Physics Process Skills and Its Acquisition on Secondary School Physics Students in Aguata and Nnewi Education Zones of Anambra State

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Abstract. This research work aimed at studying Physics process in skills and its acquisition by senior secondary students who wish to pursue Physics at Senior Secondary, the subject enables the students to participate in technology related studies in tertiary institutions. Many students opt out of Physics at the end of Senior Secondary level. Physics process skills are central to the acquisition of scientific knowledge which is useful in solving problems in society. Physics science as an integral part of science is known to be very important in a nation’s development. The process skills of physics are invaluable tools for learning physics, and the acquisition of these skills has therefore been greatly emphasized in recent times. However, the often reported poor performance of secondary school students in physics, especially in this research to ask whether secondary school physics students actually acquire and use physics process skills in their study of physics, and to what extent. This study, conducted in Anambra State of Nigeria, was intended to provide empirical evidence to answer these questions. It was further intended to determine how such factors as gender and school location affect students' acquisition of physics process skills. Fourteen (14) physics process skills identified from the National Curriculum for Science (Physics) as the most frequently' occurring skills, were studied. The design of the study was survey in which the researcher studied events as they are in their natural setting. Six research questions were posed and addressed while three hypotheses were formulated and tested at the 0.05 level of significance. A total sample of 756 SS three (3) physics students (514 Boys and 242 Girls) randomly drawn from both, urban and rural secondary schools in two education zones Aguata and Nnewi of Anambra State participated in the study. A Test of Physics Process Skill (TOPPS) designed by the researcher was the instrument used for gathering data. The data collected were analyzed using means and standard deviations for answering the research questions, while the analysis of variance (ANOVA) was used for testing the hypotheses. The major findings of this study are that: (i) the level of acquisition of physics process skills among Anambra State Secondary school physics students was generally low; (ii) gender is a significant factor ($p<.05$) in the students' level of acquisition of physics process skills, in favour of the male students; (iii) students located in urban schools were significantly superior ($p<0.5$) to their rural located counterparts in their acquisition of physics process skills; (iv) there was no significant interaction effect ($<.05$) between gender and school location in students' level of acquisition of physics process skills. A number of educational implications were pointed out and relevant recommendations made. Limitations of the study were noted and suggestions for further research made.

Keywords: Acquisition, Skill, Analysis, Variance, Instruments, Standard deviations, Urban, Design (Physics Process Skills)

1 INTRODUCTION

Since science process skills are central to the acquisition of scientific knowledge which is useful in solving problems in society, then science such as Physics has been viewed as an instrument that can aid development in many countries. It plays important and dominant roles in spearheading technological advancement, promoting national wealth, improving health, and accelerating industrialization (Validya, 2003). During the twentieth century, science through agricultural research ensured food security through the green, white and yellow revolutions.

Aided by genetic engineering, use of artificial fertilizers, and carefully executed irrigation systems, many developing countries benefited (Holt-Giménez. 2008). Sufficiency was ensured in cereals, wheat, leguminous plant seed, milk and dairy products outputs (Sreedharan, 2011)). This ability to feed mankind happened despite acquired longevity due to breakthroughs in medical care. This food security has not been enjoyed by many sub-Saharan African countries (Borlaug, 2000). Among the sciences, physics is considered a fundamental science subject (Wenham, Dorling, Snell & Taylor, 1984). It imbues learners with systematic thinking and supplies the theories necessary for understanding the mechanics of how the things mankind relies on work. It provides students with analytical, problem solving and quantitative skills which are important for many sciences. Physics prepares students to synthesize and analyze data and to present their findings in understandable formats. Systematization of the scientific problem solving technique is employed. The link between physics and other sciences is profound. It continues to expand tremendously in the contemporary world.

However, physics education has been undergoing a crisis. Enrolment in physics courses at all levels is low in many African countries. Reasons for this range from: inadequate lower level preparation, weak mathematics 'background, lack of job opportunity outside the teaching profession, inadequate teacher qualification as well as possession of below standard pedagogical content knowledge (Semela, 2010). Many students consider physics as lit abstract and theoretical (House of Lords, 2006). The subject is considered devoid of applications in the day life. Many students find the subject boring, unenjoyable (Hirschfeld, 2012). Interest in high school is decreasing, learning motivation is declining, and the examination results are getting worse (Garwin & Ramsier 2003). In many school settings, little time is allotted for the discipline compared to language and mathematics, the other important subjects (Tesfaye & White, 2012; UNESCO, 2010).

Practical work may be considered as engaging the learner in observing or manipulating real or virtual objects and materials (Millar, 2004). Appropriate practical work physics enhances pupils' experiences, understanding, skills and enjoyment of physics. Practical work enables the physics students to think and act in a scientific manner. The scientific method is thus emphasized. Practical work induces scientific attitudes, develops problem solving skills and improves conceptual understanding (Tamir, 1991). Practical work in physics helps develop familiarity with apparatus, instruments and equipment. Manipulative skills are acquired by the physics learners. Expertise is developed for reading all manner of scales. The observations made and results obtained are used to gain understanding of physics concepts. Science process skills, necessary for the world of work are systematically developed (Manjit Ranesh & Selvanathan 2003). Firsthand knowledge is generated. Abstract ideas can be concretized. Naïve, neonate and scientifically primitive ideas can be challenged (Osborne, 2002). Tacit knowledge of scientific phenomena can be gained (Collins, 2001). Practical work creates motivation and interest for learning physics. Students tend to learn better in activity based courses where they can manipulate equipment and apparatus to gain insight in the content. Millar (1998) has suggested that practical work should be viewed as the mechanism by which materials and equipment are carefully and critically brought together to persuade the physics learner about the veracity and validity of the scientific world view.

If practiced in the right manner from the early secondary school period, critical thinking skills can be attained, from practical work in physics. Practical work puts the physics students at the center of learning where they can participate in, rather be told about physics. In this way the desire and eagerness to know more about what the subject can offer is developed.

