The Effect of Scientific Literacy An Approach to Technological Achievement in Physics Education among Students in Aguata/Nnewi Educational Zone, Anambra State.

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Abstract: The study sought to investigate the effect of scientific literacy an approach to technological achievement in physics Education with gender and location as independent variables. There is a growing demand for the science educators to improve the learning of physics particularly in the development of the world due to the critical role it plays in terms of technological advancement. Many approaches and methods are applied with the intention of improving literacy achievements in the subject. The STS approach is an approach that espouses science technology approach specific contents and methods. Three themes are embodied in the physics content: physics discipline content, technology discipline content and the context of both, the society. Emphasis is laid on communication skills. The methods it espouses are those that encourage critical thinking and problem-solving rather than discovery. The traditional science instruction on the other hand, places high premium on science discipline content with little emphasis on technology and society. It also espouses methods that lead to discovery e.g. inquiry and directed -discovery methods. To carry out this investigation, three research .questions and nine null hypotheses guided the researcher. A quasi-experimental design of the pretest-posttest non-equivalent control group was adopted. A population of 3,017 SSII & SSIII physics students from 88 schools and Aguata and Nnewi Educational zone was identified. From this, 246 SSII & SSIII physics students were sampled from 4 secondary schools. Each one was stratified into rural and urban and one male school and one female school were sampled from each stratum. For each school sampled, two classes of SS II & SS III were randomly assigned to either the experimental or control group. The former were taught using the STS approach while the latter were taught using the traditional science instruction approach. The regular class teacher taught each. Two topics were selected from the physics core curriculum: momentum and force of gravity. This was on the basis that they are related and ample STS content derived from them appropriate STS concepts were identified from these topics and infused into the lesson for the experimental group. Two testing instruments were used to collect data- a self-made Physics Achievement Test (PAT) and an adapted scale for scientific literacy (Scientific Literacy Scale, SLS). After trial testing, The former gave 071 for SLS while the later gave 0.84 for SLS and 0.6 for PAT. The research questions were answered by descriptive statistics while the null hypotheses were analyzed by ANCOVA and Regression analyses. The results showed among others that the STS approach is better than the traditional approach in the development of scientific literacy and achievement in physics; the STS approach has a differential effect on scientific literacy and achievement in physics in favour of rural students; STS approach aids development of an understanding of the nature of science more than STS interactions and basic Physics concepts; there is no relationship between scientific literacy and achievement in physics, however, STS approach mediates between scientific literacy and achievement to produce a

weak positive relationship. The implication for science education is that the STS approach should be adopted for the teaching of physics in the present millennium. This is because it will enhance the much-desired scientific literacy. It was therefore, recommended that Nigeria should, like other countries, revise the physics curricula to incorporate STS tenets and practicing physics teachers be retrained in this line.
Keywords. Achievement, Effect, Investigate, Literacy, Physics, Quasi experimental design

1. INTRODUCTION

In literature there are different definitions of scientific literacy and there is a widely spread idea of the impossibility a single definition including all characteristics of the notion to be given. According to Hazen (2003), scientific literacy is a system of basic science knowledge, the way of its formation and development of ability for its creative use in daily round, for solving problems, related to improvement of life standard. Scientific literacy is based on acquisition of scientific knowledge and skills on intellectual, communicative, social, and interdisciplinary levels. Holbrook (2000) opined that scientific literacy is much more than acquisition of a system of knowledge and knowledge about its formation. It presupposes knowing basic scientific principles and it is a blend of conceptions, history and philosophy. So an opportunity is given to a person with scientific literacy to answer certain questions, to understand the news in media to have a personal position in civil and cultural work, and such related to economic productivity. A person having scientific literacy is able to interpret and foresee natural phenomena. Scientific literacy is not specific and full of exotic phrases language used by experts. Having it students and all other people will not necessary be able to make new medicine or to determine the orbit of a spaceship. According to PISA (2008) "Scientific literacy is the ability to use scientific knowledge, to identify questions and make conclusions based on evidence, so as to understand and support decision making related to nature and human induced changes in it."

Fensham (1988) think scientific literacy is:

a. Understanding basic natural science notions, phenomena, and conceptions
b. Knowing the stages and character of scientific work and of research work (planning, performing, and analysis of an experiment; producing and checking-up a hypothesis; presenting the results)
c. Having common knowledge of structure and essence of science (scientifically and cognitively orientated themes, which are object of study, history of science, etc.)
d. Insight into relationships between science, technology, and society.

Physics is an important subject for economic, scientific and technological development (American Physics Society, 2008; Zhaoyao, 2002). Empirical studies from the field of Physics Education Research (PER) have outlined essential suggestions about physics curriculum which are generally accepted and believed to widen the knowledge and increase the horizon of understanding of physics by learners. Among the essential suggestions are:

(a) The method of teaching physics should be guided discovery instead of the traditional lecture method used in teaching the subject. This was recommended due to the fact that, learning efficiency and effectiveness take place during explanation, experimentation and discussion;
(b) There should be interaction between the physics teacher and the students. In this case, it is believed that if genuine and helpful interaction exists between the teacher and students, the students will be able to inform teachers what they find difficult in physics thereby reducing the difficulties they (students) encounter (Adeyemo, 2010, 101). These features are essential because it is believed that if they are dully and critically

followed and applied in any given situation and at any given time, teachers will be able to make physics easy to comprehend by learners (Adeyemo, 2010).

