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ACQUSITION OF SCIENCE PROCESS SKILLS AMONG SENIOR SECONDARY SCHOOL STUDENTS IN ENUGU STATE OF NIGERIA

BY

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DEPARTMENT OF EDUCATION

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CERTIFICATION

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DEDICATION

This Project is dedicated to ALMIGHTY GOD who gives me LIFE; my beloved parents and uncles - Chief Philip Ezeoha; Chief Samuel Ezeoha and Mr. Okafor Nnamani.

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I am profoundly grateful to my Supervisor - Professor Anthony Ali. His kindness, advice, amazing intellectual leadership and resourcefulness, will remain a source of inspiration to me.

I thank all the Lecturers in the Department of Education who contributed in various ways to ensure the success of this work.

I am also appreciative of the role played by the Principals, Science Teachers and SSS Science students of the schools where the study was conducted. The study would have remained a dream if these people had not co-operated.

My most sincere gratitude goes to my beloved parents and my uncles - Chief Philip Ezeoha, Chief Samuel Ezeoha and Mr. Okafor Nnamani. I thank them very sincerely for their various contributions towards the success of this work and for their encouragement throughout my academic pursuit.

Above all, I shall remain eternally grateful to Almighty God for protecting and guiding me in my life endeavours.

Finally, the contributions of my friends as well as Mr. U.O. Ukpai who typed the final work are appreciatively noted.

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ABSTRACT

The study was conducted in order to investigate the acquisition of science process skills among Senior Secondary School students in Enugu State of Nigeria. In realisation of the immense importance of science and technology, and also of the fact that without science no meaningful national development will be achieved, there was a need to carry out a study in order to find out those factors that influence the acquisition of science process skills among our senior secondary school students. This led to questions as to whether students actually acquired some selected skills, which process skills are necessary for learning science in secondary schools, and if factors like sex, school location, parents' level of education and the socio-economic status of the families had effect on the acquisition of science process skills among students.

After reviewing related literatures in order to sharpen the focus of the work, a survey/descriptive study was designed. The subject sample consisted of eighty (80) Senior Secondary I students. The two sexes were equally represented in the sample. The subjects were selected randomly from eight Secondary schools which were located in Abakaliki Education Zone of Enugu State. The parents of the students were given questionnaires to fill in order to elicit responses concerning home background of the students. The science

teachers were also given questionnaires to fill in order to find out which science process skills are necessary for learning science in secondary schools.

Four null hypotheses were tested in an attempt to answer the questions which were posed. Consequently, t-test was used to test for significance of difference between mean scores of groups that were compared. Level of significance was kept at 0.05.

The results indicated that some of the science process skills, for instance, inferring and predicting were poorly developed in the students. School location whether urban or rural was observed to have effect on the scores of the students in the process skill tasks. The sex of the students - male or female had no influence on their acquisition of science process skills because they were found to have performed evenly in the skill tasks. However, students from families of high socio-economic status acquired more process skills than those from families of low socio-economic status.

The educational implications of the results of the study were stated, recommendations were made and suggestions were offered for further research.

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CHAPTER ONE

INTRODUCTION

Background of the Study

The development of any country is predicated on a sound science, mathematics and technology and much of the skills, attitudes and processes that are required for development and growth are taught in Schools beginning from Primary schools to tertiary institutions.

Developed countries of the world achieved their position of eminence by dint of hardwork based on a scientific approach to life. This era, therefore, is commonly referred to as the "Technological Age", which is an acceptance of the fact that the growth of a nation economically, socially and even politically is guided by its advancement in science and technology. There is now improvement in medicine, communication, transportation, agriculture, physical facilities and infrastructures because of influence of science, technology and mathematics.

What is Science? There are many definitions of what science is. Webster's New Twentieth Century Dictionary defined science as systematized knowledge derived from observation, study and experimentation carried on in order to determine the nature or principles of what is being studied. Contributing to the meaning of science, Osuala (1982) defines science as "an organized body of

knowledge as well as a method and system of deriving truth". Highlighting the nature of science Opong (1981) pointed out that "Science is knowledge obtained by observation and testing of facts."

Craig (1962) defined science as:

> "an active, dynamic field, constantly demanding willingness to make new observations, to repeat experiments, to consider new facts, and to challenge earlier conclusions. Science is, therefore, the methods by which new information is uncovered, new principles arrived at, old principles modified or discarded. Science is an intellectual search involving inquiry, rational thought and generalization.

On the other hand, National Policy on Science and Technology (1986) states that "Technology" means the ways of doing things through the application of knowledge derived from systematic investigations of natural forces and materials. It leads to the development of processes and devices indispensible to the stable enhancement of the quality of life and to human progress. Ikoku (1989) defined technology as "the rational utilization of energy in any process designed to satisfy a need." Jones (1971) pointed out the distinction being made between science and technology by his assertion that:

> "Science is available in a world-wide system of publications accessible to anyone who knows the language (of publication). Technology is not so readily accessible, partly because of industrial secrecy and property rights, but also because technology must be learnt by doing. Technology is thought of as "know-how" while science is usually regarded as "know-why". Thus science is essentially a methodology which is employed to produce and accumulate knowledge while technology produces goods and services or wealth.

Science demands the understanding of events in nature, logical search and verification of data. It is a relentless, continous and never-ending attempts to find more accurate descriptions of events.

The nature of science encourages the learners to search for and hopefully find solutions to problems. At this instance, science is viewed as an active process. The view of science as a process was reported by the American Association for the Advancement of Science (AAAS) through the publication of a Science Curriculum entitled Science - A Process Approach (SAPA) in 1967 for Elementary Schools. Gagne (1965) in his seminar papers presented to the American Association for the Advancement of Science conceived science as consisting of process skills. For Gagne, the pre-requisite knowledge and application of concepts and principles can be obtained only if the students have certain underlying capabilities - the science processes which are needed to practise and understand science (Finley, 1983). In SAPA,

13 process skills are identified. The skills are: Observing, Classifying, Communicating, Measuring, Using time/Space relations, using numbers, inferring, predicting, controlling variables, interpreting data, formulating hypotheses, defining operationally and experimenting. According to Finley (1983), the processes are hierarchically organized with the ability to use each upper level dependent on the ability to utilize the underlying process. Gagne (1965) pointed out that "observation is considered to be the fundamental skill by the virtue of its position at the foundation of the hierarchy of skills needed to discover the broad knowledge required to conduct enquiry." The major features of the processes, according to Finley (1983) are:

i) Each process is a specific intellectual skill used by scientists and applicable to understand any phenomenon.

ii) Each process is an identifiable behaviour of scientists that can be learnt by students. The processes are generalisable (transferable) across content domains and contribute to rational thinking in everyday affairs.

Through the acquisition of science process skills, rote learning is minimized or even stopped and science is then seen as a productive and practical oriented venture. At this instance, what the teacher imparts to the students are regarded as more meaningful for the solution of day-to day problems. The teacher's work in the area of science is

much more appreciated and more easily understood.

The acquisition of science process skills help the child (student) to develop self-confidence and self reliance about and the understanding of the world around him. The acquired process skills help him in the meaningful exploration of his environment and he is placed at a position of solving his world problem.

No other part of the world needs a sound science and mathematics education for technological development as much as the Third World countries. Areas of the world such as Africa, Central America, the Caribbean, tropical South America and the Pacific Islands grouped as "under-developed" or third world (United Nations, 1959) are associated with low income per capita, external indebtedness, low labour productivity, relatively large population, dependence on primary products, low life expectancy and high infant/maternal mortality. On the other hand, countries aptly described as advanced or developed are those which are leading in science and technology. Such countries dominate in matters affecting world economy, politics and obviously world security. Their citizens enjoy a better quality of life than the citizens of the "under-developed" countries in terms of cheaper and more available food, better health facilities and more efficiently functioning social services. These glaring facts about science and technology have, as it were gingered

up all countries into what is called the "technological race."

Nigeria, for instance, is principally an agricultural country blessed with natural vegetation, good soil and a relatively predictable climate. Various sophisticated equipments and machines have been developed for mechanized farming. The increasing use of fertilizers and insecticides has brought better agricultural yields. Harvested crops which do not go for immediate processing are preserved by the use of chemicals and stored away in a controlled atmosphere, thereby ensuring the continuity of food supply all the year round. All fishing in the high seas is now carried out by scientific methods.

Science and technology have put at our disposal the necessary tools and equipment with which to improve the standard of living of people in the villages so as to halt the drifts to urban areas - through the provision of facilities and amenities like electricity, pipe borne water, medical facilities, establishment of cottage industries and cottage hospitals. Improved transportation and communication promote better trade and inter-city travel as well as enhance economic progress. Messages are carried by post, radio, telephone, television, telegraph, radar and telex.

Health is Wealth. The economic wealth of any nation depends on the well-being of its peoples for high labour productivity. In this respect, the role of science and technology are emphasized by the advances made in medicine and public health engineering. Through mobile cinemas health education has been spread to every village and hamlet in in the country. Application of medical knowledge and scientific techniques has relieved man of pain using anaesthetics, antibiotics and other medicines; it has lengthened the life span of man, it has also produced the artificial kidney; it has enabled man to carry out heart trnasplants and it has enabled man to plan the size of his family. However, one of the greatest health problems of developing countries is high infant mortality due to malaria, Pneumonia, gastro-entritis, measles, poliomyelitis, Diptheria, diahorrea and whooping cough. Reduction of infant mortality through immunization or vaccination and Oral Rehydration Theraphy (ORT) will make available to the country a larger prospective high level manpower which is very essential for development.