It is worth noting that for science physics teaching to be meaningful and relevant, it must adequately reflect the nature of physics. That is, it must not only be process-oriented, but it should also emphasize the products of physics. It should also promote effective reaction to physics and stress the attitudes such as – honesty, open and critical mindedness, curiosity, suspended judgment and humility" which characterized scientists and the scientific enterprises. Science process skills have been described as mental and physical abilities and competencies which serve as tools needed for the effective study of science and technology as well as problem solving, individual and societal development (Okeke, 1989). The American Association for the Advancement of Science (AAAS) classified the science process skills into fifteen (Amabo, 2000). These are: observing, measuring, classifying, communicating, predicting, inferring, using dumber, using space/time relationship, questioning, controlling variables, hypothesizing, defining operationally, formulating models, designing experiment and interpreting data. According to the Nigerian Educational Research Council 1990), science process skills can be classified into two categories as basic and integrated process skills. The basic (simpler) process skill provide a foundation for learning the integrated (more complex) skills. Basic science processes are vital for physics learning and concept formation at the primary and junior secondary school levels. More difficult and integrated science process skills are more appropriate at the secondary and tertiary school levels for the formation of models, experimenting and differencing. Hence both basic and integrated science process skills are relevant and appropriate at the senior secondary schools level in Nigeria. According to Nigerian Educational Research Council, 1990), the basic science process skills comprised of observing, measuring, classifying, communicating, inferring, using number, using space/time relationship and questioning while integrated science process skills are controlling and manipulating variable, hypothesizing, defining operationally, formulating models, designing experiment and interpreting data. Physics practical skills are science process skills. They are taught as part and parcel of the physics curriculum. Science process skills are cognitive and psychomotor skills employed in problem solving. They are the skills which sciences use in problem-identification, objective inquiry, data gathering transformation, interpretation and communication. Science process skills can be acquired and developed through training such-as are involved in science practical activities. They are the aspect of science learning which is retained after cognitive knowledge has been forgotten. Using science process skills is an important indicator of transfer of knowledge which is necessary for problem-solving and functional living. The skills on the physics graph practical work cannot be completed without creativity.

The federal government in 1982 introduced a 60:40 ratio of university admission policy in favour of the sciences over the arts. To further emphasize the importance of science educators, physics educators have continued to develop new curricula materials in science as well as evolve new teaching/learning strategies to facilitate more meaningful teaching and learning of science in their schools. Science processes skills are generalizable intellectual skills needed to learn the concepts and broad principles used in making valid inductive influences (Gane, 1970). Science process skills as defined by the American Association for the Advancement of Science (AAAS), are a set of broadly transferable abilities, appropriate to many science disciplines and reflective of the true behavior of scientists. These skills transfer to other curriculum areas and children who have learned them think analytically and are more successful with new problems. There are fifteen items as skills as listed by the AAAS.

Observing, Classifying, Counting, Measuring, Communicating, Formulating hypothesis, Making Operational definitions, Using numbers, Recognizing spatial relations, Formulating models, Predicting, Identifying and Controlling variables, Interpreting Data, Experimenting, Inferring.

The above listed process skills of science in general have either been expanded or condensed by different physics educators, educational agencies or curriculum experts. The Nigerian Educational Research Council (NERC) science panel, for instance, adopted a slightly modified version of the above AAAS list. Although this investigation deals with the science process skills, and how they relate to physics, there is not much difference between science process skill and physics process skills. For instance, Ali (1981) explained that process skills for physics are not vastly or fundamentally different from those listed above except that for physics their operation are more specific and therefore more easily identifiable when used.

Science educators have continued to stress the importance of the process skills in learning science. The skills as enumerated by the American Association for the Advancement of Science (AAAS) and modified by the Nigerian Educational Research Council (NERC) Gagne (1970) argued that the pre-requisite knowledge of science concepts and principles can be obtained only if the students have certain underlying capabilities- science processes, which are needed to practice and understand science.

Neil (1972) in his contribution agreed that the development of science process skills in children is the major objective of science education.

The objective of both the primary and post primary school curricula has also stressed the acquisition of these skills. For example, the general objectives for teaching science in Nigeria Primary Schools as stated in the Core Curriculum for Primary Science (F.M.E., 1980) stated among others that, given the opportunity, Science Education should enable the Nigerian child to:

i. observe and explore the environment;
ii. develop basic science process skills including observing, manipulating, classifying, communicating, inferring, hypothesizing, interpreting data and formulating models;
iii. apply the skills and knowledge gained in science to solving everyday problems in his environment.

Similarly, the National Curriculum (F.M.E., 1985) stated that the objectives for Integrated Science are aimed at enabling the child who is exposed to it acquire the following skills:

(i) observing carefully and thoroughly;
(ii) reporting completely and accurately what is observed;
(iii) organising information acquired;
(iv) generalising on the basis of acquired information;
(v) predicting as a result of generalization;
(vi) designing experiments (including controls where necessary) to check predictions;
(vii) using models to explain phenomena where appropriate,
(viii) continuing the process of inquiry when new data do not conform to prediction.

All these emphasize the importance of process skills in learning In seeking to improve the teaching of science, the AAAS had outlined certain attributes, which are characteristics of the scientific enterprise. According to Nwona (1982), the AAAS sold the idea that "It will be more economical to import these attributes than to seek or hope to impart all the facts and figures that have resulted from scientific research". These attributes are the science process skills, and they apply to scientific activity at all levels of education.

It would appear therefore, that these process skills assist the individual not just to gather information but to process this information for effective living.

Campbell and Okey (1977) supported this view and added that these skills learnt in science transfer to other curriculum areas. They saw the science process skills as "the methods of collecting, analyzing and acting upon information used in solving problems" and argued that the major activities in analyzing any data involve classification, inference, prediction, verification and hypothesis formulation.

Since the AAAS published its list of these, the science educators and curriculum experts have modified them by either expanding or condensing them to suit their special needs or expectations.

The process skills may be classified into two types; basic and integrated as follows:

(a) Basic science process skills

1) observation; 2) classification; 3) communication; 4) measuring; 5) using spatial relations; 6) using numbers; 7) inferring and predicting.

