tested after the treatment was administered. The population of the study comprised all the 309 under graduate science education students of Abubakar Tafa Balewa University, KSCOE Ankpa study center, Kogi state. In this study 300 level to 500 level students were selected for the study. The reasons being that those levels are already exposed to the teaching and learning of Science Education and are available for the research work. These category of students have covered a considerable quantum of the science education syllables at 300 level, 400 level and 500 level compared with those in 200 level and those in 100 level simple Random sampling techniques was used to assign the level of students into the 3 groups that is two experimental groups and one control group. From the sampling the 500 level was assigned to control group 400 level to experimental group and 300 level to experimental group 2. Similarly, random sampling technique was used to assign teaching strategy to each of the experimental groups. Through random sampling by balloting demonstration teaching strategy was assigned to experimental group 1 while inquiry based strategy was assigned to experimental group 2 and the central group was assigned traditional lecture method. The number of students in each of the selected levels forms the sample size for the study. That is 300 level is 65 (male= 38 & female=27) students, 400 level is 67 (male 39, female=28) students and 500 level is 68 (male =40, female=28) students making a total sample size of

200 (M=122, F=78) students in the department of science education out of the total population of 309. Out of the sample size of 200, 122 students were male, while the remaining 78 students are females. Experimental group was taught science education (Physics, Chemistry, Biology and Mathematics Education using demonstration teaching strategy, Experimental group 2 was taught using inquiry based teaching strategy, while the control group was taught using traditional lecturer method. All the teaching was done by following the detailed lesson notes prepared for the 2 experimental groups and the control group.

The instrument used for data collection was tagged science and technology literacy level test (STLLT) constructed by the researchers with forty multiple – choice items from the four major courses offered in the science education department based on the developed lesson plan. These courses are physics, chemistry Biology and mathematics education. The items in the instrument had four options A-D to aid achievement of the purpose of the study. The instrument was made up of four major sections according to courses based on expected science process skills noticeable for required at nominal level, functional level, cultural level and multi-dimensional level of scientific and technological literacy. The four section of the S&T literacy test were put in a single instrument tagged STLLT and the title is proceeded by the demographic data of the respondents and information.

The instrument were face and content validated by four experts, one from each of four discipline, all in Science Education department Abubakar Tafawa Balewa University, KSCOE Ankpa. 20 copies of the instrument was trial tested in a School in the neighboring State, not part of the sample area of the study. The reliability index was determined using Kuder-Richardson 21 formula (K-R21) and was found to be 0.82. The choice of Kuder-Richardson formula was because the instrument STLLT was dichotomously scored. The reliability estimate of 0.82 shows that the instrument is reliable for the study. At the beginning of the experiment STLLT instrument was administered to both students in respective groups with the aid of the course lecturers. At the end of the test, scores of the students on the pre-test were recorded and kept the same instrument STLLT was administered to the student at the end of the treatment period. The scores obtained from the post-test were later subjected to statistical analysis. Mean and standard deviation were used to answer the research question while the analysis of

Covariance (ANCOVA) was used to test the null hypotheses at an alpha level of 0.05 level of significant

Results

Research question 1: what is the effect of science and technology literacy for sustainable development when taught using inquiry based, demonstration strategy and tradition lecture method.

Table1: Mean and Standard Deviation Scores of Student Level of Scientific and Technological Literacy in Science Education.

S/N	Strategies	N	Pre-Test STLL		Post-test on STLL		Mean Gain score	Mean Gain Differences
			Mean	SD	Mean	SD		
1.	Inquiry based strategy	65	60.50	26.00	120.90	13.80		
		60.40						
2.	Demonstration Strategy	67	61.79	27.70	108.80	15.20	47.10	
3.	Traditional Lecture Method	68	60.60	26.60	94.90	18.20	34.30	
	Total	200						

STLL: Scientific and Technological Literacy Levels

Results in Table 1 revealed that at pretest, science education students taught using inquiry based strategy had mean acquisition of scientific and technological literacy skills score of 60.50 with a standard deviation of 26.00. While science education students taught using demonstration strategy had mean acquisition of scientific and technological skills score of 61.70 with standard deviation of 27.10. And for students taught using traditional lecture method their mean scientific and technological literacy skills score was 60.60 with a standard deviation of 26.26. At the posttest, science education students taught using inquiry based strategy had mean acquisition of scientific and technological skills score of 120.90 with standard deviation of 13.80, while students taught with demonstration strategy had mean acquisition of scientific and technological skills score of 108.80 with a standard deviation of 25.20. And the students taught using traditional lecture method had

mean acquisition of scientific and technological literacy skills score of 94.90 with standard deviation of 18.20, representing nominal, functional, structural and multidimensional literacy levels.. The mean gain score of students taught with inquiry based strategy was 60.40, while for those taught with demonstration strategy, their mean gain score was 47.10 and students taught using traditional lecture method had mean gain score of 34.30. The result therefore, show that students taught using inquiry method had higher mean acquisition of scientific and technological literacy skills score compared to those taught using demonstration and traditional lecture method those students taught with demonstration strategy equally had a higher mean gain score compared to those taught using traditional lecture method. This can be seen from a mean gain core difference of 13.30 in favour of inquiring based strategy and followed by demonstration strategy with mean gain score difference of 12.80. the result indicates that inquiry based strategy has the potential of enhancing students acquisition of higher level of scientific and technological literacy skills for effective and constructive contribution to the societal needs for sustainable development .