Side by side with modern medicines, research is being actively embarked upon to develop our native herbs for curing many diseases. Our medical schools should, therefore, include the study of herbs in their curriculum. By so doing a body of knowledge might be evolved which could form the basis of a new industry that could produce drugs from herbs along scientific lines.

One of the problems facing developing countries especially Nigeria, is inability to benefit from modern science toward providing decent living accommodation for her over-increasing population at a cost within the reach of the average individual. The answer to this problem can only be found in the economic use of available materials and land through the application of scientific and technological knowledge.

By application of scientific methods of breeding, it is possible to accelerate the growth rate of animals (cattle), increase milk output and double the harvestable carcass of the animals.

Nigeria is rich in mineral resources such as oil, tin and iron. So far, only a few minerals have been discovered and still fewer have been mined. The application of up-to-date scientific techniques will no doubt reveal more mineral deposits, it will increase the productivity of our mines through mechanization, it will enable us to tap the by-products which are found with the primary minerals, such as gas with oil and columbite with tin, which would otherwise be wasted.

Man has to protect himself against hazards from natural causes like gales, floods and earthquakes. The weather forecast which gives the advance warning of cyclones, the building of levees or embarkments along the courses of rivers to contain flood waters, and the seismographs used

for detecting shock waves signalling imminent earthquakes have been evolved through the application of science and technology.

Taboos, witchcraft and superstition, although gradually dying down are still rampart in developing countries especially in Nigeria. Sometimes an illness is explained away as a spell cast by an enemy, and instead of going to the hospital for proper treatment, a witch-doctor is invited to drive away the spell which may result in aggravating the illness. Such beliefs are incompatible with national development. The proliferation of scientific knowledge will eliminate such bad social attitudes.

From the foregoing account, it is evident that all wealth is created by man's labour and his labour is guided by his education and acquired scientific skills. The richer and more skilful countries attained their affluence through the advances which they have made in science and technology. The younger nations of the world (developing countries) must, therefore, take a cue from the experience of the bigger or developed nations in directing their energy and resources towards a balanced economy, a state which could only be reached through scientific and technological advancement.

Realising the immense contributions of science and its influence on national development, the Federal Government of Nigeria stated in her National Policy on Education (1981) that:

i) A greater proportion of education expenditure will be devoted to science and technology; and

ii) Universities and other levels of education system will be required to pay greater attention to the development of scientific orientation. To this end, more Colleges of .Technology and Polytechnics will be opened in a bid to improve technological and science education. From this statement, it should be noted that the Federal Government of Nigeria cannot be described as unaware of the immense value and power that accrue from science and technology.

However, the steps that should be taken so as to maximize the benefits that can accrue from the application of science and technology involves producing more and better scientists, training more and better technologists; and encouraging, promoting and co-ordinating scientific and industrial research. The best way of producing more and better scientists is to expand and improve a sound science education programme. If this is to be achieved, these factors are vital pre-requisites.

Firstly, there is need to encourage more students to study science. In order to do this, science as a subject should be introduced into primary schools so that many students will be exposed to the subject early. At the university level, science should be accorded a higher quota than the humanities in the allocation of student places.

Secondly, more qualified and dedicated science teachers are needed; teachers who teach not only scientific facts and techniques but inculcate the spirit of science and an attitude of inquiry in the minds of the students.

Thirdly, the science teachers should be given incentives, regular payment of salaries and encouragement. Furthermore, regular seminars, conferences, workshops and in-service courses should be organized so as to keep the teacher aware of and up-to-date in curriculum development as well as for professional growth.

Fourthly, adequately equipped laboratories should be provided by the government so as to enable students carry out practical work in all science subjects.

Fifthly, the government should encourage and promote the writing of Mathematics and Science books at all levels.

Sixthly, the government should establish up-to-date science libraries as well as provide adequate science audio-visual aids for teaching science subjects.

Furthermore, the use of mother tongue in the teaching of science at least in the elementary school level should be encouraged so that children will see science as part and parcel of their own culture. There is also the need to popularize science by the dissemination of scientific knowledge through radio, television, and printed media such as Newspapers and journals; and to implant science among

the general populace especially in children by establishing science clubs and museums and by organizing public lectures by scientists and technologists.

Above all, the science curriculum should be designed to reflect aspects of relevance, usefulness and teachability. The content and methodology of the existing curriculum should be re-assessed. In other words, the re-examination of what to teach and how to teach it should be carried out so as to ensure functional education. The content of the science course should be such that it is interesting, relevant to the child's experience with the physical world and it should be structured into a continuous development of scientific concepts and skills from the primary school up to the university level. The methodology must be such that it discourages note memorization, eliminates authoritarian teaching; fires the imagination, inculcates the spirit of inquiry and it imbues the power to perceive, understand, to experiment, discover, to draw conclusions and to predict.

The Government of the Federal Republic of Nigeria seems to be adequately aware of the need for the acquisition of the science process skills. The government organized a National Curriculum Conference in 1969, one of whose outcomes was the revision of subject curricula at different levels of education to lay more emphasis on the acquisition

of skills. Following this, various bodies and associations have contributed to ensure the development of such curricula that would emphasize the acquisition of process skills. Such curricula include the Nigerian Primary Science Project (NPSP); the Nigerian Secondary School Science Project (NSSSP); the the Nigerian Integrated Science Project (NISP). The NSSSP is a curriculum in biology, chemistry and physics and was developed by the Comparative Education and Adaptation Centre (CESAC). Several science bodies such as Science Teachers Association of Nigeria (STAN) and National Education Centre (NEC) have contributed immensely to the development of the various science curricula. Recently, the curricula for Junior and Senior Secondary School Science have been developed. Such curricula include Integrated Science Curriculum for Junior Secondary Schools, and Science Curriculum for Senior Secondary Schools which consists of Biology, Chemistry and Physics.

Statement of Problem

The importance of acquiring science process skills by Senior Secondary School students cannot be over-emphasized. This is because possession of these skills will help our students in the solution of day-to-day problems as regards science as well as make them to be more scientifically literate. The possession of these skills will equally help to develop our nation scientifically and technologically.

According to Victor and Lerner (1975) "if the science programme is to be effective, the programme should be evaluated continuously. Definite and adequate provision should be made to ensure that the evaluation is dynamic and continous rather than perfuctory and sporadic." The same holds for teaching and learning generally. What students are taught, the materials used, teaching methods, as well as the set objectives of the school system, need to be evaluated regularly to ensure that resources are properly utilized and set goals are achieved. It is against this background that the study which tries to assess the extent students make use of process skills during science lessons can be viewed.

Ofoegbu (1984) found out that the actual acquisition of science process skills differ from students to students. But what might be the cause of this variation? The problem of this study centres on possible factors that influence acquisition of science process skills by our Senior Secondary School students. Is it due to the influence of home environment? Could it be due to location of schools - urban/rural? Could it be due to inability of teachers to impart the science skills to students on time? Could it be the method used by teachers in teaching these students? Could it be the poor attitude of students

towards science that hinder the acquisition of these skills? Could it be due to the gender of the students? This research tends to find possible answers to these questions.

Purpose of the Study

This study is geared towards achieving the following:

1. determine through observation and experimentation the level of acquisition of process skills by Senior Secondary School students.
2. identify the factors that affect the acquisition of science process skills.
3. investigate the extent to which each of these factors is seen to influence the acquisition of the skills.

Significance of the Study

The desire among Nigerians for the country to achieve mass scientific literacy is clearly stated in the constitution of the Federal Republic of Nigeria, 1979. Achievement of mass scientific literacy is likely to lead to the achievement of mechanized agriculture, increasing human life span and automating production. This is why the Science Teacher Association of Nigeria (STAN), Institutes of Education of Nigerian Universities, Federal and State Ministries of Education, Nigerian Educational Research Council (NERC) and individuals are making efforts to improve science curricula. Such curricula are usually

evaluated in stages during development (formative evaluation) and when completed, so that the outcomes are assessed against the background of the philosophy and goal underlying them (summative evaluation). This is to encourage acquisition and application of science skills to the solution of day-to-day science problems. Since science skills are indispensable in science activities, this present research work/study will, therefore, help to:

i) identify some of the factors that militate against the acquisition of science process skills by Senior Secondary school students.

ii) Create awareness of the possible factors that would enhance the acquisition of science process skills.

iii) Identify some teaching methods and audio-visual aids that would facilitate students' acquisition and application of science process skills.

iv) Make recommendations to science educators on the possible solutions to the problems involved in the acquisition of science process skills.

v) Help to exploit avenues for helping and encouraging our students to acquire science process skills.

Research Questions

For this study, the following research questions will be answered:

1. What science process skills are necessary for learning science in secondary schools?
2. In which of the selected eight process skills namely observing, experimenting, measuring, classifying, using time/space relations, communicating, inferring and predicting do the senior secondary schools (SSS) students demonstrate greater acquisition?
3. Which gender performed better than the other in their achievements of science process skill tasks?
4. Are there any significant differences in the acquisition of science process skills between the students from families of average/high socio-economic status and those from families of low socio-economic status?
5. Are there any significant differences in the process skill achievements of urban and rural Senior Secondary School students?
6. Are there any significant differences in the acquisition of science process skills between student whose parents are fairly/highly educated and those whose parents are not/little educated?

Hypotheses

The following null hypotheses were tested:

H_{o1} There is no significant difference ($P < 0.05$) in the acquisition of science process skills between boys and girls as measured by their mean process skill scores.

H_{o2} There is no significant difference ($P < 0.05$) in the acquisition of science process skills between the students from families of average/high socio-economic status and those from families of low socio-economic status as measured by their mean process skill scores.