(b) Integrated Science Process Skills

(1) controlling variables; (2) interpreting data; (3) formulating hypothesis; (4) defining operation; (5) experimenting;

Those classified as basic by AAAS according to Young (1974) provide foundation for learning the more complex integrated skills. Finely I983) contended that the skills are hierarchically organized from simple to complex ones in such a way that the ability to use each upper level process is dependent on the ability to use the simpler underlying process. He concluded therefore, that the skill of observation is the most fundamental skill and is at the foundation of the hierarchy of skills while the other more complex skills like experimentally are to the top. For example one has to possess the skill of observation before going on measuring, etc.

Adey and Harlen (1986) defined process skills as the processing strategies that a person brings to bear in solving a problem. Some skills they argued make cognitive than others.

Physics as one of the subjects taught at the senior secondary schools consists of two complimentary components: a theoretical component and a practical component. The theoretical component involves cognitive teaching/learning of ideas, concepts, theories, laws of the subject. The practical component involves undertaking activities (usually hand-on use/manipulation of equipment, tools, etc.). Ali and Aigbomian (1993) have noted that the major purpose of such activities is to establish a basis for explaining/understanding physics phenomena. They noted that such activities could be practical work in the laboratory demonstration of some physics concepts by the teacher or students, field work, special project and so on. Such activities in physics when undertaken by students enable them acquire, to acquire, sustain and or enhance physics process skills.

A process skill is the demonstration of a clearly defined competence needed to bring about changes toward a certain result or expectations. For physics, therefore, such demonstration of competence is within this subject area. This definition is in line with that one earlier made by Ali and Aigbomian (1983). Physics Processes Skills can also be defined as the physical practices which are undertaken in physics, through clearly defined procedures is with the ultimate intention of enabling the learner to understand and appreciate the laws of physics.

The Science Teachers Handbook (1988) published by-the Science Teachers Association of Nigeria (STAN) observed that the processes and skills of science can be useful employed in children's everyday activities. it helps children to observe and recognize the importance of asking for, obtaining and testing evidence before drawing conclusions. It also helps them to appreciate the value of trying things out practically, by the way of experiments.

The importance of process skills is further stressed by Gardiner (1980) who referred to them as "tools for problem solving". He argued that although it is necessary to accumulate past information, what is even more necessary is the skill to process such information.
By Finely's (1983) description, the science (physics) process skills have the following characteristics.

- each process is a specific skills used by all scientists and applicable to understanding any phenomena;
- each process is an identifiable behaviour of scientists that can be learned by students,
- the process skills are generalizable (transferable) across content domain and contribute to rational thinking in everyday affairs.

It can be seen that the possession of these skills is important not only for the student, but also for the teacher. Finely (1983) stated some reasons why these skills are important to both. The process skills, according to him, are important because:

(a) they are the foundations for learning science especially physics and making valid inductive inference;
(b) they can be used to sort out information from accumulated facts;
(c) by using them, the individual learns the heuristics of learning, i.e. he learns how to learn.

These skills therefore, contribute to the development of other skills, and as a toll for processing information, they help the child to explore the environment and apply them to other areas of life. A teacher who possesses such skills will therefore be a confident teacher, as he will be more capable of assisting his students.

Having seen the importance of the physics process skills in the teaching and learning of science to both the teacher and the learner, the question of how these skills can be best imparted, is more or less a vexing one. Since emphasis has changed from content to processes of physics, this change should also be reflected in both the curriculum and in teaching strategies. The recent changes in curriculum with a consequent shift from content to processes of physics, have resulted in particular changes also in instructional techniques. Thus, the status of the physics student has changed from that of a passive receiver of information to that of an active participant in the physics teaching/learning process.

Physics educators have advocated the use of methods which involves children in hand's-on activities. Such methods as constructivism, discovery and inquiry are being stressed. Blough and Schorz (1964) observed that children are by nature are investigators, they have tendencies to manipulate materials and are serious to find out what happens. Harlen (1987) agreed that the process skills can best be developed through the inquiry mode of instruction and advocated that children should be encouraged to learn things in their environment by manipulating, observing and finding answers as it helps them think for themselves.

Abdullahi (1981) asserted that the need for changes in science teaching methods may have become necessary due to the shift from product-oriented to process-based science curricula, changes which, he argues, have brought about a gradual shift in educational objectives from imparting knowledge to processes of learning through individual investigation. Ali (1983) agreed with this view and added that theories of science and science teaching have evidenced a variety of modification. He therefore suggested that science teaching/learning processes be geared towards "problem solving".

Though evidence is not conclusive, some research results (Ali, 1983) seem to suggest that discovery and other hands-one activity methods, significantly aid children's development of science process skills. As a result of the shift from content-oriented to process-oriented curricula now being adopted in most part of the world, methods of teaching are also changing. Greater emphasis is now being placed on science teaching methods which involve the children in plenty of activities-both mental and manipulative. Results of some investigations

Ali (1984) Amabo (2000) etc, tend to support the view that these activity-oriented methods may be more effective in teaching the process skills of physics.

Physics is taught at the senior secondary school level, that is, from the first to the third year of the senior secondary course. There are two components of physics, the theory and the practical. The practical component consists essentially of process skills. Physics examination syllabus is prepared by the West African Examinations Council (WAEC) which also handles all the aspects of the final examination at the end of the senior secondary course. The textual materials for the teaching of different subjects are prepared by other educational agencies.
Process skills form an integral part of school certificate physics practicals. This is seldom done in schools; hence many pupils do not enroll in it.

There is evidence however of very low enrolment in physics at the secondary school level. In 1987, a National workshop on the development of basic science was held at the University of Nigeria, Nsukka where it was observed that over the years, there had been a fall in the quality and substantial number of candidates offering to study physics. Ndili (1987) observed an alarming and sharp decrease in the number of adequately qualified and sufficiently motivated young people available and willing to study physics in tertiary institutions. He also noted that a crisis situation had manifested, in a number of ways, including low student enrolment in physics, shortage of qualified physics teachers and low achievement in physics, in schools. Aminu (1989) remarked that pass rates in physics are so abysmally low that one wonders whether the average youth is grasping even the most basic principles of science.

It will assist them to make adjustment if and where necessary in order to obtain expected results and achieve stated objectives. Furthermore, there is also the need to determine whether such factors as gender or school location have any effect on students' level of acquisition of physic process skills.