Teaching methods are the most important techniques employed by teachers to realize the objectives of a lesson (Borich, 2007; Fishburne & Hickson, 2001). Thus, teachers of all disciplines including physics use various teaching methods for achieving lesson objectives. For physics students to achieve their full potential in schools, it would seem to be essential that teachers engage in effective teaching practices (Borich, 2007; Fishburne & Hickson, 2001). Classroom based investigation has been able to determine effective research-based teaching practices that are related to positive learning outcomes. In a review of research studies that showed an impact on student achievement and learning, the authors summarized effective teaching methods and outlined five teaching behaviours that were supported by research and to which teachers should pay attention. These behaviours are: lesson clarity; instructional variety; teacher task orientation; engagement in the learning process; and student success rate (Borich. 2007; Hickson & Fishburne, 2001).

The impact that science and technology have solved many of human's problems, also created some problems as well. The enthusiasm about Science and Technology (S & T) being able to solve most of man's problems has waned, and there is a growing awareness of the adverse effects of the practice of science and technology. Despite this, science still appears a mystery for great numbers of people, and largely inaccessible even to men and women who believe themselves educated. The prevailing atmosphere calls for new goals of science education, which has, hitherto been the production of competent scientists and technologists (Zirnan, 1980). These new goals, which include an understanding of the scientist and the practice of science, an understanding of the interaction between science, technology and society- can be summed up as scientific literacy (Champagne and Lovitts, 1989; American Association for the Advancement of Science, 1993; Lee, 1949) Hurd, 1998) Scientific Literacy (SL) is the ability of individuals to be well informed and consequently live satisfactorily and conveniently in a techno-science culture. This implies an ability to think critically, solve socio-scientific problems, and take part in collective decision-making as well as ability to communicate effectively in a socio-techno-science culture.

Thus, Botero (1997, 204) submits "that access to scientific and technological information and understanding has become a fundamental component of citizenship in modern societies". In this age of computers, lasers and intercoms, where the day to day life of an individual amounts to operation of gadgets, a nation like Nigeria where the greater percentage of the populace have low level SL (Usua, 1976; Bajah. 1982; and Ogunniy L. 1982) and poor achievement in the sciences (Usua. 1976; Dunuji, 1976; Postlethwaite, 1991; Donghong. 1997; and Nkpa. 1997), stands the danger of being left behind in the race for development. Since the techno-science culture has become the mediating culture of the global village, the importance of scientific literacy and high achievement in the sciences cannot be over emphasized.

Since scientific literacy implies the promotion of "socially responsible and competent citizens' (Solomon, 1993; and Hurd. 1998). it follows that a science curriculum that seeks scientific literacy among the students will make for functional science education in this age. The Science-Technology-Society (STS) approach provides a framework for school science curricula given this new goal. Educators believe the transformation of school science into the STS context will make for an effective science education. STS is a new approach in science education around which educators are rallying in order to resolve the present crises in .science education. According to Kuhn (1970) and Davis McCarthy, Shaw and Sidani-Tabbaa (1993) four signs illustrate the breakdown of a science paradigm: (1) expressions of explicit

discontent. (2) proliferation of alternative theories, (3) discussions and debates over legitimate methods and (4) emergence of new paradigms. These signs can be used as indicators also in educational paradigms. And it cannot be denied that these four signs abound in science education, especially in Nigeria today. World War II led to the socialization of science and the breakdown of science as professionalized field of study. The breakdown emerged in Ihe 1960s in explicit discontent culminating in the 1969 curriculum conference in Nigeria. This hallmark in Nigerian education has led to the proliferation of alternative theories. The emergence of the Science Education Project for Africa (SEPA). Nigerian Integrated Science Project (NISP). the core curriculum in the different science subjects are all efforts to resolve the crises. These have however, not fully handled the said problem as is evident from the continued cry of educators (Cole. 1975: Bajah. 1982: Nkpa 1997) and the public (Ajaero, 1986) about the relevance of school science to the Nigerian Society.

In Nigeria, this has resulted in concrete activities and programmes like the institution of the Science Teachers' Association of Nigeria's (STAN) STS subject panel. Other programmes include the Early Learning Science Series for Africa (ELSSA), which emerged primarily to further the objectives of project 2000+ (Science Teachers Association of Nigeria, 1997). Internationally, US project 2061 (Science for All Americans) and Benchmark for Science Literacy are in the lead, while others like Canada. (Science A Way of Knowing) Britain, Spain, follow. While many conferences have been organized, workshops and seminars held. ELSSA is the first attempt at innovation in line with STS approach at the curricula level in Nigeria, at the primary level. At the secondary school level NERDC is experimenting on the introduction of population and family planning education. A number of NGOs are involved in this effort which is being tried out in 12 states of this Federation as at the moment.