H_{o3} There is no significant difference ($P < 0.05$) in the acquisition of science process skills between the students in urban secondary schools and those in rural secondary schools as measured by their mean process skill scores.

H_{o4} There is no significant difference ($P < 0.05$) in the acquisition of science process skills between the students whose parents are fairly/highly educated and those whose parents are not/little educated as measured by their mean process skill scores.

Scope and Delimitation

The study will be limited to one education zone out of the three education zones of Enugu State due to time constraint, finance and some logistic problems like non-availability of means of transport to some Secondary Schools in the rural areas. The study among other things, involved the observation of the SSS students and since observation takes a long time to accomplish, one education zone was considered ideal for this study. By means of random sampling, Abakaliki education zone was selected for the study and the study will cover eight Secondary schools

within the zone.

The study will be based on the performance of subjects in the application of eight out of the fifteen science process skills emphasis on which was recommended by Nigerian Educational Research Council (NERC). The eight are: (1) Classification, (2) Inference (3) Experimenting, (4) Measurement (5) Observation, (6) Prediction, (7) Using space/time relationship, (8) Communication. The rest of the 15 are controlling or manipulating variables, counting, questioning, formulating models, formulating hypothesis, interpreting data and making operational definitions. The fifteen science process skills are a modified version of the 13 skills developed by the American Association for the Advancement of Science (AAAS) termed - Science - A Process Approach (SAPA). The skills interplay to produce scientific literacy. This study will, therefore, base on these eight science process skills for meaningful results.

CHAPTER TWO

LITERATURE REVIEW

Introduction

This chapter deals with review of literature and is carried out under the following sub-headings namely:

i) Importance of Science.

ii) Methods of teaching science and influence on achievements, interests/motivation.

iii) Essence of teaching and learning science process skill acquisition.

iv) Why process skill acquisition is low.

v) Importance of process skills in science.

vi) Recent studies on process skills in science.

vii) Summary of the reviewed literature.

2.1 Importance of Science

The significance of science are so immense that every action of man has become science based. For any citizen to live the "good life" he must be aware of science. Science has proved itself indispensable in the improvement, development and civilization of the mankind. According to Bajah (1977) the society in which we live is now becoming scientifically and technoligically complex. For any country to survive technoligically, it must have science background. Such science background should include all the principles, theories, and process skills. The knowledge acquired through science

and technology will enable learners exert their maximal efforts in their bid to tame their environment. Science has contributed tremendously in the field of agriculture, engineering, medicine, pharmacy, nursing and other science-based vocations.

The applications of science and technology have somewhat even if not profoundly, affected our lives and indeed poses some clearly defined challenges to our traditional life styles. For example, Nigerians' reliance on the local native harbalist, native doctor and "rain maker", for material and spiritual well being has wanded or died down in some communities. In essence, African countries are getting more and more exposed to the boon and bane of science and technology. The boon, for example, has led to the production, storage and distribution of more nutritious food, wider range of better and more innovative medical treatment, and easier and more efficient means of transportation and communication. Another benefit derived from science is the development of scientific literacy in the community. Scientific literacy implies the possession of a basic core of cognitive awareness and perhaps, fundamental technical skills in science. Ali (1985) stated that a scientifically literate society in African countries will be in a better position to make feasible, sane and valid decisions on issues directly related to their lives. In other words, a scientifically aware society will be able to understand, evaluate and make

decisions on science-related issues like birth control, abortion, famine and nuclear energy as these affect their lives. Scientific literacy also helps in the reduction of supersitious belief in the society, for instance, the incidence of witch-craft and death by poison.

Following sputnik in the U.S.S.R. and interest generated by it and other controlled scientific breakthrough, for example, the first atomic explosion by the U.S. at Alamogordo in New Mexico, African countries were conciously aroused to the belief that science held a great potential for mankind in terms of providing him with the means to lessen life's burdens on earth, for instance, in the prevention and treatment of diseases as well as solving the prblem of hunger by producing enough food and to check erosion menance. The sudden realization of this role of science was translated into developing and introducing science curricula in our schools.

Prior to self-rule (before 1960) some systematic science instruction were provided in Nigerian primary and secondary schools. Specialist courses like Biology, Chemistry and Physics were not taught then. Rather, Nature Study, Health Science and General Science were taught (Ali, 1985). According to Taiwo (1975), the first wave in the changes of school curricula dates back in 1878 and it was in that period that science was introduced in Nigerian (Primary) schools.

This science (in the primary schools) was referred to as Nature Study (Choyton, 1980). Soon after political independence, Nigeria gradually began to introduce more structured science curricula which stressed the role of the laboratory in science teaching as well as the role of science in technological growth and development. The introduction of WAEC (West African Examination Council) in 1950 further enhanced curriculum growth and development not just in science but in other school subjects.

The significance of science and the realisation of technological advancement derivable from it brought about a wave of change in Nigerian education life. In the early 1930s some science oriented schools were established and such schools included Government Colleges at Ibadan and Umuahia (Abdullahi, 1982). The realisation of the fact that Nigeria would hardly make any tangible national progress in the absence of science led to the founding of Higher College, Yaba in 1934. The Yaba Higher College started the training of science masters (Obioma, 1986). This higher college continued to train science masters who assumed their duties and laid foundations for the modern science curriculum in Nigeria.

The significance of science became widely known that the need for science education was generated. The essence of science education gained a wider popularity that by 1957, such

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popularity led to the formation of Science Teachers Association of Nigeria (S.T.A.N) which has since then been helping in the task of science curriculum reforms to suit the need and aspirations of the Nigerian society as well as to make Nigeria a self-reliant nation. Since science is a backbone for any national development, any national education that ignores science has no base. Science generates in the learner the capability to understand and explore his environment. Science helps in the applicability of ones potential for the survival of man and his progress.

Science has given light to modern technology. As science is important, so is technology important. The two go pari passu and are contextually linked. In Nigeria, high quality technology education depends on effective science education (Obioma, 1986). According to Okafor (1984), technology education is important not only for providing tools and machines, technology composes of the non-material innovations such as techniques, knowledge, experience, organisation, planning etc. This modern technology has its root in science. It is science that creates avenues for modern technology and hence the national development.

The technical skills and competencies that are desirable for becoming a scientist can be acquired through the study of science and technology. The role which science has to play in improving the lives of the people in Africa

(especially in Nigeria) do not depend on greater scientific knowledge only. Some aspects of this role will depend on the ability of the scientists in applying the science they have learnt in solving local problems. Also the ability of the scientists in managing the application of science through research and development, is another essential aspect which will likely make the realisation of material well-being achievable in African countries.

Ali (1985) emphasized that the role of science in our societies can be achieved if the objectives of science education are achieved by our students. The science education objectives are: acquisition of factual science information, the development of methods of thinking and testing thoughts, induction and application of science principles and formation of positive attitudes toward science, form the bedrock for grooming our future scientists and technologists.

2.2 Methods of Teaching Science and Influence on Achievements, Interests and Motivation

According to Ali (1985) achievement in learning science is often the outcome of interaction between the teacher, the students and the materials and equipment used for instruction Onwuka (1981) rightly pointed out that "different subjects demand different methods of approach". The teacher can make use of any of the teaching methods depending on the circumstance.

Recent studies on teaching methods of science include those of Eze (1982), Ali (1983), Nworgu (1985) and Obioma (1986). Ali (1983) attempted to find out the operational definitions of guided-discovery and expository methods of teaching science. He also proposed to find out the effects of the two teaching methods on initial learning, retention and transfer of learned materials, and on attitude toward Mathematics. The students used were Sixth (6th) Form Primary School graders. They were assigned to two treatment groups and a control group. Mathematical tasks were selected from the year 5 and 6 Elementary School work in Mathematics as described by the Nigerian Education and Research Council (NERC). He used seven instruments to collect data. Six were administered on the students while the other one was used to rate teacher behaviour. His results show that students taught by the expository method were superior to the students taught by the discovery method. On transfer and retention, the students taught by discovery method were significantly superior to those taught by expository methods. Another findings is that the discovery treatment group demonstrated more favourable attitude towards Mathematics than expository treatment group.

Ali's work is commended for the fact that the operational definitions of the teaching methods were clearly stated. His findings on initial learning is consistent with those of Kittell (1957) and Haslerud and Meyers (1958) that the most highly directed groups are superior in initial learning of tasks. His findings on retention and transfer is also consistent with most of the early work apart from that of Kersh (1962) and Wittrock (1963). His finding on attitude twoards Mathematics corresponds with Bruner (1977) advantage of discovery learning which is the shift from extrinsic to intrinsic rewards in learning. It is also an affirmation of Kersh (1962) work on motivation outcomes of discovery learning.

According to Ridgewell (1976), "all that a teacher requires when selecting a mathod of teaching any science topic is to look for a method that will best motivate the students." In their own investigation, Moore (1973), Anderson (1971) and Reed (1968) consider the motivation of the students as indispensible avenues to cause learning take place. Motivation occurs usually when the teacher employs useful methods in imparting the knowledge. According to Gadner (1974) the student that are more organised and achievement motivated usually attain higher level in academic work. Akubue (1991)

stated that motivation can come through self-interest, successful experience, realistic goal-setting and through attention and interest. In other words, motivation is of two types namely self-motivation which is intrinsic, that is, stemming from a deep desire of the student to learn science or achieve well in any other thing; and motivation which is externally - induced, for instance, the teacher giving the student a reward, praise or recognition or any other reinforcement skills.

Akubue (1991) stressed that the teacher should revive students' interest in a subject by developing the habit of changing from one method of teaching to another so as to control the length of time spent by children in sitting, standing, reading or working or the amount of time the teacher spends on the different phases of a lesson. To sustain interest the teacher should provide the activity on the part of children, avoid monotony through stimulus variation and introduce contrasts, use teaching aids and as much as possible employ illustrations that are tailored to the learner's age, experience and maturity.