Statement of Problem

To what extent do secondary school physics students in Anambra State possess and demonstrate the process skills of physics. A secondary problem investigated in this study is how gender and school location influence students' acquisition of these skills.

Purpose of Study

The purpose of this study was to determine the extent to which Secondary school physics students possess and demonstrate the process skills of physics and how such factors as gender and school location affect students' acquisition of these skills.
Specifically, the study sought to:

1. determine the extent to "which secondary school physics students possess and demonstrate the process skills of physics;
2. ascertain the extent to which gender influences secondary school physics students' acquisition of physics process skills;
3. ascertain the extent to which school location influences secondary school physics students acquisition of physics process skills.

Significance of Study

Physics process skills at the secondary school level, serve as mental and psychomotor behaviours which secondary school physics students use to acquire the understanding of ideas, principles and practices in the physics topics they are taught.

Owing to the importance of physics process skills the physics curricula developed in 1980 by the relevant Federal Government agencies, emphasized activities as a means of learning physics concepts, laws, principles and ideas.

It is against this background that the significance of this study needs to be discussed as follows:

1. This study is considered significant because it provides empirical data on how well or otherwise physics students had acquired physics process skills. Such data can be used by physics curricular experts, science teachers associations for senior secondary school physics curricular renewal/formation development and upgrading.
2. Furthermore, such data when made available to secondary schools physics teachers are expected to enable them reappraise their teaching strategies for greater effectiveness in imparting those physics process skills students were found deficient in.
3. Evidence obtained from the study would most probably assist educational planners in formulating policies and initiating actions which are most likely to improve the level of teaching and learning of physics in secondary schools. Thus the research findings of this study will be published to the above audience which will most probably find them useful.

A knowledge of factors which affect students' acquisition of physics process skills is useful to the physics teacher and other science educators.

This is because knowledge of these factors could then be addressed prior to the teaching and learning of secondary school physics, especially in terms of what has to be done by physics teachers and or physics students prior to teaching.

Research Questions

In order to investigate the problem of this study, the following research questions were posed to guide the study

1. What is the students’ mean score in the Test of Physics Process Skills (TOPPS)?
2. To what extent does students’ mean score in Test of physics process skill depend on their gender?
3. What is the effect of school location on students mean score in Test of physics process skills?
4. What proportion (%) of the students acquired each of the physics process skills?
5. What proportion (%) of male and female students acquired each of the physics process skills?
6. To what extent does the proportion (%) of students who acquired each of the physics process skills depend on school location?

Hypotheses

The following null hypotheses designed to enable the investigation of the problem of this study were tested:

1. There is no significant difference ($P \leq 05$) between the male and female students mean achievement score on a Test of Physics Process Skills (TOPPS);
2. There is no significant difference ($P \leq 05$) between urban and rural students mean achievement scores on a Test of Physics Process Skills (TOPPS);
3. There is no significant interaction effect, ($P \leq .05$) of gender and school location on students mean scores in a Test of Physics Process Skills (TOPPS).

Scope of Study

This research is mainly concerned with the determination of the acquisition of physics process skills among Senior Secondary schools (SSIII) physics students drawn from

Secondary Schools in Anambra State and how such factors as gender and school location affect the acquisition of these skills. The following fourteen physic process skills were selected: measuring; manipulating instruments; observing; following procedures; recording data; reading measuring instruments; mathematical computation; tabulating data; plotting graphs; interpreting graphs; taking appropriate precautions; predicting; drawing accurate conclusions and identifying variables.

The fourteen physics process skills were selected because a study showed that they were the most frequently occurring skills in the "activity" section of National Curriculum for Senior Secondary Schools (Physics).

The choice of Senior Secondary (SS III) students was informed by the fact that this category of students, having had up to two years of physics, were considered to have at this time, had sufficient exposure in physics as to possess physics process skills.

Among factors that could influence students' acquisition of physics process skills are gender level of intellectual development of learner, teaching methods, school location and availability of physics equipment and material. Only the factors of gender and school location were studied. The reason for this is that results of research on the influence of these two factors on students' acquisition of physics process skills appear to be inconsistent and inconclusive.

METHODOLOGY

Design of the Study

The design of this study is a survey. It is a survey because it is concerned with investigating (identifying, interpreting and describing) events in their most natural settings and without manipulating any variables, According to Ali (1992) a survey is a study which seeks to document and describe what exists or the present status of existence or absence of what is being investigated. The study determined a naturally existing phenomenon which in this case is the level of physics process skills –acquired and demonstrated by the research sample.

Also, according to Nworgu (1988), Survey studies aim at collecting data on and describing in a systematic manner, the characteristic features or facts about a given population. The researcher developed and used an instrument to collect and describe observed data on the level of acquisition of process skills in physics among a sample of senior secondary school physics students. The researcher did not manipulate any variable in an effort to determine the level of acquisition of process skills by the senior secondary school physics students’ sample of the subjects.

Survey design was deemed appropriate for this study partly because it has been successfully used by other research workers who carried out studies similar to the present study, hence the researcher decided to use the survey research design for this study.

Area of study

The study was carried out in Anambra State of Nigeria. Currently, there are six education zones in Anambra State, namely Aguata, Awka, Onitsha, Nnewi, Ogidi and Otuocha. A preliminary study shows that schools are located in both urban and rural areas of the six zones and are distributed almost evenly in the six zone. The study is limited to only two if these zones, namely; Aguata and Nnewi. The choice of the two zones was by simple random sampling.

Population

The population of this study comprised of all the 4621 senior secondary three (SS III) students in ail the urban and rural located senior secondary schools enrolled in physics in Aguata and Onitsha education zones of Anambra State. The researcher used senior secondary III students and senior secondary II (SS II) physics students, because, SS III students who are in the senior school certificate examination class were deemed to have had sufficiently adequate exposure to secondary school physics (more than either SS I or SS II) to warrant their being tested on the levels of their acquisition of physics process skills.

There were one thousand and ninety-seven (1,097) physics students registered for physics in the fifty-six (56) secondary schools in the two zones in the 2015/2016 session when this study was conducted.