Jegede (1988) reviewing the development of STS curricula in Nigeria. documents that as at the time, only two universities in the country, Ahmadu Bello University, Zaria and the University of Ibadan had introduced STS courses in their Teacher Education programmes. According to him, none exists at the secondary school level. While many faculties of Education have since introduced such courses in their teacher education programmes, the central control of curricula at the secondary school level confounds such innovative idea. Every effort therefore, has to be made to operalionalize and delineate the STS curricula as well as establish its superiority (if at all) over the traditional approach and this project is one such effort in this direction. The students should be equipped for such critical thinking and problem solving, given the enormous impact of S & T on society. The students should understand the nature and processes of the scientific enterprise so as to appreciate his place in it and make informed decision when the need arises. They should also understand that the scientists are as much human as anyone else. This will equip them for democratic decision making rather than leaving it for supposed experts'. Researchers are also by no means agreed on the interaction of gender and teaching methods on achievement. While some researchers believe teaching methods and gender have significant interaction effects on achievement (Ofoegbu, 1984: Obioma, 1986; and Nwosu 1987). Nworgu (1985) found no such effects exist. It would seem that no such comparisons exist for the STS approach which is a new approach.

Furthermore, Jenkins (1997) posits that most people do not experience science in isolation but as part of broader social issues. The experiences of an individual and his/her world-view may affect his level of scientific literacy and achievement, it follows therefore that SL and achievement may differ for physics students and the populace generally in different locations. It becomes worthwhile to investigate if STS approach can bridge this gap in performance and levels of achievement in physics and SL respectively by sex and location as well as enhances and increases these generally.

The issues of methods and contents as well as the relevance of science education have been the concern of science educators and psychologists. The problem is usually what method(s) to use for what topic(s) and group of students, or what content for a particular group of students and culture. It has been established that the status of the two leading indicators of the science education enterprise, scientific literacy (SL) and achievement, are not satisfactory in Nigeria (Cole, 1975 and Usua 1976; Bajah, 1982; Ogunniyi. 1982; Postlethwaite. 1991; and Nkpa, 1997). It is therefore important to find out what methods and eontt.iis can improve achievement in the sciences and the level of scientific literacy. Most STS literature in Nigeria is as position papers. STS methodology has not been researched into nor delineated. This study has helped to do this. This is important if the claims of proponents about the merits of STS including development of problem-solving and critical-thinking skills in students are true.

In line with the rest of the world, .including UNESCO's call to achieve scientific literacy by the year 2000 and beyond in project 2000+; and as an attempt to address this problem of low level scientific literacy and lack of relevance. Nigeria should not be left out in the quest to improve science education. One way to contribute toward finding solutions to the problem of low-level SL. poor achievement in and relevance of the sciences is to empirically determine how Science-Technology-Society (STS) as a new approach to science curricula can affect SL and achievement. So the question is what is the effect of STS approach on scientific literacy and achievement in Physics?

Purpose of the Study

The broad objective of this study was to compare the effects of instruction using STS approach and the traditional science instructional approach on scientific literacy and achievement in Physics. The specific objectives that derived from it were to:

1. Compare the effects of STS approach and the traditional science instructional approach on the level of scientific literacy among SSII and SSIII Physics students
2. Determine the effects of STS approach and the traditional science instructional approach on the level of scientific literacy among SSII and SSIII students, by sex and location
3. Compare the effects of STS approach and the traditional science instructional approach on achievement in Physics among SSII and SSIII Physics students
4. Assess the effects of STS approach and the traditional science instructional approach on achievement in Physics among SSII and SSIII Physics students by sex and location
5. Determine the relationship between level of scientific literacy and achievement in Physics
6. Determine the interaction effect of location, sex and teaching approach on levels of scientific literacy and achievement in Physics among SSII and SSIII Physics students.
7. Determine which of the chosen aspects of scientific literacy (basic Physics content, nature of science, and interaction of science, technology and society) is best developed by the STS approach.

Two teaching approaches were compared in this work. These are the Science-Technology-Society (STS) approach and the traditional science approach. This work was done with SSII and SS III physics students. For the STS group, STS content was integrated with "valid" physics content at the category 3 of the STS structural categories. This means STS content was purposefully infused into the physics lessons. The following content was covered: (a) Physics discipline content: Physics Students should be able to explain floating and sinking objects. (b) Physics Student should be able to explain sample mechanisms and floating of objects via the principles of mechanics (c) Physics Students should understand that

in nature energy doe not arise. The researcher chose reproduction and family planning .because they are related and the principles of mechanics need practical sessions, (d) STS content: a basic science content floating of object, the nature of science, interaction between science: technology and society.