Other various methods for teaching science include the following: use of laboratory investigations, lesson/lecture method, discovery method, questioning techniques, using demonstrations, photomicrography, science field trips and tours, as well as using special projects for teaching science out of school. Out of the numerous methods involved in the

imparting of knowledge and skills many educators (Bruner, 1961; Ausubel, 1961; Ali, 1986; Olarinoye, 1982) have identified discovery method as a powerful avenue of exposing the learner to find out an answer to a problem. Onwuka (1981) suggested that learners should be provided with opportunities to discover new truths, new rules, new methods of tackling problems as well as new values for themselves.

Ali (1985) emphasized the use of laboratory investigations for teaching science. This is because science involves doing experimental, observational and laboratory-oriented work. This implies that effective science should be laboratory-centred. Laboratory activities should be investigational in approach so that they can provide students the opportunity of acquiring science skills. A science investigation represents a process for determining the truth of a particular science concept through a process of empiricism. An investigation in science broadly encompasses four major aspects: a statement on (a) the specific purpose of the investigation (b) identification and assemblying of the materials and equipment needed for all the stages of the actual experimentation and or control conditions, (c) what has to be done at every stage while using the materials and equipment supplied. In other words, an outline sample of a laboratory activity consists of (i) instructional objectives (ii) concepts to be developed

(iii) materials needed and (iv) procedures involved and (v) report. Specific laboratory skills to be cultivated and nurtured include: observation, data collecting, recording, analysing and interpreting data. Audio-visual materials can be very useful and rewarding teaching tools if their use in the laboratory or classroom is carefully and properly planned (Ali, 1985).

Another method for teaching science is lecture (lesson) and is very common. Alexander and Halverson (1956) described lecture as "the process whereby the teacher's notes are transferred from his notebook to those of his students without passing through the minds of either". Tropp (1972) defined lecture as "a chalk and talk" teaching approach. Lecture is a method of teaching which involves the teacher telling his students what he thinks they need to know and the students listening and copying what they think the teacher needs them to know. The teaching of secondary school science should not be dominated by lectures. This is because even under the best of teaching-learning conditions, talking and listening are limiting methods of learning. Lecture teaching approach encourages memorization (rote-learning) among the students and very often what students learned from lectures are soon forgotten, usually after examination (Ali, 1985). However, lectures if used properly can help in achieving knowledge and understanding of science among the students who are being lectured. A lecture should be a

clear and comprehensive presentation of up-to-date information on the topic the teacher wants to lecture on. One of the best fundamental ways of making a lecture effective is for the teacher to ask students questions and encourage them to ask questions during lectures (Onwuka, 1981).

Questioning techniques are also used for teaching science. A question can be defined as a statement seeking information from the respondent. For teaching and learning purposes, questions are used for evaluation in order to determine students' readiness to learn new skills/concepts (entry behaviour). Questions are also used to encourage and motivate active students' participation as well as to enable them think and seek (alternative) explanations.

According to Amidon and Hunter (1967) there are two types of questions which are used in teaching namely: narrow and broad questions. Narrow questions are those which seek short, factual answers. These kinds of questions can be used to determine whether students understand ideas or to verify their understanding of what was taught or done. However, broad questions are those which seek to elicit a variety of probable answers and the emphasis is more on the logic of the answer presented. In general, board questions are intended to provoke the thought processes of the respondent.

In their own consideration, Owen (1956) and Howard (1968) regard the use of demonstration as a powerful method in science teaching. A science demonstration can be described as a science experiment or activity carried out by a science teacher in full view of his science students who do not participate but only watch what is going on. Even when one or two students participate in a demonstration, the degree of their participation may only involve helping the teacher to hold something or mix something, which is an inactive participation. Demonstrations in science are useful alternatives to students laboratory activities when materials and equipment may not be enough for the students to use. It may also be that it is potentially a dangerous activity especially if it is carried out by inexperienced hands such as students in lower secondary school classes. Science demonstrations may serve as useful illustrations prior to a difficult and complicated experiment that the students would eventually be expected to carry out. The Secondary School science teacher should carry out a pre-trial of a demonstration before carrying it out in class. This will afford him the opportunity of changing things (equipment, materials or procedures) should such a need arise.

Ali (1985) pointed out that science field trips and tours are very effective for teaching science. Field trips generally refer to outdoor trips for studying the ecology of a particular habitat or land use survey. The outdoors, for example, parks, game reserves, lakes, quarries and industrial plants are all replete with study materials or phenomena directly related to science. Tours usually refer to visits to indoor establishments like the brewery, the museum, hospital or a university.

Although the school is the central location for learning, the outdoor equally holds its own as a source that if well utilized can develop and stimulate students in their science education studies. The use of the outdoor as instructional resource offers the possibilities for exposing the curious, searching and wondering student to the variety of experiences that he is taught in science, Mathematics and Geography lessons. The use of the outdoor for science teaching offers the science teacher the opportunity of adding relevance, variety and interest to science lessons. Field trips and tours to places where the students are not used to may be exciting but going on such trips or tours requires that the science teacher plans for the safety of the students he is going to take during such field trip or tour. He may need to visit the site and make notes on safety problems and how to overcome them. (Ali, 1985).

Effective teaching of science out of schools can be carried out using special projects. Special project in science is a science work which a student has to complete on his own, usually after school. The type of science project carried out by the individual or a small group of science students depends on what they want to study and the feasibility of studying it. Some project may involve work in the school's laboratory with little need for additional materials and equipment or constant teacher supervision. Others may involve work outside the school with obvious need for science materials and equipment (Ali, 1985).

The teacher should encourage his students to select and successfully complete projects they are interested in. The choice of p a project should be made by the student in consultation with his teacher who now serves as a resource person (advising, guiding and supplying items needed for project work) while the project is in progress. According to Ali (1985), there are two types of special projects in science. The first type are projects which require reporting events observed either through literature search or through observations of natural phenomena. The second type of projects are those in which scientific experiments are carried out thus requiring the unity of theory that was taught in class and practice gained from laboratory work. Such experiments are much more likely to succeed if

both a clever mind and clever hands are employed. Science projects can be carried out through science clubs where they exist. The science teachers should be actively involved with science clubs existing in schools where they teach.

According to Onwuka (1981) co-operative methods are very essential, for teaching students. All educational effort is to enable learners to acquire socially desirable knowledge, attitudes and skills. Teachers should deliberately foster co-operation by providing the pupils with opportunities for co-operative action both in and outside the school. It is expedient that individuals must continually bear the interests of the group in mind. The expected team spirit can be developed by the way teachers present their lessons. Co-operative activities can be developed through frequent class discussions as well as where teachers allow pupils to assist one another. Pupils who have the opportunity of discussing and solving problems together develop more team spirit than those who always work on their own as individuals.

The problem method of teaching science is also very important. When confronted with a problem, normal human beings almost always endeavour to discover its solution. Attempts to solve problems often lead to the discovery of new facts which contributes to the growth of knowledge (Onwuka, 1981). The problem method is an

application of the unit idea because it embraces a continous, meaningful, well-integrated activity beginning with a problematic situation and ending when the problem has been solved and the solution checked. The series of actions involved in the process constitutes a unit of experience.

The solution of a problem often takes a number of steps. First, one considers or examines the nature of the problem. Secondly, one gathers relevant data or information about the problem. Thirdly, one provides a tentative solution, a hypothesis. The fourth step is to test the hypothesis by examining its likely implications, that is, what results from such a solution. Finally, one applies or modifies the solution, and tests it for acceptance or rejection; for instance, the problem of erosion in tropical African can be solved using the problem method (Onwuka, 1981).

On acquisition of science process skills, Ragubir (1969) and Strawitz and Malone (1987) found a significant difference when different teaching methods are employed. Contrasting results were found by Jaus (1975), Riley (1979) and Zeitler (1985). These latter group of researchers found no significant difference in acquisition of science process skills when they used different teaching methods. Alexander and Halverson (1963) explained that no single method of teaching is superior to the other and as such one method should not be used in preference to others.

2.3 Essence of Teaching and Learning Science Process Skill Acquisition

The process skills identified through the AAAS survey in Science: A Process Approach (SAPA) include the following: observing, classifying, using number and space relationship, measuring, communicating, raising questions, predicting, i inferring, collecting and interpreting data, hypothesizing, controlling variables, manipulating variables, making operational definitions, experimenting and manipulative skills (Ajeyalemi, 1990). The essence of teaching and learning science process skill acquisition is to enable students to:

1) Observe and explore the environments. In other words, it will develop in the child the ability to adapt to his environment.

2) Explain simple natural phenomena.

3) Lay a sound basis for scientific and reflective thinking;

4) Develop scientific attitudes including curicusity, critifal reflection, objectivity, patience, perserverance, honesty, team work and co-operation, open-mindedness, being sceptical, flexibility of thought, suspending judgement until all available data is collected; enthusiasm, creativity, research zeal and willingness to accept criticism.

5) Apply skills and knowledge gained through science to solving everyday problems in the environment, that is, develop ability for solving problems scientifically.

6) Develop self-confidence and self-reliance through problem-solving activities in science.

7) Develop a functional awareness and sensitivity to the orderliness and beauty in nature.

8) Give the child opportunities for developing manipulative skills that will enable him/her to function effectively in the society within the limits of his/her capacity.

9) Promote scientific literacy for functional living in society.

10) Understand and appreciate events in their environment and stimulate the desire to continue to understand the world around them.