Sample and Sampling Technique

The sample used in this study consisted of seven hundred and fifty-six (756) physics students drawn from forty-two (42) out of the eighty-eight (56) secondary schools in Aguata and Nnewi Education zones, who registered students for physics. Five hundred and fourteen (514) of these students are males while two hundred and forty-two (242) are females Four hundred and sixty-eight (468) of them are from schools in urban locations while two Hundred and eighty-eight (288) are in rural located Secondary schools. Table I shows the distribution of sampled schools by gender and school location, while Table II shows the distribution of students by gender and school location.

The stratified random sampling technique was used initially to compose the secondary school sample of the study. Schools were stratified on the basis of:-

a) School type: all males, all females and coeducational;
b) School location: urban and rural.

Table 1: Distribution of Sampled School by Gender and School

GENDER	SCHOOL LOCATION		
	Urban	Rural	Total
All-Male	5	4	9
All-Female	4	3	7
Coeducational	16	10	26
Total	25	17	42

Table 2: Distribution of Students by Gender and School Location

GENDER	SCHOOL LOCATION		
	Urban	Rural	Total
Male	320	194	514
Female	148	94	242
Total	468	288	756

After identifying the schools which registered students for physics in May/June Senior School Certificate Examination, the schools were grouped into two - urban and rural located schools. This is to ensure the students from both locations were represented in the study. The schools in each location were then sub-grouped into three; - all male, all female, co-educational. Random samples were then drawn from each of these sub-groups. All the SS 111 physics students in school samples drawn from the different groups were considered the sample of this study; altogether they were 756 such students.

By using this technique in composing the sample on the basis of school type and school location, categories, the researcher was able to ensure that the randomly composed sample represented the defined group in the population from which it was drawn, and that every SS III physics student in the two education zones under study in Anambra State Secondary Schools had an equal and fair chance of participating in the study.

Instrument for Data Collection

Two instruments were used for collection of data pertinent to this study. They are:

(i) The Test of Physics Process Skills (TOPPS) and

(ii) The Physics Process Skill Observation Checklist (PPSOG).

Both instruments were developed by the researcher The TOPPS was for testing the possession of the physics process skills while the PPSOC was designed for checking of the skills observed to be possessed and demonstrated.

The TOPPS is made up of two sections. Section A is a practical skills test consisting of one practical experiment which each subject is expected to set up, perform and obtain data and for answering questions. The practical skills test assessed the possession of the first six listed physics process skills which are directly observable namely; (1) measuring; (2) manipulating instruments; (3) observing; (4) following procedures; (5) collecting/recording data; and (6) reading instruments correctly.

Section B of TOPPS consists of open-ended, short answer questions based on the practical experiment. Responses to these questions serve as indicators to possession or non-possession of the remaining eight listed process skills, namely: (1) tabulating data; (2) mathematical computations; (3) plotting graphs; (4) interpreting graphs; (5) taking appropriate precautions; (6) identifying variables: (7) predicting; and (8) drawing accurate conclusions.

The process skill observation checklist is designed for use in checking off the skills observed to have been performed.

Research assistants were trained by the researcher on the use of the checklist which carries appropriate behavior indicators of the possession of each skill. When any of the skills was exhibited, the observe ticks off the appropriate column. In this way, only those skills which were observed to have been exhibited by a student were ticked, while the second part was for checking off the 8 process sills (on the list, but) which are not directly observable but the possessing of which can be demonstrated in the answers to the questions following the experiment.

Method of Data Collection

After composing the sample of respondents, the researched again undertook a familiarization trip to the schools to confirm that they were still willing to release their SS III students to participate in the study.

The researcher trained thirty-five (35) science teachers drawn from the schools used for the study, as his research assistants. This was to enable them effectively use the physics process skills checklist - one of the instruments for data collection.

The training consisted, among others, of:

i) explanations ;on how to observe each student while carrying out the practical aspect of the test;
ii) drill on how to recognize when a specific process skill has been exhibited by a subject and to correctly check it off on the check list.

The Physics process skills checklist consisted of a list of:

i) the specific behaviour indicating possessing of a particular process skill
ii) the physics skills under study;

iii) a space for checking off when each skills has been exhibited on time limit for checking off each skill.

The students were directly observed as they performed the practical lest, and by using the checklist, the skills exhibited by each subject were ticked off. The first six process skills listed, were directly observable skills, while data for the rest were obtained from the written test.

Validation of the Instrument

The first draft of TOPPS was subjected to face validation by five experienced secondary school physics teachers in Anambra State, two senior lecturers in physics at the Chukwuemeka Odumegwu Ojukwu University, five experts in measurement and evaluation and a Chief Technologist. Thus by expanding and spreading the sources of face validation of the instrument, a more diverse and extensive input into the test was achieved. The purpose of the face -validation of TOPPS was to produce an instrument deemed appropriate, useful and relevant for investigating the problem of the study.

The comments, suggestions, criticisms, and so on made independently by the face-validators were reflected in the second draft of the (Instruments which was then subjected to field trial.

For instance, each face validator was expected to rate the (appropriateness of each item, as a physics process skills at the secondary school level vis-a-vis the physics curriculum. Based on the rating, any item which received less than 60% of being appropriate was dropped. Only those items which were highly rated by all the respondents as being appropriate were included in the second draft of TOPPS. The field validation of TOPPS was carried out in Anambra State. The researcher administered the second draft of TOPPS to one hundred and thirty-seven (137) SS III students in Aguata and Nnewi Education zones outside the zone of the study of Anambra State secondary schools (eighty-three - 83) students in urban located schools and fifty-four (54) in rural located schools) and" 'used their scores in establishing the reliability co-efficient of the instrument.

Reliability of the Instrument

The test-retest reliability technique using the same Anambra state students as applicable to criterion referenced testing was used in determining the reliability co-efficient. The re-testing interval was three weeks and this was deemed an appropriate timing so as to minimize transfer effects of testing and re-testing over a short period or the masked effect of regression arising from over-extending test-retest interval. The correlation co-efficient of the test was 0.87. Thus the TOPPS was considered to have a high internal consistency.