The two aspects were covered by the STS package while the control was taught force and momentum with the traditional science instructional approach. The independent variables were, therefore, teaching approach, sex and location. The dependent variables were scientific literacy and achievement in physics. Three aspects of scientific literacy tested were nature of science, interaction of science, technology and society and basic physics concept (cell) motion. This is because these were fully covered by the traditional physics discipline content chosen. Other areas of scientific literacy, ethics that guide the scientist in his work, and socio-scientific problems were excluded because they do not derive directly from the physics topics treated in this work.

Research Questions

The following research questions guided the study:

1. To what extent did the STS approach and the traditional physics instructional approach differentially affect physics students' level of scientific literacy by gender and location?
2. To what extent did the STS approach and the traditional science instructional approach differentially affect students' achievement in physics by gender and location?
3. What aspect of scientific literacy chosen is best developed (nature of science, interaction of science, technology and society, basic scientific concept) by the STS approach?

Hypotheses

The following null hypotheses guided the study and were tested at .05 level of significance:

H_{o1} There is no significant difference between the mean Scientific Literacy Scale (SLS) scores of the experimental and control groups.

H_{o2} There is no significant difference between the mean physics Achievement Test (PAT) scores of the experimental and control groups.

H_{o3} There is no significant difference between the mean Scientific Literacy Scale (SLS) scores of males and females taught by the STS approach.

H_{o4} The level of scientific literacy among students does not influence their achievement in physics significantly.

H_{o5} Teaching approach does not interact with scientific literacy in influencing achievement in physics.

The works in this are do not have any trend as yet, the areas of interest and methodologies differ and as such no generalization can be made. They do not even measure the same attributes. Their constituents of scientific literacy are so broad that some defy any form of streamlining into any scientific literacy theme. Chiappetta (1993) is commended for the identification of broad themes of scientific literacy.

METHODOLOGY

The survey design and quasi-experimental design were employed for the study. The survey design was considered most appropriate since questionnaire was used for Physics Achievement (PAT) and more economical since many subjects can be studied at the same time (Mitchell & Jaley, 2004). Also a quasi experimental design of the pre-test post-test non equivalent control group was employed. This design is suitable for studies where absolute control of all the variables involved cannot be achieved. For this study, the number and

academic ability of the physics students could not be fully controlled, as intact classes were used. The physics students were also having their normal school session; therefore, interaction between the experimental and control groups may not have been absolutely excluded. A pre-test was therefore administered to account for the non-equivalence of 'the groups. The pretest scores were used as a covariate to the posttest scores during analysis.

Table 3; Pretest/Posttest Non-Equivalent-Control Group Design

Grouping	Pre-testing	Research Condition	Post-testing
GP 1 - Experimental	0_1	x	0_2
GP 2 - Control	0_1	x	0_2

Key
0 represents administration of test
x represents treatment

The study was carried out in Aguata and Nnewi Education Zones of Anambra State. This zone was divided into two: urban and rural, Aguata and Nnewi urban are comprised of 42 secondary schools, while there are 46 secondary schools in the rural area. This division enabled analysis on the urban/rural dichotomy. The population comprised ail the year two senior secondary school of SS II and SS III Physics students. These were 3,017 in number as at 2015/2016 academic session in 88 Secondary Schools (State School Management Board, Statistics Office). At this stage of secondary school, students are generally between 16 and 18 years of age. They would have reached the formal level of cognition and are expected to be able to reason abstractively. They would have completed two years of science education in one or all of the core sciences including Mathematics. They are, thus, expected to be scientifically literate. The sample consisted of 246 SSII and SS III physics students. From each of the locations
(urban/rural) two schools were randomly selected by balloting. The schools were stratified along gender lines before the selection was made. On the whole, four schools took part in the study, two male schools and two female schools.

For each school selected, two classes of SSII and SS III were randomly chosen. This again was by balloting. Since intact classes were used, it is expected that each shall be composed of all categories of achievers. This assumption was based on the fact that most schools place students in classes randomly. All the schools selected met this basic assumption, that is. that students' placement in classes was not determined by their abilities. The classes were assigned to the two research conditions by a toss of the coin.

Table 2: Sample of Schools (Statistics)

LOCATION / Gender	URBAN	RURAL	TOTAL
Male	1	1	2
Female	1	1	2
Total	2	2	4

The students were pretested before commencement of treatment; and again immediately after the four-weeks treatment period. The tests were collected and stored after each administration. Equal amount of time (1½hrs) was allowed the two groups in answering the questions. This time was considered appropriate because from the trial testing it took the students one hour to answer an average of 14 questions on SLS and 20 questions on PAT.

The Cronbach Alpha reliability model was used to determine the internal consistency of SLS, with the posttest result. This gave a coefficient of 0,71. The coefficient of stability determined by the Pearson Product Moment model gave 0.60 for PAT and 0.84 for SLS.

The intact classes were assigned to either the experimental or the control group. While the experimental group was taught with the STS approach, the control was taught by the traditional teaching approach (TSI -Traditional Science Instruction). The normal class teacher taught the two groups in each school.

Two topics from the Physics core curriculum were covered. These are human reproduction and family planning. The two topics are related, Again, the two topics selected are amply related to social issues.