11) Acquire necessary skills and attitudes that will enable them make decisions necessary for solving basic problems in a rapidly changing world, and perform some simple scientific operations needed to earn a living and become useful members of their society; ensure a sound foundation of basic scientific principles and facts in those who may later seek to make a career as scientists, science educators or technologists.

12) Develop awareness of the importance of science and technology in national development.

13) Expose students to practical experiences in physical and biological sciences.

14) The essence of teaching and learning science process skill acquisition is to motivate students' creative output in science and technology. It will also help to increase and strengthen the theoretical and practical scientific and technological bases of the nation. (National Policy on Science and Technology, 1986).

Gagne (1965) maintained that the prerequisite knowledge of concepts and principles of science can be obtained only if the students have certain underlying capabilities - the science processes - which are needed to practise and understand science. This is because he considered science as being of process approach. The acquisition of the process skills by the learners would not only make them to solve some pressing problems involving science but will also make them to see science as being both process and product-oriented. Jans (1975), Adey and Harlen (1986) and Okebukola (1985), see the process approach to science as very significant in the acquisition of skills. This has created new era of science teaching and learning process in the realm of Nigerian education.

Many educators have considered the development of scientific process skills in children to be a major objective of education (Gagne, 1970; Herron, 1970; Neive, 1972; Zeitler, 198). At this instance, there has

been a shift from exclusively teaching of science content for the sake of knowledge to the process that generates skill acquisition in learners including the primary school pupils (Goodlad, 1966; Renner, 1973; Zeitler, 1981).

2.4 Why Process Skill Acquisition is Low (Factors Militating against Science Process Skill Acquisition)

With the great emphasis on the acquisition of skills in science among the junior and senior secondary school students, one would expect almost all the students to acquire the science process skills to help them in day to day living. Okebukola (1985) investigating on the students' acquisition of science process skills using the old WAEC syllabus, found that the Nigerian final year students for West African Examination Council (WAEC) had not acquired the process skills. In his comparison on the degree of acquisition between the "basic" and "integrated" he found that the "integrated" process skills are most affected.

The recent emphasis on the development and acquisition of science process skills grew from two sources. One is the science learning theory of Gagne (1965) as contained in his seminal papers presented to American Association for the Advancement of Science (AAAS). Another is the interpretation of Piagetian theory in terms of the need for child "active learning" (Adey and Harlen, 1986). Various researchers (Good, 1977; Okey, 1982 Adey and Harlen, 1986), have found that the process skills are related to cognitive

functioning. Ryman (1974a, 1974b and 1977) carried out an empirical work on the classification within Biology and came up with an answer that the acquisition of skills for classification of living things is dependent on intelligent level. If cognitive level is related to skill acquisition level, should the factors that affect cognitive development also affect skill acquisition? Again, it would be good to ask if our secondary school students are acquiring the skills in science as envisaged by their science curriculum. Since these youths are our hope for future technological and scientific development it would be of necessity to investigate the factors that facilitate or hinder their acquisition of science process skills with a view to normalising unfavourable situations. Should these students be left to fate, several things may impinge on their progress in the acqusition of science process skills and we may seem not to know the cause of their handicaps in scientific progress. The earlier we know and study the factors that promote or militate against acqusition of science process skills, the more positive will be our way to develop in our youths the skills which are necessary for scientific developments.

Some factors that militate against process skill acqusition include: (a) methodology of teaching (b) Gender influence (c) Family background and (d) Students' environment/location.

According to Ajakaiye (1987) other factors that seriously affect the acqusition of science process skills are as follows: poorly equipped laboratories and shortage of teaching materials and audio-visual aids; lack of relevant curricula and textbooks; inadequate trained science teachers; poor quality of science teaching and poor funding of basic science research in our schools and universities.

a) Methodology of Teaching: As children develop morphologically and physiologically, a tendency arise that they also develop in skills and acquire a lot of them. However, the development and acquisition of these skills are dependent on factors acting within or outside a subject. These factors actually determine the rate and level of development and acquisition of these skills. For instance, in his work, Zeitler (1981) found the competency of the teacher as a force acting to determine the rate and level at which the learners would develop and acquire the skills. If the teacher himself has not acquired the skill which he wants his students to acquire, how will this teacher impart the skills meaningfully and honestly to the trainees? Several studies have been conducted to investigate the effects of training teachers in the process skills and teachers subsequent use of the skills in the classroom (Butts and Raun, 1969; Ashley and Butts, 1972; Briet, 1972)

According to Zeitler (1981), the results of several studies as regards the influence of the competency of the teacher on the development of skills in the learner indicate that trained teachers in the basic process skills tend to (1) have a positive attitude towards them (2) be competent in their use (3) prepare lessons which teach the skills and (4) teach skills in their classroom. Through this process, the child, who has been given to the teacher to acquire the knowledge and skills is exposed to a wider realm of intellectual and cognitive development. In his study on the influence of practice on the acquisition of process skills, Zeitler (1981) used practising teachers to know how practice could influence the acquisition of skills. He came up with a view that constant training or practice helps in the more and more acquisition of skills.

The following teaching methods are essential for imparting of knowledge and science process skills to students and making them learn effectively namely; questioning method, discovery method, practical/experimental method and demonstration method. Above all, the teacher has to arouse interest in the students and motivate them for meaningful learning to take place.

b) Gender Influence: According to Okeke (1990), education in Africa has from the colonial era discriminated against women. Males have always had a head start over women in all

aspects of education. Many African countries have not bothered enough to change the practice and the gap between the sexes continues to widen. Limited access to secondary education for girls means limited chance of science and technology education. The gender stereotyping of science, mathematics, and technology as reflected in the strong masculine image of science, is one strong, penetrating factor inhibiting girls in science and technology. Even after the reduced number of girls are in secondary schools, they receive a different quality of education - the boys are taught science and technical subjects, while the girls are taught Home Economics, Health Science and nutrition, Needlework, some Biology, and rarely physics and chemistry. Many of the all Girls' Schools do not have trained female science teachers and equipment for science education unlike what is obtainable in all Boys' Secondary Schools and because of this boys acquire more science process skills than girls.

Deboer (1987) carried out a research on the achievement in science for males and females. He found out that future achievement is dependent on the previous ability. In his remarks, whether males or females, "students who believe they have ability in science expect to do well in the future and are likely to continue to take science courses". With respect to science skill achievement,

he maintained that "the evidence which is accumulating shows that males usually perform somewhat better on achievement tests in science but females earn equally or better grades in science classes."

Ofoegbu (1984) investigating the gender effect in the acquisition of science process skills among Elementary School pupils found that there were gender related differences. In his work, he discovered that there were gender related differences when the children were taught by either directed discovery method or expository method. Furthermore, Obioma (1986) carried out some work in physics and found that there were gender related differences in performance using either of the methods.

In their investigation on Sex-Related Differences on A Test of Volume and Density, Howe and Shayer (1981), found a sex related difference favouring boys an initial performance of two samples (one British, one America) of 10-and 11-year old children on a task of volume and density. According to them, after a period of classroom instruction that included opportunities for children to interact with appropriate materials and each other both boys and girls performed at a higher level on the task, but the difference between them remained the same.

Many studies have been carried out on the Piagetian stages of cognitive development and the acquisition of skills as it relates to males and females (Deluca, 198 ; Lazarowitz, 1981; Dale, 1970; Modgil, 1974); the result of these works reveal some disparity between the acquisition of skills by males and females. For instance, Deluca (1981) carried out a research involving male and female students. Such a research intended to find the capabilities of both sexes to bend thin rods. In the research, it was found that males performed significantly higher than females. It was also found that males conformed to the Piagetian stages of cognitive development whereas their female counterparts could not conform to the sub-stages of pre-operational stage (2-4 years), intuitive stage (four to seven years) and concrete operations (eight to eleven years).

In his research on the correlations of Junior High School students' Age, Gender and Intelligence with ability to construct classification in Biology, Lazarowitz (1981) found a significant gender difference between boys' classification ability and that of the girls. According to his finding, boys' classification ability was higher than that of the girls in the 7th grade. This finding corresponds with the finding of Witkin et. al (1962) who maintained that boys' analytical thinking scores were higher than that of the girls.

According to Piaget and Inhelder (1967, 1974), there are logical and infralogical grouping of structures which develop during the concrete operational period. According to them logical groupings consider classifications and relationships between sets of discrete objects, for example, in the arrangement of sticks of different lengths in an ascending order. They went further to emphasize that infralogical groupings consider spatial and temporal relationships within continous system, for instance, the construction of a straight line objects. The available data suggest gender related differences in both logical and infralogical grouping of structures. The data also tend to suggest increase in gender related differences with age in favour of males for attainment in science (National Assessment of Education Progress, 1977, 1978).

Sex differences in science achievement have also been given some biological interpretations. According to Fennema and Sherma (1977) and Sherma (1978) these differences are ascribable to differences in the spatial abilities of males and females. Spatial abilities are said to result from innate differences in the nature or degree to which males and females use the right and left hemisphere of the brain for spatial reasoning. Spatial abilities are related to the development of the right hemisphere of the brain. The males are known to use the right hemisphere more than the left. The females use the left more. These differences in spatial

abilities are observable during adolescence, from sixteen years of age. (Fennema and Sherma, 1977)

In his own investigation about Sex Differences in Problem Solving Ability, Graybill (1975) found evidence of a gender difference in problem solving tasks, where girls lagged behind boys in the developments of logical thinking ability as defined by Piaget and Inhelder. As pointed out by Graybill (1975), the differences were beginning to show around the age of eleven years.