Data Analysis

The data obtained in this study were analyzed through the following procedure:

(a) computation of means, standard deviation and percentages for answering-the research questions;

(b) two-way analysts of variance (ANOVA) for testing the three hypotheses. The data were tabulated and described on the basis of the respective research -questions and hypotheses. Thus, each research question or hypothesis was discussed completely before the next one was handled.

RESULTS

The analyses were focused on answering the respective research questions and testing the formulated hypotheses which have been stated in this study.

The mean score of all the students in TOPPS was obtained similarly the mean scores of each sub-group; boys students, girls students, urban located and rural located students, urban boys and urban girls students; rural boys and rural girls students were obtained. All these were aimed at answering the research questions and testing hypotheses.

Research Question One:

What is the students' mean score in the Test of Physics Process Skills. (TOPPS)?
Table 3 below was used to answer the above research question:

Table 3: Mean and Standard Deviation of Students Scores in the Test of Physics Process Skills

Group	Number of students	Mean score	Standard Deviation
All students	756	(34.6%)	2.02
Male students	514	(36.1%)	1.97
Female students	242	(31.4%)	2.07
Students in urban locations	468	(37.1%)	2.00
Students in rural locations	288	(30.4%)	1.92
Male students in urban locations	320	(38.1%)	1.89
Female students in urban locations	148	(35.1%)	2.16
Male students in rural locations	194	(32.8%)	1.99
Female students in rural locations	94	(25.3%)	1.61

From the table it can be seen that the students have an overall mean score of 34.6% with a standard deviation of 2.02 in the Test of Physics Process Skills (TOPPS).

The male students had a mean score of 36.1% with a standard deviation of 1.97 while their female counterparts had a mean score of 31.4% and a standard deviation of 2.07, showing that the male students had a higher mean score than the female students. Students in urban locations had a mean score of 37.1% with a standard deviation of 2.00 while their counterparts in the rural location had a mean score of 30.4 and a standard deviation of 1.92. This also shows that the students in urban locations had a higher mean score than their rural counterparts.

A further examination of the table reveals that male students in urban locations had a mean score of 38.1% which is superior to their female counterparts of 35.1%. The standard deviation scores for the urban male and urban female students are 1.89 and 2.16 respectively. Male students in rural locations had a mean score of 32.8% with standard deviation of 1.99 while their female counterparts had a mean score of 25.3% and standard deviation of 1.61.

Research Question Two:

To what extent does students' mean score in Test of Physics Process Skills (TOPPS) depend on their gender?
This research question was answered using Table 4.

Table 4: The Z-Test of Difference Between the Mean Scores of Male and Female Students in TOPPS

Group	No	$\overline{X}$	SD	Mean Difference	Z-Cal	Z-Crit	Decision
Male	(51.4	36.1	1.97	0.66	4.18	1.96	Sign.
Female	(24.2)	31.4	2.07	0.66	4.18	1.96	Sign.

Table 4 shows the mean standard deviation (SD) of students in TOPPS, it reveals that the male students had a higher mean score of 5.05 (or 36.07%) with a standard deviation of 1.97, while their female counterparts had a mean score of 4.39 or (31.36%) with standard deviation of 2.07. Thus the male students had a higher mean score on TOPPS than their female counterparts.

The mean score of male and female students were further subjected to a test, to determine whether there was a statistically significant difference between them. The result of this test is shown in table 4 above.

Table 4 reveals a difference of 0.66 between the mean scores of male and female students in favour of the males and a calculated Z-score of 4.18 against a critical value of 1.96 at the 0.05 level of significance.

Since the calculated value of the Z-score is greater than the critical value at the stated level of significance. It means that there is a significant difference between the mean score in TOPPS of male and female students. Since the difference in the mean scores of both groups is in favour of the mean students, it shows that the mean score of the male students is significantly higher than that of the female students.

Research Question Three

What is the effect of school location on student's mean score in a Test of Physics Process Skills?

The data used for answering research question three are shown in table 5.

Table 5: The Z-Test of Difference Between the Mean Scores of Urban and Rural Located Students in TOPPS

Group	No	$\bar{X}$	SD	Mean Difference	Z-Cal	Z-Crit	Decision
Male	51.4	36.1	1.97	0.66	4.18	1.96	Sign.
Female	288	31.4	2.07	0.66	4.18	1.96	Sign.

From table 5 there is a difference of 0.94 in the mean scores of urban and rural students. This difference is in favour of urban students. The table further shows a calculated Z-score of value 6.49 band a critical value 1.96 at the 5% level of significance. The calculated value of the Z-score is greater than the critical value at the stated level of significance.

The means that there is a significant difference between the mean scores of urban and rural students in TOPPS. Since the urban students had a higher mean score than their rural counterparts, this shows that urban students performed significantly better than the rural students in TOPPS.

Research Question Four

What proportion of students acquired each of the Physics Process Skills?

This research question was answered using table 6 shown below.

The data for answering this research question are shown in tables 8 and 9. While table 8 shows the proportion of students in urban and rural schools who acquired each skill, table 9 shows the result of a Z-test of difference between the proportion of students in urban and rural located schools who acquired each physics process skill.

Table 6: Proportion (%) of Students Acquiring each of the Physics Process Skills

Physics Process Skill		Proportion(%) of students who acquired each of the Physics Process Skills	
		Number N	Proportion (%)
1.	Measuring	225	29.8
2.	Manipulating Instruments	235	31.1
3.	Observing	288	38.1
4.	Following Procedure	227	30.0
5.	Recording Data	256	33.9
6.	Reading Measuring Instruments	250	33.1
7.	Mathematical Computation	77	10.2
8.	Tabulating Data	191	25.3
9.	Plotting Graphs	175	23.1
10.	Interpreting Graphs	120	15.9
11.	Taking Appropriate Precautions	54	7.1
12.	Identifying Variables	91	12.0
13	Predicting	88	11.6
14.	Drawing Accurate Conclusions	85	11.2

The information in table 6 shows that the proportion of students who acquired each of the physics process skills ranged from as low as 7.1% (i.e. 54 students out 756) for the skill of taking appropriate precautions to 38 .1%. Thus the highest proportion of students (38.1% acquired the skills of observing while the lowest proportion of 7.1% or 54 out of 756 acquired the skill of taking appropriate precautions.