The content of the STS (experimental) group included all the above, this is, the content for the control and the following STS content:

(i) Nature of science (particular reference to floating and sinking of objects (ii) Simple mechanisms and floating objects via principles of mechanics (iii) Energy does not arise in nature.

The researcher infused these into the lesson notes for the step by step incorporation of these various contents into the STS science lesson. Subsequently, the teachers taught the various groups, adhering strictly to the lesson notes. There was to be no reference to these STS content as different or separate from the main lesson. They were taken as a matter of course during the lesson periods. These were excluded from the lessons given to the control group. The SLS items were content free in relation to the lessons taught. Thus, judgment could be made on the level of scientific literacy based on this instrument for the subjects. Before commencement of the research conditions, the teachers were educated on STS curricula methodology. This included the rationale for STS, its goals and the various approaches to STS science. Secondly, the particular lesson notes used in this work were carefully studied. A micro teaching session was then done to more clearly show the differences between STS science and the traditional science approaches.

To control the non-equivalence of the groups, a pretest was administered to the Ss at the beginning of the treatment. The regression of scores that emanated from this was handled by ANCOVA, while intact classes were randomly assigned to experimental and control groups. The groups being taught by their normal class teachers who handled both experimental and control groups took care of Hawthorne's effect. This is because the students were not aware of their involvement in an experiment. The teachers taught with the same lesson notes prepared by the researcher. Careful consideration and study was made of the instruments and the experimental procedure. The teachers went through a two-day workshop with the researcher.

The research questions were answered using means and standard deviations. The decision-rule for research question 3 was based on the mean of each item. The values of the three categories sum up to 6 (3+2+1). This when divided by 3 gives 2. Any variable where the students' mean score was 2 or below shows a naive view. When the value was between 2.01 and 2.5, it shows the view has merit and if it is between 2.51 and 3, the view is realistic. Hypotheses 1-3 were tested using Analysis of Covariance (ANCOVA), while hypotheses 4 and 5 were analysed by regression analysis.

This study presents the analyses of the data collected from this research. This is done in respect of each research question and null hypothesis. Descriptive analyses (means and curricular deviations) were used for answering the research questions, while null hypotheses 1-3 were tested using analysis of variance. Regression analyses were used for analysing hypotheses 4 and 5. All the hypotheses were tested at .05 level of significance. Two instruments: Scientific Literacy Scale (SLS) and Physics Achievement Test (PAT) were employed in gathering dnia. The highest score obtainable by the students on PAT is 20 while the lowest score obtainable is 0. For SLS, the highest score obtainable by the students is 60 while the lowest obtainable is 20.

RESULTS

The answer of the research questions is purely descriptive and three research questions guided this study.

Research Question 1

To what extent did the STS approach and the traditional science instructional approach differentially affect students' level of scientific literacy by sex and location?
Data for answering the first research question are presented in Tables 3, 4, 5 and 6.

Table 3 Mean and Standard Deviation Scores of the Experimental Group (males) data by Location on SL.

	Mean		Standard	Deviation
	Urban	Rural	Urban	Rural
Pretest	36.54	40.66	4,49	4.41
Posttest	37.89	52.28	4.44	6.61
Gain	1.35	11.62	4.30	8.17

Table 4 Mean and Standard Deviation Scores of the Experimental Group (females) data by Location on SL,

	Mean		Standard Deviation	
	Urban	Rural	Urban	Rural
Pretest	33.23	36.54	4.16	3.05
Posttest	34.85	39.83	3.99	3.57
Gain	1.62	3.29	4.84	4.27

Considering the effect of STS by gender and location for the experimental group, results as presented in Table 3 and 4 show that during pretesting, the rural male students had the highest mean score (40.66). This is followed by the rural female students and urban male students, both of which tied at 36.54. The lowest pretest score was by the urban females 33.23, With regard to the post-test scores on SLS, the rural male students obtained the highest score (52.28). This score is followed by that of the rural female students (39.83). The urban male students followed by obtaining a score of 37.89 and the urban females obtained the lowest score of 34.85.

The rural males made the highest pretest to posttest change score (11.62). The second highest pretest to posttest change scores was obtained by [he rural female students (3.29). The urban female students came third with a change score of 1.62. The urban male students obtained the lowest pretest to posttest change score. This indicates that STS approach enhanced the level of SL among rural students than urban students.
Looking at the standard deviation scores, it would appear that whereas the rural male students obtained the highest pretest and posttest scores, they had a high variability in performance (4.41, 6.61, and 8.17 i.e. pretest, post-test gain respectively).

Table 5 Mean and Standard Deviation Scores of the Control Group (males) data by Location on SL.

	Mean		Standard	Deviation
	Urban	Rural	Urban	Rural
Pretest	38.45	41.04	3.83	2.26
Posttest	39.91	43.59	5.88	5.43
Gain	1.46	2.55	5.68	5.99

Table 6 Mean and Standard Deviation Scores of the Control Group (females) data by Location on SL.