In recent years, topics on sex differences in science achievement and sex differences in participation in science courses have received considerable attention (Deboer, 1984a, 1984b, Steinkamp and Maehr, 1983). Most of these works centre on the comparison of intellectual development of the males and females and their consequent acquisition of skills. For instance, Steinkamp's and Maehr's meta-analysis of 406 comparisons of male and female group means showed small but statistically significant effect in sizes in science achievement that favoured men. The results correspond with those of Kelly (1978) and Combert and Keeves (1973) who found slight sex differences in science achievement favouring males in large number of countries across the world.

Treagust (1980) pointed out that the "society considers non-discrimination between males and females to be of paramount importance for comparable academic and employment opportunities between genders." In this case, both males and females should be equally exposed to all forms of learning opportunities for the acquisition of knowledge and skills. In spite of this, recent research indicate that both males and females have not achieved equally in competence involving science and mathematics (Ernest, 1974; Maccoby and Jacklin, 1974; Piburn, 1979). Okebukola (1987) did not consider gender as a significant factor in the skill acquisition in practical chemistry. Bajah (1979) claimed that boys are superior to girls in school achievement. But Wozencraft (1963) found a higher achievement in favour of girls. All these show that a point has not been arrived at on the use of gender as a factor in skill acquisition in science. Hence, among other things, this study will investigate the impact of gender as a factor in the acquisition of science process skills.

c) Family Background: The family is a primary place for learning and socialisation. A child is born into the family. The members of the family, all things being equal, cater for the child. They look after the child for survival and the fate of the child is, to a very high degree, dependent on the attitude of the members of the family towards him. Some children develop the attitude of being introverts

as a result of the way they were brought up by their parents as well as by other members of the family. On the other hand, others learn to be extroverts as a result of their encounter with the members of the family.

Genero (1986) in his consideration of science learning identified museums, planetariums, natural centres and zoological as well as botanical gardens as informal science centres. He views these centres as places where parents could take their children to and learn by themselves the conditions of things as they are by themselves. In these areas, children can learn, along with their parents, the things of life as they are. It is then believed that in enlightened families where parents have acquired sufficient education and where there is fund to permit field trips, children enjoy the act of going with their parents to visit various places of interest and as such learn. According to Averch (1974); Bridge, Judd and Moock, (1979); Centra and Potter (1981) both school and non-school variables are associated with cognitive achievement and consequent acquisition of skills. Among the variables, the students' background variables are of tremendous importance.

In their investigation of the background variables, Schibeci and Riley (1986) pointed out that home environment, home work and parents' educational background had substantial influence on the students' learning. This shows that the economic status of the parents and the conditions of the home in general have impact on the learning of students. According to Walberg and Rasher (1979); Willey and Harmschfeger (1974), Coleman, et. al (1982) there have been some previous researches that have identified family and family size, ethnicity and some economic status of the parents to have some correlations with students' learning. The emphases indicate that the learning of students have some relationship with the nature and status of the family from which they have come. For instance, the relationship between science learning and parental education suggests that students whose parents are more highly educated perform significantly above students whose parents have less education (Haertel, Walberg, Junker and Pascarella (1981); Kremer and Walberg, (1981).

Children attend schools from different family backgrounds. Some go to schools from poor families whereas others go from well-to-do families. Likewise, in some families the parents are illiterates whereas in others the parents are fairly educated or very well educated.

If this is the paramount case, should one then expect all these children who attend school from these divergent families to be alike in mental development or in the acquisition of skills? If there are differences among these children from different family types, how can we come up with a view that the nature of the families is among the factors that help in influencing the children's cognitive level and their acquisition of skills? Scott-Jones (1984) expressed conceptual concerns. She observed that "the context in which parents and children live are important in understanding the family's influence on cognitive development and academic achievement. The family is itself an important context but is embedded in other contexts." She suggested that there should be a need to study "children who develop normally or excel under conditions, such as low-income status. The family may be able to cope with adverse conditions in a manner that prevents the expected effects on the child."

In an examination of possible theoretical environment models, Walberg and Majoribanks (1976) proposed that comprehensive measures of family environments are likely to mediate completely the effects of socio-economic status on children's academic performance. Kahl (1961) suggested that in the lower middle class, it is possible to identify "getting by" and "getting ahead" families.

According to him, in "getting by" families, children are encouraged to enjoy themselves while they were young. The children were told "to stay in high school because a diploma was pretty important in getting jobs but they were allowed to pick their curriculum according to taste" in contrast to his feeling; parents who believed in "getting ahead" started to apply pressure at the beginning of their children's career. They encouraged high marks, paid attention to what was happening at school; stressed that good performance was necessary for success and they suggested various occupations that would be good for their sons (Kahl, 1961).

In his own study, Marjoribanks (1980) investigated the ability and attitude correlates of academic achievements based on family group differences. He found that there are moderate family group differences in children's performance. He also discovered that there are variations in the children ability, attitude toward school and Mathematics achievement. He concluded that:

> In general the study indicated that the family may act as a critical substratum variable that influences the relations between children's attitudinal and cognitive attributes and their academic performance.

However, it has been viewed that in some families the prevailing condition is emotionally satisfying for the learner but academically not satisfying. In their discussion about this, Harmschfeger and Wiley (1976)

identified many families as having Television (T.V). This particular gadget is of vital importance in leisure, but according to them, T.V. has negative impact on academic work due to great amount of time being used in its watching. To what extent can T.V. viewing help in cognitive development and the acquisition of skills? It is well known that although T.V. viewing in some homes interrupts academic work, it appears that it contributes to skill acquisition. For instance, through T.V. some children watch how to sing, how to dance and even how to dissect. Some children, through imitation acquire these skills. In this case, it appears that the socio-economic status of the family helps in boosting skill acquisition.

According to Bloom (1984); Seginer (1983); Walberg (1984); another family background variable that tends to reinforce the acquisition of skills and academic achievement is parental involvement. Parental involvement variables often include components such as actual or perceived expectations for school performance (Keith, 1986); verbal encouragement regarding school work (Marjoribanks, 1983); direct reinforcement to improved academic performance (Karaker, 1972) or general academic guidance and support (Bloom, 1984). Parental attitudes toward child education and career aspirations are related both to student past performance

for direct parental involvement in compensatory education programmes (Keith, et. al, 1986).

In some families, there are already existing beliefs for achievements or for failures in certain areas of human endeavour. The logic about this is that family belief about achievement in certain tasks influence both parents' behaviour and children's performance (Hess, McDevitt and and Chilimei, 1987). A considerable body of research and theory supports this view. Some families have already created the belief for achievement. In such a case, the children born into the families are induced to believe that they were created for achievement purposes. These individuals endeavour to learn with care all forms of skills presented to them. In their investigation in family characteristics, Marjoribanks (1980); Hess and Holloway (1984), found that parents' attitudes towards achievement has some relationship with their children's learning. As a result of inbuilt feeling or belief about the nature of their families, a number of parents compel their children to learn and subject them to certain conditions that would enhance the occurrence of learning. Hence, Hess et. al (1987) pointed out that one way of influencing children's achievement is by promoting the value of their efforts.

On the whole it has become paramount to indicate that the family has some impact on the child's learning. The family takes a responsibility of inculcating into the child, the things that it considers worthwhile. Central to those desirable things that the family imbibes into the child is learning which encompasses the acquisition of knowledge, facts, concepts and skills necessary for the child's future living. Among other things, this study will investigate the impact of the family (family background) on the child's acquisition of science process skills.

d) Student Environment/Location: A large number of home environment variables have been found to correlate with science achievement. For students of various ages, the availability of encyclopedias and newspapers and the presence of science equipment in the home, the use of books and libraries by family members, and the amount of television viewing and time spent on science homework have all been associated with science achievement (Keeves, 1975; Kremer and Walberg, 1981; Miller and Suchner, 1987; Wlaberg, et. al, 1981; Walberg , et. al, 1982; Uguroglu and Walberg, 1986). Other measures of home environment, including father's education and occupation; mother's occupation prior to marriage, religious affiliation, and size of family, are associated with student science achievement (Keeves, 1975).

In his work, Durojaiye (1976), supported the view that environmental influence has impacts on the congnitive development and subsequent acquisition of skills. Children of urban and rural areas may have different experiences. These experiences would likely affect their acquisition of skills. In the urban areas, driving of cars is a common phenomenon. This is not the case in rural areas. In some rural areas, there are no accessible roads for cars to ply. In some rural areas, dwellers spend months without seeing cars. In this case, the experiences of the urban and rural dwellers in relation to car driving differ. If the people in the urban areas are exposed to driving, for them to learn how to drive would be a very easy task. However, for the rural dwellers, the case may not be of the same nature because driving may be a very difficult task for them.

According to Inomiesa (1989), the differences in achievement between urban and rural pupils are said to be due to differential environmental stimulation. The urban school pupils are said to be exposed to the moderning effects of science and technology and so perform better. On the other hand, the pupils in schools in the rural areas have no such experiences on which to draw.

Alcyideino (1989) pointed out that there are many rural areas where the common bicycle is still an object of curiousity, where the most usual means of transport for

goods is still the human head or the backs of animals because of immotorable roads. In some of these areas, the use of pipe-borne water supply is unheard of let alone electricity. In such an environment, therefore, the developing child finds himself growing up without coming into contact with a vast number of stimulus objects on which our modern society depends. The presence or absence of new stimulus objects in the environment has always a significant influence on the development of the child as Piaget pointed out. An illustration of the differences in scientific concept attainment as a result of differential environmental development was provided by a study carried out by Poole (1968) using Hausa children from three areas: very isolated rural localities, city centres and areas of intermediate status. The result strongly indicated that urban children are superior in scientific concept attainment.