Table 1 equally revealed that the students were almost at the same level of scientific and technological literacy level before the treatment. Inquiry based strategy group had mean of 60.50 with standard deviation of 26.00, Demonstration strategy group had mean of 61.70 with standard deviation of 27.10 and traditional lecture method had mean of 60.60 with standard deviation of 26.60.

Research question 2: what is the influence of gender on students' level of scientific and technological literacy possessed in science education?

Table 2: Mean and Standard Deviation for Strategies on Level of Scientific and Technological Literacy by Gender

S/N	Strategies	Gender	N	Pre-Test Mean	SD	Post-test Mean	SD	Mean Gain score	Mean Gain I
1.	Inquiry based 31.40 Strategy	Male	38	31.00	10.70	62.40	6.70		
2.40		Female	27	29.50	12.30	58.50	7.10		
29.00									

2. Demonstration Strategy	Male	39	31.95	12.80	52.10	7.20
	Female	28	29.75	14.30	48.70	8.10
20.15						
18.95	1.20					

Results in Table 2 revealed that at the pretest male science students taught using inquiry based strategy had mean acquisition of scientific and technological literacy skill score of 31.00 with standard deviation of 10.70 while the female counter part had mean score of 29.50 standard deviation of 12.30, on the other hand, science students taught using demonstration strategy at pretest the male had mean acquisition of scientific and technology social literacy skills score of 31.95 with standard deviation of 12.80, the female counter parts had mean score of 29.75 with standard deviation of 14.30. At posttest male science students taught with inquiry based strategy had mean score of 62.40 with standard deviation of 6.70 while the female counter part had mean score of 58.50 with standard deviation of 7.10. At posttest, male science students taught using demonstration strategy had mean acquisition of scientific and technological literacy skills score of 52.10 with standard deviation of 7.20 while the female counterpart had mean acquisition of scientific and technological literacy skills score of 48.70 with standard deviation of 8.20.

The men score of male students taught with inquiry based strategy is 62.40 with mean gain score of 34.40 while the mean score of the female is 58.50 with mean gain score of 29.00 scientific and technological literacy skills as shown in table 2. This indicate that the male students acquired scientific and technological literacy skills better than the female counter part with a mean score difference of 2.40 which is not significant. Also table 2 show that male science students taught using demonstration strategy has a mean score of 48.70 with mean gain score of 18.95. this means that the male students did better than the female in the acquisition of scientific and technological literacy skills and the mean difference is 1.20 which is also not significant. It was also observed from table 2 that mean gain score difference of the students taught using inquiry based strategy enhances better acquisition skills than the demonstration strategy. Further analysis to show whether gender have significant influence on students mean acquisition of scientific and technology skills score would be determined by testing the hypothesis.

Ho¹: The level of scientific and technological literacy possessed by science education students is not significant

Table3: Analysis of Covariance (ANCOVA) of Acquisition of scientific and technological literacy skills of students taught science education using based strategy demonstration teaching and traditional lecture method

Source	Type III sum of squares	Df	Mean Square	Partial Eta Squared	F	Sig
Corrected Model	2143.176	4	535.794		5.286	
Intercept	25225.016	1	25225.016		248.855	
Pre-STLLT Method	496.112	2	248.056		2.447	
Gender	705.758	2	352.878		105.653	
Method Gender	321.967	1	321.967		3.176	0.081
Error	19563.25	193	101.364			
Total	563706.00	200				
Corrected Total	21301.031	199				

Table 3 reveals significant outcome for method $F(1,199)=105.653$; $P=0.000<0.05$. Since the P value is less than 0.05, the null hypothesis is rejected. This implies that there is significant difference in the mean acquisition of scientific and technological literacy skills of students taught Science Education using inquiry based strategy, Demonstration teaching strategy and traditional lecture method in favour of those students exposed to science education using inquiry based strategy. The partial eta square of 0.456 obtained for the strategy means that 45.6% of the students' acquisition of scientific and technological literacy skills in science education are accounted for by the strategy employed.

Hypothesis Two

H O². The level of scientific and technological literacy possessed by science education students based on gender is not significant

Table 3 reveals no significant outcome for gender $F(1,199)= 3.17$; $p =0.08$ 0.05 . Since the value of p is greater than 0.05 , the null hypothesis is retained. This implies there is no significant different based on gender of the student. That is to say the level of scientific and technological literacy possessed by science education student based on gender is not significant. However, the difference in the mean acquisition of scientific and technology literacy skill scores of male and female students could be due to the strategy employed by the teachers and their teaching styles. The partial eta square of 0.017 obtained for gender means that 1.7% of students' acquisition of scientific and technological literacy skills in science education are accounted for by gender.