	Mean		Standard	Deviation
	Urban	Rural	Urban	Rural
Pretest	35.40	37.77	4.31	5.26
Posttest	35.87	38.52	4.17	3.53
Gain	47	75	287	555

Results as shown in Tables 5 and 6 for the control group reveals these students to have achieved the highest pretest score. The urban males, rural females and urban females in that order followed them. During the posttest the same order of achievement was repeated. The gain scores also showed that the rural null the highest pretest to posttest score. They were followed by their urban counterparts, then the rural females and lastly, the urban females. The rural males of lowest standard deviation score during pretest and the rural females during the posttest. The lowest standard deviation for the gain score was obtained by the females. The result indicates that the urban females consistently scored very low on scientific literacy.

Research Question 2

To what extent did STS approach and the traditional instructional approach differentially affect students' achievement in physics by sex and location?

Data answering research question two are presented in Tables 7,8,9 and 10.

Table 7 Mean and Standard Deviation Scores of the Group (males) data by Location on PAT

	Mean		Standard Deviation	
	Urban	Rural	Rural	Urban
Pretest	12.32	12.79	12.79	1.4

Post-test	14.96	15.28	15.28	1.89
Gain	2.64	2.49	2.49	2.5

Table 8 Mean and Standard Deviation Scores of the Experimental Group (females) data and Location on PAT

	Mean		Standard Deviation	
	Urban	Rural	Urban	Rural
Pretest	12.60	13.15	1. 77	1.67
Posttest	13.44	16.07	1.31	1.46
Gain	.84	2.29	2.22	2.32

With regard to PAT, it can be seen from Tables 7 and 8 that the rural female subjects obtained the highest pretest score (13.15). The score of 12.79 obtained by their male counterparts follows this. The urban females came next with a score of 12.60 while their male counterparts obtained the lowest pretest score (12.32).

In respect of the posttest scores, again the female rural students obtained the highest score on PAT (16.07). This is followed by the score of 15.28 obtained by their male counterparts. The urban male subjects obtained the next higher score (14.96), while their female counterparts obtained the lowest score (13.44).

From the gain scores, the rural female subjects had the highest pre-test to posttest change score (2.29). The urban male students followed by a score of 2.64. The rural male students obtained a score (2.49) that is only higher than that of the urban female students (.84).

During the pretest the greatest variability as revealed by the standard deviation scores, was among the urban male subjects with a score of 2. This is followed by the variability among the urban female subjects with a score of 1.77. The variability among the rural female subjects (standard deviation score of 1.67) is greater than that among their male counterparts (standard deviation score of 1.4) but lower than that of the urban subjects. With regard to posttest variability, the rural males obtained the highest standard deviation score (1.98). The next was tint of the urban males (1.75). The rural female subjects variability followed (1.46). Their urban counterparts recorded the least variability as revealed by their standard deviation score of 1.31. It would appear from the above, that STS approach did very little for the achievement of urban female subjects. The contrary can be said of their rural counterparts.

Table 9 Mean and Standard Deviation Scores of the Control Group (males) data by Location on BAT

	Mean		Standard Deviation	
	Urban	Rural	Urban	Rural
Pretest	13.32	12.26	2.58	1.43
Posttest	15.58	13.33	1.66	1.64
Gain	2.26	1.07	2.08	2.01

Table 10 Mean and Standard Deviation Scores of the Control Group (females) data by Location on PAT

	Mean	Standard Deviation

	Urban	Rural	Urban	Rural
Pretest	13.00	12.53	1.85	1.98
Posttest	14.93	14.66	2.09	1.67
Gain	1.93	2.13	3.01	2.53

On physic achievement, the urban males obtained the highest pretest score. They were followed by the urban females, the rural females and the rural males in that order. The posttest scores followed the same pattern. However, the gain scores revealed that only the urban males surpassed the rural females in the scores.

Research Question 3

What aspect of scientific literacy (nature of science interaction of science, technology and society and basic physics concept-ceil; as tested in this study was better developed by the STS approach?

The variables are:

(a) Questions from Interaction of science, technology society

(b) Questions from Basic physics concept-floating of object

(c) Questions from Nature of science

The data are presented in Table 10. A three-response category was established (Realistic. Has Merit, and Naive). These were given point values of 3. 2, 1 respectively. Therefore any variable with a score of 2 or below is naive If the students' mean score on a variable is between 2.01 and 2.49, the view has merit while if the mean score is between 2.5 and 3 it is realistic.

Table 11 Mean and Standard Deviation Scores of the Experimental Group Data on Scientific Literacy Variables

	Mean			**Standard Deviation**		
Variable	Prefect	Posttest	Gain	Prefect	Posttest	Gain
Interaction of Science, Technology and Society	1.78	1.94	0.16	0.26	0.36	0.38
Basic Physics Concept	1.96	2.20	0.24	0.49	0.63	0.68
Nature of Science	1.64	1.89	0.25	0,34	0.45	0.53

With regard to the effect of STS approach on SL variables. Table 11 indicates that the lowest pretest score was for the nature of science (1,64). For STS interactions the pretest mean on SLS was 1.78. While the highest pretest score on SLS was for the basic physics concept (1.96), again for the post-test scores on SLS. The highest mean score of 2.2 was for the basic physics concept. The mean score of 1.94 for STS interactions follows this. The nature of science records the lowest mean score. Whereas the lowest pretest to posttest change score was obtained for STS interactions (0.16), the highest was obtained for the nature of science (0.25). The change score as revealed by the gain score for basic physics concept was 0.24. The lowest variability (0.26 and 0.36) was obtained for STS interactions. This is followed by the variability for the nature of science, while the highest variability (0.49 and 0.63) was obtained for the basic physics concept. The implication of the above mean and standard deviation scores is that instruction did very little lo improve students conception of STS interactions.