Home training is also a necessary way for the development and consequent acquisition of process skills. In some homes, the parents allow their children to explore their environment. These children touch, manipulate and in many instances cause breakages of domestic materials. In doing this, they acquire and acquire skills by trial and error. By exploration, the child develops more cognitive reasoning. In such a home, the child continues to develop what Piaget (1972) refers to as "causal reasoning." Piaget

has enormously contributed to our view on the influence of environment on cognitive development. According to Chauhan (1978), Piaget has studied developmental process of understanding knowledge and working of the child's mind. Researchers (Good, 1977; Adey and Harlen, 1986), have found that the process skills are related to cognitive development. There is indication from their researches that children develop and acquire these process skills in line with their cognitive development.

Piaget (1952) identified three stages of cognitive development in children. The stages are:

i) Sensory-Motor Control Stage: This is the earliest stage of life ranging from the time of birth to two years. At this stage, the child reacts to each object on the basis of its physical characteristics, and symbolic activity is minimal. At this stage the development of skills in the child is very little or absent.

ii) Operational Stage: This stage starts from two to eleven years of age. It involves a gradual increase in the child's ability to extract concepts from experience and to gain control through anticipation of consequences. This stage consists of three substages. The substages include:

a) Pre-Operational stage (two to four years); The child at this stage forms the ability to represent absent things by sounds and by imitative action, internalising the external world and building up images of it in his mind.

(b) Intuitive stage (four to seven years): During this stage the child widens his/her activities and learns to classify objects into permanent features and classes. Ability to compare and contrast at this instance, can be done.

c) Concrete Operations (eight to eleven years): At this stage the child still prefers concrete to abstract things. He/she can now deal with the world of events and things.

iii) Formal Operations Stage: This stage starts from the age of twelve years and proceeds on. At this stage, there is ability to master formal operations through logical deduction and consideration of hypotheses and consequences. The Piagetian theory on the cognitive development goes hand-in-hand with acquisition of skills.

Commenting on the contribution of Piaget to the understanding of how environment helps in the intellectual development and consequent acquisition of skills, Durojaiye (1976) pointed out that:

> Piaget has helped us in our present view of intelligence as a cumulative building up of more complex and flexible experience, what Piaget called "Schemata". This build-up of complex and flexible experience occurs through the interaction of the growing child with his environment. Schemata depend on active exploration and experimentation by the child, and on arousal and reinforcement by the environment. Thus forming a schema or a logical insight is dependent on adequate environmental stimulation and the manipulation of the concrete environment by the child.

The individual's environment directs him towards certain experience. It is the experience that would affect his general reaction within the environment. Contributing to the effect of environment on the development and progress of man, Fafunwa (1967) pointed out that "Sociological and Anthropological studies have enabled us to know that a child's cultural background plays an important part in his growth and development, that amount of social and cultural pressure which he experiences influences the extent to which he could continue to ask questions". Emphasising on the impact of environment on the acquisition of skill and knowledge, Britton (1972) maintained that "teaching occurs in a societal context and so the environment influences the rate of internalisation." In their own contribution, Nnachi et. al (1985) pointed out that "psychology of education has made up to understand that man is made by nature and nurture.

There is, therefore, no doubt that adverse environmental conditions can ruin the potentials of many gifted children."

In Erickson's scheme of eight stages of man, he emphasized the important role of parents and larger environment in helping to develop the human infants' basic trust, confidence, industry etc. In his emphasis on the influence of the environment on the child's development, Erickson (1950) pointed out that "the systems of child training represent conscious attempts at creating out of human raw material that configuration of attitudes which is (or once was) the optimum under the society's particular natural conditions and economic-historic necessities." In his investigation on the influence of environment on science education, Obi (1979) maintained that rural children lack basic amenities which are essential to learning but they are exposed to natural vegetation, rivers etc. On the other hand urban children are exposed to all forms of modern gadgets and equipment, which to some extent, are lacking in rural areas. Environment, therefore, tends to influence one's attitude, skill acquisition and knowledge.

Individuals usually learn to seek the means to achieve the goals they have set for themselves. These usually include the special skills required for the solution of day-to-day life problems. The fulfilment of one's goal and desires usually depend on the environment, among other

factors. In his own contribution on the influence of environment and culture, Maduka (1980) pointed out that:

> Some cultures offer rich opportunities for psychological satisfactions and fulfilment of potentials. Others are limiting, repressive and rigid. Some provide fulfilment opportunities for certain groups but not for others - the leaders but not for followers, the wealthy but not the poor, the men but not the women. But in any group both the goals that an individual learns to seek and the means by which he learns to achieve them depend on the opportunities and limitations of his local setting and on his own role in the group.... Therefore, culture and the environment regulate many of the individual's actions and behaviour.

In his own study about the Ecocultural Factors in Operational Thought, Ehindero (1982) treated environment and culture hand in hand. In any human habitation, it now becomes difficult to separate culture from the human location. This is because a society is made up of a group of individuals who share a way of feeling, reacting, thinking, acting and doing things. In this case, the culture of any group helps in influencing their life within that particular environment. Contributing to this view, Cohen (1971) emphasised that within the context of recent anthropological theory, the concept of culture is now focussed on culture as a group's way of adapting to recurrent problems encountered in its habitat. Ehindero (1982) further pointed out that:

> The basic tenet in this concept is that the interaction of individual's with their habitats (ecological) and the group-shared behavioural patterns that are adapted to the group habitat (cultural) will, no doubt, influence not only their rate of intellectual development but the overall stage the adult individuals of the environment reach their thinking processes.

In this case the environment and culture become interwoven. This is because culture influences the attitude and general behaviour of a people within an environment. Within this environment, the culture may enhance or mutilate the cognitive development of skills. If in a location, the females are forbidden in riding bicycle, how do we think that these females will ever acquire the skill involved in the riding of the bicycle. If the females from the areas where female riding of bicycle is forbidden are compared with the females of another area where the riding of bicycle by females is much allowed, will we expect these two groups of individuals to have equal status in skill acquisition in relation to bicycle riding? According to Ehindero (1982) "ecocultural framework may limit alternative probabilities and possibilities, or constrain the development of certain operational thought processes."

Within ones environment, he interacts with both animate and inanimate objects. He utilises the available materials within the environment. In this case, he influences the environment and the environment on the other hand influences him. The experiences one encounters from

the people that live around him also becomes a source of one's pattern of life. Take for example, some towns have individuals who are zealous and highly aspiring. In such towns, every one tries or almost tries to be like the ones that have achieved. It is believed that this is one of the reasons why some towns have eminent individuals in large numbers. On the other hand, some towns have individuals that do not aspire for very high positions. Such individuals only try as much as they can to meet and satisfy their daily needs. It is believed that this is why some localities have people that are backward.

A number of researchers have carried out some work on the influence of environmental condition on the cognitive development and acquisition of skills (Dasen, 1973; Bovet, 1973; Philip and Kelly, 1975; Kishta, 1979). The results have been the positive and negative influences of the environment. For instance, favourable environmental condition has been found to favour cognitive functioning. Hence Piaget (1972) pointed out that "the formation of operations always requires a favourable environment for " "co-operation" that is, to say, the operations carried out in common." If this is the case, what influence has urban location on the acquisition of skills? Does it enhance or retard skill acquisition in science? What of

the rural location? Does it favour or inhibit skill acquisition in science? This research therefore intends among other things, to investigate the impact of the child's environment on his acquisition of skills.

2.5 Importance of Process Skills in Science

The word "Science" is derived from a Latin word "Scientia" which means knowledge. Conant (1959) defined science as "an inter connected series of concepts and perceptual schemes that have developed as a result of experimentation and observation." Woodbourn and Obourn (1965) described science as "that human endeavour that seeks to describe with ever increasing accuracy, the events and circumstances that occur or exist within our natural environment." Highlighting the nature of science : Opong (1981) pointed out that "science is knowledge obtained by observation and testing of facts." The nature of science encourages the learners to search for and at last find solution to problems. At this instance, science is viewed as an active process. The view of science as a process was reported by the American Association for the Advancement of Science (AAAS) through the publication of a science curriculum entitled Science - A Process Approach (SAPA) in 1967 for elementary schools. It was Gagne (1965) who presented seminal papers to the American

Association for the Advancement of science. In Gagne's papers, science was conceived as consisting of process skills and the papers viewed science as a process. Science process skills, as reported by Good (1977) Adey and Harlen (1986), are thought processes related to cognitive development process. It has been variously used in relation to cognitive functioning and in so many cases the term "process skills" refers to the processing strategies that a person brings to bear in solving a problem. The implication of this is that problem solving is dependent on students' proportional reasoning ability (Gabel and Sherwood, 1983).

The SAPA curriculum of American Association for the Advancement of Science (AAAS) divided process skills into two. The two divisions of the skills are basic process skills and integrated process skills. The basic process skills are observing, classifying, communicating, measuring, using space/time relations, using numbers, inferring and predicting. The integrated process skills are controlling variables, interpreting data, formulating hypotheses, defining operationally and experimenting (AAAS, 1967). However, the skills will be generally considered. Yeany et.al (1986) consider these process skills as providing indispensable avenue for the scientists to solve their

problems. Hence both basic and integrated process skills are essential in the solution of day to day problems.

The question on science process skills has become an indispensable and central focus in science education. According to Berger (1982), the measurement of the students' use of science process has been a goal of science education since the late 1960s, when the curricula materials emphasising the process approach to teaching science appeared. The development of science - A Process Approach has resulted to the focus on problem solving skills in science education. Science processes have now become indelible aspect of science learning.