Discussion of Findings

The finding revealed that the students taught science education using inquiry based and demonstration teaching strategies acquired scientific and technological literacy skills better than those taught using traditional lecture method. The study equally revealed that the students taught science education using inquiry based strategy had higher mean acquisition of scientific and technological literacy skills score than those taught using demonstration teaching strategy. This means that science education could be better taught using inquiry based strategy as a students' Centered teaching strategy for better acquisition of sustainable development in the society than the Demonstration teaching strategy that is more of teacher centered approach. It Is a known fact that researchers in science education such Ogundale (2014), Umoru (2015), Uba (2016), Udu (2019) and Abuh (2023) show that student centered methods of teaching are more effective than teacher centered, traditional lecture methods, in enhancing students "acquisition of scientific and technological literacy skills for the advancement of the society. The analysis of the hypothesis revealed that there is a significant differences in the mean acquisition of scientific and technological literacy skills of students taught science education using inquiry based strategy, and demonstration teaching strategy. The reason being that inquiry based strategy is a student centered learning process where the teacher acts as a facilitator or coach rather than a lecturer. According to Tom (2016) inquiry is a "building" process that moves learners along a continuum when they are en-cultured in the practice of inquiry which enable students acquire scientific skills. This finding is in agreement with Udu (2017) who revealed that innovative based

strategy (Inquiry based strategy) proved more effective than other methods in enhancing students' acquisition of scientific skills in science education. Similarly the study concurs with Ogodo, Ogirua and Ozedu (2019) that revealed that there are significant differences in students' acquisition of scientific and technological literacy skills when taught basic science using guided inquiry based strategy and conventional teaching method in favour of those taught using guided inquiry based strategy. The result of the study is equally in line with Omeize (2018) who compared inquiry based strategy and conventional teaching methods on senior secondary one (SS1) chemistry students and revealed that inquiry teaching method favours students' acquisition of scientific literacy skills more than those taught using conventional methods. In the same vein, the study agrees with the study carried out by Ogundale (2014), Umoru (2015) and Uba (2016) respectively using guided inquiry based strategy and traditional lecture method which revealed that students taught with guided inquiry based strategy acquired more scientific literacy skills as indicated by their higher mean achievement scores than those taught using traditional lecture method in enhancing sustainable development in the society.

Furthermore, the finding for the study revealed that there is no significant difference based on the gender of the students on the level of acquisition of scientific and technological literacy skills possessed by science education students. The result of the study is in agreement with Trow-Bridge and Orji (2021) which revealed that gender has no significant influence on students' level of acquisition of scientific and technological literacy skills in basic science. The insignificant relationship between gender (Male and Female) and acquisition of scientific and technological skills could be attributed to the fact that both genders have equal interest and attitudes towards the study of science and technological education. The study is in agreement with Ube (2016) that students' acquisition of scientific and technological literacy skills is not gender based. The result of the study also concurs with Obi (2019) which showed that students' acquisition of scientific and technological literacy skills is not gender based but teacher's teaching strategies and style. On the contrary, the study by Udu (2017) revealed that there is a significant relationship between gender and acquisition of scientific and technological literacy skills among secondary school students with female students possessing higher scientific and technological literacy levels than the male counterparts. Also, Chris (2018) revealed that students' literacy skills are influenced by gender difference with female having dominance in most literacy levels.

Conclusion

These result indicates that there is significant differences in the mean acquisition of scientific and technological literacy skills of students taught Science Education using inquiry based strategy, demonstration strategy and traditional lecture method in favour of the students exposed to science education using inquiry based strategy being a perfect students centered learning approach and followed by those exposed to science education using Demonstration strategy, which is more of teacher centered approach to teaching and learning. The finding of the study also revealed that there is no significant difference based on the gender of the students on the level of scientific and technological literacy skills possessed by Science Education students. That implies that gender male or female has no influence on the level of students' acquisition of scientific and technological literacy skills.

Recommendations

Based on the findings of the study the following recommendations were made

1. Teachers should adopt the teaching strategy such as inquiry strategy that is gender friendly in the teaching of science related discipline for maximum achievement of scientific and technological literacy skills that can help individuals' needs and the need of the society.
2. Teachers should use instructional strategies that are students' centered and that encourages hands –on- activity during teaching and learning that can help students acquire higher level of scientific and technological literacy skills for effective and functional living in the society.
3. Number of periods per week should be increased for Science Education classes, so as to give enough time for class activities, as students centered approached require time.
4. Science teachers who are already in the field should be sponsored for training and retaining through attending seminar and workshops on regular basis so as to acquaint them with science teaching more especially as it relates to the use of activity based methods of instruction such as guided inquiry and demonstration strategy.

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