Test of the Null Hypotheses

Analysis of Covariance was used to test the significance of the difference between the mean scores in hypotheses 1-4. Regression analysis was used in test for causal relationship between SL and achievement in physics for hypothesis 4 and 5. All the F-values were tested at .05 level of significance. The covariant was involved in the analysis of variance for hypothesis 1 - 3 because interaction between the pretest and posttest is expected. The objective is to remove the influence of the covariant and involve all the data obtained from the study. This will control the variance in those dependent variables due to knowledge existing prior to instruction. Regression was used for null hypotheses 4 and 5, because these hypotheses seek to find out the relationship between scientific literacy and achievement in physics. It is expected that an adequate level of SL will influence achievement in the sciences positively. Regression will therefore show whether the level of SL affects students' achievement in physics.

Null Hypothesis 1

There is no significant difference in the mean scores of the experimental and control groups on SLS.

Results testing hypothesis one are presented in Table 15 below.

Table 12 Analysis of Covariance of Mean Scores on Scientific literacy Between the Experimental and Control Groups

Source of Variation	Sum of Square	DF	Mean. Square	F	Significance
Explained	2522.64	1	1261.31	36.161	S
Residual	8476.05	244	34.88		
Total	10998.68	245	44.89		

N=246, P<.05, Critical F =3.84

Since the obtained F value of 36 .16 is higher than the critical value of 3.84 at 1 and 244 degrees of freedom, the first null hypothesis of this study is rejected. This means that the observed difference in mean score on SLS between the experimental and control groups is significant. The residual (within group) sum of squares of 8476.05 is however much greater than the explained or between group sum of squares (2522.64) indicating that the difference may not be fully explained by treatment.

Null Hypothesis 2

There is no significant difference in the mean scores of the experimental and control groups on PAT.

The results of the ANCOVA for testing hypothesis two (HO_2) are presented in Table 16.

Table 13 Analysis of Covariance of Mean Scores on Achievement in Biology Between Experimental and Control Groups,

Source of Variation	**Sum of Square**	**DF**	**Mean Square**	**F**	**Significance**
Explained	88.47	1	44.23	13.07	S
Residual	822.37	244	3.38		
Total	910.84	245	3.72		

N = 246; P<.05; Critical F = 3.84

From Table 13, the obtained F-value of 13.07 is higher than the critical F-value of 3.84 at 1 and 244 degrees of freedom. The second null hypothesis of this study is therefore rejected as stated. The difference in mean scores of the experimental and control groups on PAT is significant.

Null Hypothesis 3

There is no significant difference in mean scores of males and females taught by the STS approach on SLS.

Result for testing hypothesis three (Ho_3) is presented in Table 14.

Table 14 ANCOVA of Mean Scores of the Experimental Group Between Males and Females on SL

Source of Variation	Sum of Squares	DF	Mean Square	F	Significance
Explained	2710.47	1	1355.23	34.11	S
Residual	5085.78	129	39.73		
Total	7796.24	130	59.97		

N = 131: P<.05; Critical F = 3.84

Since the obtained F-value of 34. II is higher than the critical F-value of 3.84 at 1 and 129 degrees of freedom, the null hypothesis is rejected as staled. The STS approach differentially affects the sexes on SL. This difference is in favour of the males.

Null Hypothesis 4

The level of scientific literacy among students did not influence their achievement in physics significantly.

The data for testing this research hypothesis are presented in Tables 15 and 16.

Table 15 Regression of Achievement in Biology on Scientific Literacy using Pretest Data

Multiple R -.03051
R Square .00093
Adjusted R Square -.00316
Standard Error 1.81325

Source of Variance	Sum of Squares	DF	Mean Square	F	Significance
Regression	.747	1 244	.747 3.288	.227	N.S
Residual	802.242				

N = 131, P<05,F = 3.84

From the regression analysis, obtained F-value at 1 and 244 degrees of freedom is .227. This value is lower than the table F-value showing that the level of scientific literacy does not influence the achievement of students in physics.

Therefore, the null hypothesis of no relationship is accepted as stated. The R square or coefficient of determination of .001 shows that SL cannot explain the variance in achievement in physics. The Extremely small regression sum of squares (0.75) lends credence to this as compared to the large residual sum of squares of 802.24.