Research Question Five

What proportion of male and female students acquired each of the Physics Process Skills? This research question was answered using data on table 7 below.

Table 7: Proportion of Male and Female Students who Acquired the Physics Process Skills

Physics process Skills		Proportion (%) of male students who acquired the Physics Process Skills		Proportion of female students who acquired the Physics Process Skills	
		Number N	Proportion (%)	Number N	Proportion (%)
1	Measuring	154	20.4	71	9.4
2	Manipulating Instrument	165	21.8	70	9.3
3.	Observing	188	24.9	100	13.2
4.	Following Procedure	148	19.3	81	10.7
5	Recording Data	151	20.0	105	13.9
6.	Reading Measuring instrument	180	23.8	70	9.3
7	Mathematical computation	62	8.2	15	2.0
8.	Tabulating Data	128	16.9	63	8.3
9.	Plotting graphs	100	13.2	75	9.9

10	Interpreting graphs	92	12.2	28	3.7
11	Taking appropriate precautions	42	5.6	12	1.6
12	Identifying variables	57	7.5	34	4.5
13	Predicting	63	8.3	25	3.3
14	Drawing Accurate Conclusions	72	9.5	21	1.7

An examination of table 7 above reveals that the proportion of male students who acquired the physics process skills ranged from 5.6% in taking appropriate precautions to 24.9% in observing. For female students, the proportion who acquired the skills ranged from 12.6% for taking appropriate precautions to 13.9% in recording data.
The table further reveals that for each physics process skill, the proportion of male students who acquired it was greater than the proportion of female students who acquired that same skill.
However, for both male and female students, the proportion of students who acquired each skill was less than 30%.

Research Question Six:

To what extent does the proportion (%) of students who acquired each of the Physics Process Skills depend on school location?
The data for answering this research question are shown in tables 8 and 9 while table 8 shows the proportion of students in urban and rural schools who acquired each skill, table 9 shows the result of a Z-test of difference between the proportion of students in urban and rural located schools who acquired each physics process skill.

Table 8: Proportion (%) of Students in Urban and Rural Located Schools Who Acquired the Physics Process Skills

	Physics Process Skills	Proportion (%) of male students who acquired the Physics Process Skills		Proportion of female students who acquired the Physics Process Skills	
		Number N	Proportion (%)	Number N	Proportion (%)
1	Measuring	149	19.7	76	10.1
2	Manipulating Instrument	189	25.0	46	6.1
3.	Observing	158	20.9	130	17.2
4.	Following Procedure	151	20.0	76	10.0
5	Recording Data	152	20.1	104	13.8
6.	Reading Measuring instrument	192	25.4	58	7.7
7	Mathematical computation	64	8.5	13	1.7
8.	Tabulating Data	146	19.3	45	5.9
9.	Plotting graphs	125	16.5	50	6.6
10	Interpreting graphs	87	11.5	33	4.4
11	Taking appropriate precautions	41	5.4	13	1.7
12	Identifying variables	66	8.7	25	3.3
13	Predicting	60	7.9	28	3.7
14	Drawing Accurate Conclusions	65	8.6	20	2.6

	Physics process Skills	Proportion (%) of male students who acquired the Physics Process Skills		Z-Cal	Z-Crit	Decision
		Urban Located School	Rural Located School			
1	Measuring	19.7	10.1	1.54	±1.96	Not sign
2	Manipulating Instrument	25.0	6.1	6.78	±1.96	Significant
3.	Observing	20.9	17.2	2.97	±1.96	Significant
4.	Following Procedure	20.0	10.0	1.69	±1.96	Not sign
5	Recording Data	20.1	13.8	0.97	±1.96	Not sign
6.	Reading Measuring instrument	25.4	7.7	5.65	±1.96	Significant
7	Mathematical computation	8.5	1.7	4.00	±1.96	Significant
8.	Tabulating Data	19.3	5.9	4.59	±1.96	Significant
9.	Plotting graphs	16.5	6.6	2.82	±1.96	Significant
10	Interpreting graphs	11.5	4.4	2.54	±1.96	Significant
11	Taking appropriate precautions	5.4	1.7	2.16	±1.96	Significant
12	Identifying variables	6.7	3.3	2.16	±1.96	Significant
13	Predicting	7.9	3.7	1.24	±1.96	Not sign
14	Drawing Accurate Conclusions	8.6	2.6	2.91	±1.96	Significant

A close observation of table 9 reveals that a significant difference exists the proportion of urban and rural students who acquired ten of the fourteen (14) physics process skills under study in favour of the urban students. The ten (10) skills are manipulating instruments, observing, reading measuring instruments, mathematics computations, tabulating data, plotting graphs, interpreting graphs, taking appropriate precautions, identifying variables, and drawing accurate conclusions. This is because the value of Z-calculated in these ten skills are greater than the critical values of Z (which is ±1.96) at the .05% level of significance, ($P \leq 0.05$). however, for the remaining four skills of measuring, flowing procedures, recording data, and predicting, there is no significant difference between the proportion of urban and rural students who acquired these four skills. The reason is because the calculated Z-score value in each of the four skills (i.e. 1.54 for measuring 1.68 for following procedure, 0.97 for recording data and 1.24 for predicting) is less than the critical value at (P.0.05).

Hypothesis One:

The first hypothesis tested in this study was:-

There is no significant difference between male and female students mean scores in TOPPS($p \leq .05$).

The Analysis of Variance (ANOVA) was used to test the stated null hypothesis. The results of the analyses are summarized in table 10.

Table 10: Summary of 2-Way Analysis of Variance (ANOVA) of Students Mean Score in TOPPS by Gender and Schools Location.

Source of	Summary of	Degree of	Mean	F.cal	F.Table	Decision

variation	Squares	Freedom	Square			
Gender	69.93	1	69.93	18.60	3.84	Significant
School location	154.38	1	154.38	41.05	3.84	Significant
Gender	11.62	1	11.62	3.09	3.84	Not Significant
School location	28	7				
Interaction	27.7	52	3.76			
Within groups						

Analysis of Variance of Students Mean Score in TOPPS by Gender and School Location.

As can be seen from the table above, the calculated value of F-ratio of 18.60 exceeds the table value of the F-ratio of 3.84 for 1 and 752 degrees of freedom, at the 0.05 level of significance. This means that there is a statistical significant difference between the mean scores of male and female students in a Test of Physics Process Skills. Thus, the above stated null hypothesis (HO) was rejected.

Hypothesis Two:

The second hypothesis tested in this study was:-

There is no significant difference between urban and rural students mean score in a Test of Physics Process Skills ($P < .05$)

The data for testing this hypothesis are shown in table. The result of the analysis shows that the calculated vale of the F-ratio is 41.05. This is much higher than the table value of 3.84 at 1 and 752 degrees of freedom at the 0.05 level of significance.

Thus that, there is a statistically significant difference between the mean scores of the urban and rural students in a test of physics process skills. Therefore, the null hypothesis of no significant difference between urban and rural students mean score in TOPPS is rejected.

Hypothesis Three:

The third hypothesis tested was:-

There is no significant interaction effect of gender and school location on students mean score in TOPPS.

Table shows the data use in testing this hypothesis. The result reveals that there is no significant interaction effect on gender and school location on students mean score in test of physics process skills.

This is because the calculated value of F-ratio is 3.09 which is less than the critical (table) value of 3.84 for 1 and 754 degrees of freedom at 0.05 level of significance.

Thus, the above state that null hypothesis of no significant interaction effect of gender and school location was not discredited at the stated level of significance.

This result implies that the students mean score in TOPPS with respect to gender can be explained without reference to school location. Conversely, the mean score, in TOPPS, of students from urban and rural school locations can be explained without reference to their gender, i.e. whether they are male or female.

Recommendations

A number of recommendations are made on the basis of the findings and implications of this study:

1. Since the rating of students acquisition of physics process skills is rather tow, they may be a need to retrain teachers in process skills tasks. This retraining will have positive effect physics students;
2. There may be a need to recognize the disparity in resource allocation to urban and rural secondary schools, and so put in place a deliberate government policy whereby a special resource allocation (staffing, equipment, tools, etc.) are made available to rural as well as all-female secondary schools, to enable these schools teach physics to their students more effectively and realistically;
3. Workshops, seminars and conferences should be organized by professional teachers groups, Anambra State government, state post-primary schools board and institutions, for physics teachers on physics skills.

It is likely that when improvements in resource allocation occurs and This is matched with systematic retraining of physics teachers, physics teachers would be better placed to teach their physics students, and this will rub off on physics students who will in turn improve in their study of physics and physics process skills.

Conclusion

The findings of this study served as an empirical basis for making the following conclusions with regards to the acquisition of physics process skills among Anambra State secondary school students:

1. The level of acquisition of physics process skills among Cross River State secondary school students was generally poor;
2. Sex has a significant influence on students acquisition of physics process skills. Male students achieved a significantly higher mean ' score in TOPPS than their female counterparts. Similarly, a higher proportion of male students acquired each of the physics process skills under investigation than their female counterparts who acquired the same skills;
3. School location is a significant factor in students' acquisition of physics process skills. Urban-located students performed significantly better than their rural located counterparts in a physics process skills test. Also, the proportion of urban students who acquired each of the physics process skills was higher than the proportion of their rural counterparts who acquired the same skills;
4. There was no significant interaction effect between gender and school location in students' acquisition of physics process skills as measured by a Test of Physics Process Skills.

Summary of Study

Physics is a very important subject because of the invaluable role it plays, in careers such as engineering, medicine, agriculture, space exploration, among many other professions. There are basically two components of physics - the theoretical aspect and the practical aspects. Even though both aspects are inter-related, there is a general feeling that many students perform m ore poorly in physics process skills (practicals) than in the theoretical aspect. This feeling prompted the researcher to investigate and empirically document the nature and scope of physics process skills acquired by secondary school physics students, with special reference to Anambra State. Specifically, the study sought to identify the levels of acquisition of physics process skills by students.

Discussion

The study revealed that the overall physics students' level of physics process skills as measured by a test of physics process skills, was less than adequate and unsatisfactory. For instance, as shown in table 3, the overall mean score of the students' Test of physics process skills (TOPPS) was very low i.e. 454 (34.6%). Also, the highest mean score in TOPPS was for the urban male group which was 5.33 (38%). Thus the urban male group which demonstrated the highest level of physics process skill acquisition acquired on the average, less than six out of the fourteen process skills under study while on the overall the students acquired less than five out of the fourteen skills. However, certain factors identified from literature could be said to be responsible. These factors may be either be teachers-related, environment-related or student-related. This is in line with the observations of Stratwitz and Marlowe (1987) who argued that when a teacher is incompetent in the process skills he cannot plan his teaching, or use each method that will offer students opportunity to acquire the process skills.

Furthermore a look at table 7 reveals that the male students mean score was significantly, higher than their female counterparts. The table shows that a higher proportion of male students acquired each of the physics process skills than their female counterparts. This result does not appear to be supported by the findings of Nwosu (1987), Inomiesa (1989), Ofoegbu (1984) who found no significant difference between the performance of male and female students. Also Nachi (1988) observed a significant difference between the performance of male and female, but uninterestingly in favour of the females.

However, the influence of school location in urban and rural environment on students' acquisition of physics process skills investigated in this study showed that urban students were significantly superior to the rural students. An examination of tables reveals that urban students had higher means score in TOPPS than their rural counterparts. Table 5, also show that the urban students' mean score was rural counterparts. Furthermore, table 8 shows that the proportion of urban students who acquired ten out of the fourteen process skills are significantly ($P \leq 0.05$) greater than the proportion of the rural students who acquired these skills. However, for the other four skills of measuring, procedures, collecting and recording data and predicting, the difference between the proportions of urban and rural students of who acquired them was not significant.

Also, there was no significant effect of gender and school location. Interaction detected in the students' acquisition of Physics process skills. This study shows that the students' mean score on TOPPS will respect to gender can be explained without reference to school location and vice versa.

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Biography

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