Table 16 Regression of Achievement in Physics on Scientific Literacy Using Posttest Data

Multiple R .21185
R Square .04488

Adjusted R Square .03748
Standard Error 1.81571

Source of Variance	Sum of Squares	DF	Mean Square	F	Significance
Regression	19.98346	1	19.984 3.297	6.062	S
Residual	425.28601	129			

N-131,P<05,F^{1}-3.84

From the regression of achievement in physics on scientific literacy using posttest data, the F-value obtained (6.062) at 1 and 129 degrees of freedom is higher than the critical F-value of 3.84. The hypothesis is therefore rejected as stated. The R square or coefficient of determination of 0.045 shows that only about five percent of the variation in achievement in physics is explained by the level of scientific literacy-while ninety-five percent is due to unexplained sources. This is buttressed by the small regression sum of squares of 19.98 as compared to the large residual sum of squares of 425.29.

Whereas Table 15 shows no relationship, Table 16 shows a positive relationship albeit a very weak one. This implies that the relationship is mediated by another variable, which in this study is instruction. This caused the slope to rise from -0.03 to 0.21. The increase or decrease in achievement on physics as a result of 1 unit increase in scientific literacy is very marginal.

Null hypothesis 5

Teaching approach did not interact with scientific literacy to influence achievement in physics.

The result of the regression analysis is presented in Table 17.

Table 17 Regression of Achievement in Physics on Scientific Literacy with Instructional Approach

Multiple R .34615
R Square .11982 .
Adjusted R Square .11258
Standard Error 1.81637

Source of Variance	Sum of Squares	DF	Mean Square	F	Significance
Regression	109.13717	1	54.56859	16.54	S
Residual	801.70318	244	3.29919		

N = 246. P < 0.05, Critical F - 3.84

From the regression of achievement in physics on scientific literacy with instructional approach as presented in Table. 17 the obtained F-value of 16.54 is higher than the critical F-value of 3.84 at 1 and infinity degrees of freedom. The fifth null hypothesis of this study is therefore rejected as staled. The adjusted R squares of 0.112 show that scientific literacy and instruction together explain 11% of the variance of achievement in physics. The effects of the interaction between SL and instructional approach are statistically significant.

Discussion:

The findings of this work can be grouped under four broad areas: the effect of STS approach on different groups of physics students; the effect of STS approach on SL variables;

the efficacy of the STS approach was the traditional teaching approach and the relationship of Scientific literacy and achievement in physics.

The results show that the performance of the experimental group students differ by subgroup. By gender, the males performed better than the females on SL. This difference is significant going by the ANCOVA results testing it. The result showed that the STS approach fosters development of SL in favour of the males. Educators (Ziman, 1980; and Burns, 1997) had hoped that the use of an STS approach may aid females in the development of adequate levels of SL and improve their achievement and participation in science and technology. This is because science will be taught in context, which will take care of the gender issue. However, the results of the study suggest that males are still favoured by the STS approach. Noting that the experimental condition did not allow for teaching of science that begins with STS content, nor were STS methods tested, the hope that science using an STS approach will harmonize achievement of both sexes may not be categorically contradicted by this study. Bums' (1997) belief is that better participation and science literacy is based on the use of female friendly approaches.

In this study, it would seem that the STS approach harmonizes achievement of the two genders. Physics achievement has often deviated from the usual trend in other sciences as physics and chemistry where males have been demonstrated to achieve consistently higher than girls (Riis 1991). Since STS approach as used In this study harmonizes achievement of the genders, it may be worthwhile to test its effect on the genders in physics and chemistry.

Recommendations

The following recommendations are imperative from the results.

(1) Curriculum designers in Nigeria should identify important STS content for the Nigerian society and design curricula with an emphasis on STS physics content.
(2) Female friendly and compatible STS approaches, such as co-operate learning; discussions, group activities etc. should be identified for use in science classrooms to enhance participation of both genders in the sciences.
(3) Pre-service physics teacher curricula and training should emphasise the STS approach. Pre-service science teachers should also be made to take courses in the nature of science such as philosophy and sociology of physics science.
(4) Re-training should be done for already serving physics teachers.
(5) The government must also make concerted efforts at developing its industrial base so as to provide incentive for the study of science by students.

Conclusion

Conclusively, the following conclusions are drawn from the result of the study.

(1) The STS approach fosters development of scientific literacy in favour of males.
(2) STS approach harmonizes the achievement of both male and female in achievement in physics.
(3) STS approach, has a differential effect on scientific literacy and naive in physics in favour of rural students.
(4) In general, students' level of scientific literacy is low.
(5) STS approach aids development of an understanding of the nature of science more than STS interactions and basic physics concepts.

6) The STS approach does very little to influence adequacy of students' conception of STS interactions.
7) STS approach is better than the traditional approach in the development of SL and achievement in physics.
(8) STS approach interacts with gender and location in its effect on SL and achievement in physcis in favour of rural male; rural females: urban males and urban females in that order.
(9) The level of SL has no influence on achievement in biology.
(10) STS approach mediates between SL and achievement to produce a weak positive relationship.
(11) STS approach interacts with SL to influence achievement in physics.

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