Realising the importance of skills in the solution of science problems, the Federal Government among other things, states in the National Policy on Education (1981) that:

> The Junior Secondary School will be both prevocational and academic and will teach all the basic subjects which will enable pupils to acquire further knowledge and develop skills.

The earlier a child is exposed to these skills, the more he becomes familiar with them. With these skills, the child finds it easy to explore his environment and solve certain challenging problems facing him in the area of science.

The nature of science, as has been described warrants a need for a good foundation of it to be laid in our children and youths if Nigeria is to achieve scientific break-

through. Year after year, many Nigerians are sent out by the country to acquire scientific and technological skills. The hope is that these Nigerians will return to the country to use the acquired skills to solve the country's scientific and technological problems. However, if the skills are developed in our youths early in life, the government may see no reasons to send these people to oversea countries for the acquisition of science skills and as such a lot of fund would be conserved (saved).

Through the acquisition of science process skills, rote learning is minimized or even stopped and science is then seen as a productive and practical oriented venture. At this instance, what the teacher impafts to the students are regarded as more meaningful for the solution of day to day problems. The teachers' work in the area of science is much more appreciated and more easily understood. Furthermore, the acquisition of science process skills · help the child to develop self confidence and self reliance about, and the understanding of the world around him. The acquired process skills also help him in the meaningful exploration of his environment, and the child is placed at a position of solving his world problem.

The Government of the Federal Republic of Nigeria seems to be adequately aware of the need for the acquisition of the science process skills. The government organised a

national curriculum conference in 1969 one of whose outcomes was the revision of subject curricula at different levels of education to lay more emphasis on the acquisition of skills. Following this, various bodies and associations have contributed to ensure the development of such curricula that would emphasise the acquisition of process skills. Such curricula include the Nigerian Primary Science Project (NPSP), the Nigerian Secondary School Science Project (NSSSP), the Nigerian Integrated Science Project (NISP). The NSSSP is a curriculum in Biology, Chemistry and Physics and was developed by the Comparative Education and Adaptation Centre (CESAC). Several science bodies such as Science Teachers Association of Nigeria (STAN), National Education Centre (NEC), etc. have contributed immensely to the development of the various science curricula. Recently, the curricula for junior and senior secondary school science have been developed. Such curricula include integrated science curriculum for junior secondary schools and science curriculum for senior secondary schools which consists of Biology, Chemistry and Physics.

2.6 Recent Studies on Process Skills in Science

The conception of science as a process was developed out of the need to evolve effective teaching and understanding of science. It was the seminal papers of

Gagne (1965) that generated enthusiasm in the conception of science as a process. This view was facilitated by Piagetian theory of cognitive development. In his consideration about the acquisition of skills, Piaget considered the acquisition of skills as occurring stage by stage in the learner.

As noted by Zeitler (1981), some educators such as Herron, Neie, Gagne "consider the development of scientific process skills in children to be a major objective of education". The epistemologic basis of Gagne's postulation on science processes is the belief that knowledge grows by induction through sensory experience with one's environment. However, by implication the views of Gagne and other workers who share similar opinions about science require children to practise what scientists do; and this is the emphasis of the process approach to the study of science.

Looked at critically, concept (content) and process approaches to science are two sides of the same coin. Phenomena in nature are interpreted through the use of concepts; but interpretation involves mental skills which scientists employ in arriving at decisions about concepts. These are termed science process skills. The fifth edition of the Concise Oxford Dictionary (1964) defines skill as "expertness, practised ability, facility in doing something, dexterity, tact". Skill behaviour therefore, is behaviour

that indicates dexterity, expertness or proficiency.

Victor (1975) noted the need to stress both concept and process approaches to science when he stated that "the science programme should provide children with ample opportunity to to learn some of the key concepts and conceptual schemes that play such important part in their daily lives, their environment, and the world in which they live. He went further to state that children "should be given practice in leafning how to think critically and creatively. As they perform these operations they will learn concepts and conceptual schemes, and they will develop such desirable behavioural outcomes as scientific skills, attitudes, appreciations and interests." The belief among science educators that both approaches lead to the same goal of developing scientific spirit in children was precisely put by Nwana (1972) when he stated as follows:

> In fact it is commonly held that both approaches (concept and process approaches) to science teaching if properly utilized, will bring about the required scientific minds in the pupils"

Many researchers have explored several avenues on issues relating to the development and acquisition of science process skills. Some have investigated the matter on the bases of the level of acquisition. Some have investigated the matter on the bases of the methods of teaching that enhance process . skill acquisition

(Nwosu, 1987). Obioma (1986) used two teaching methods - guided discovery and expository methods to present Physics tasks to a random sample of 120 secondary school class three students. He used the methods concurrently in the same school. His result showed that generally, the guided-discovery approach to presenting physics tasks produced significantly higher gains in achievement than the expository approach. He also found that female students exposed to the discovery method performed better than the male students exposed to the expository method. His results are consistent with those of Nworgu (1985). He compared the effects of the two teaching methods on performance alone and across gender type and not within gender type. However, his result contradicts that of Nworgu who found that there was no significant difference in performance between males and females taught by discovery and expository methods respectively. Obioma's result shows that the discovery method is superior to the expository method even across gender types while Nworgu's result indicates that the expository method is much an effective method (of teaching chemistry) as the discovery when the students for the expository teaching are famales.

The purpose of the study by Strawitz and Malone (1987) was to compare the effects of two methods of instruction designed to teach pre-service elementary teachers to acquire and retain integrated science process

skills. In one section, instruction was provided by written self-paced, self-instructional materials. Results indicated that the self-instructional method was significantly more effective than the teacher-directed method.

Riley (1979) studied the effects of independent teaching and vicarious hands of teaching methods on acquisition of science process skills. His subjects were pre-service teachers. He found no significant difference in acquisition of science process skills between subjects taught by the two teaching methods.

Jaus (1975) ascertained the effectiveness of integrated science process skills instruction on prospective elementary teachers' (1) achievement on the integrated science process skills (2) selection of integrated science process skills instructional objectives (3) writing of integrated science process skill instructional objectives in lesson plans (4) writing of integrated science process skills learning activities in lesson plans and (5) attitude towards the use of these skills in the elementary classroom. He found no significant difference in all the variables tested.

Zeitler (1981) also studied the effect of teaching methods on acquisition of science process skills by pre-medical and pre-dental students in medical and dental schools.

He also found no significant differences among the students.

Ofoegbu (1984) has investigated the acquisition of science process skill on the basis of the curriculum in use; and some researchers have investigated the matter on the bases of those factors that militate against the acquisition of science process skills, for example, gender influence (Obioma, 1986); home background (Genero, et. al 1986); teaching method (Ali, 1986). Vessels (1965) argued that the home together with the school determine the store of knowledge as well as attitudes, appreciations, skills and thought processes in an individual which enable him to utilize his knowledge and prepare him to live in large society.

With regards to richness of home environment, Stewart (1977) again believed that a child in such environment develops cognitive skills which helps him to think, reason, handle symbols and to understand scientific enterprise and concepts. Furthermore, location of the home has a lot of part to play, that is why Boocock (1980) cited a research done in U.S.A. between Baltmore city children and rural Maryland children. He found out that:

> the more children's place of residence isolated them from exposure to the media, the more the children are to be retarded in certain skills.

2.7 Summary of Literature Review

In this chapter two, we have pointed out that science is the way through which we understand the natural phenomenon. We have reviewed literature on (i) importance of science; (ii) methods of teaching science and influence on achievements, interests and motivation; (iii) essence of teaching and learning science process skills acquisition; (iv) why process skill acquisition is low (that is, factors militating against the acquisition of science process skills); (v) importance of process skills in science; and (vi) recent studies on process skills in science.

Piaget (1952) pointed out that the acquisition of science process skills among children occurs stage by stage according to their cognitive development. Ofoegbu (1984) found out that the level of acquisition of science process skills vary from child to child due to the influence of those factors that hinder the acquisition of science process skills.

In her investigation on the acquisition of science process skills, Nwosu (1987) found that method of teaching influences the acquisition of skills by either males and females. She found that by using Directed-Discovery method, the females performed better than males in the acquisition of skills but by using Demonstration methods, the males performed better. All these show that a point has not been

arrived at on the use of gender as a factor in skill acquisition in science. Hence, among other factors such as students' environment/location, family/home background, teaching methodology; this study will investigate the impact of gender as a factor in the acquisition of science process skills.

CHAPTER THREE

RESEARCH METHODOLOGY 79

This study tried to find out the factors involved in the acquisition of science process skills by the Senior Secondary School students. Presented in this chapter are research design, population, sample, instrumentation, data collection procedure and method of data analysis.

3.1 Area of Study

The area under study was Abakaliki Education Zone of Enugu State - Nigeria and the research was carried out among the senior secondary school students in the zone.

3.2 Research Design

This study is a survey on the factors involved in the acquisition of science process skills by the senior secondary school students. It is, therefore, a descriptive design and involved the use of questionnaires and observation. This study is said to be descriptive because the researcher was interested in investigating the extent of existence of process skills without manipulating any variables.

3.3 Population

The target population for the study was made up of all the senior secondary I students from two hundred and ninety (290) secondary schools in Enugu State, the parents of the SS I students and the SS I Science teachers (that is, Biology, Chemistry, Physics, Mathematics and Agricultural Science

teachrs). The reason for using the SS I students is that they might have attained formal operations stage which according to Piaget (1952) starts from the age of 12 years onwards. According to him, there is ability to master formal operations through logical deduction and consideration of of hypothesis. Another reason for using SS I science students for this research work is that they have at least completed 3 years study in integrated science.

This study had to involve parents because from them responses would be provided in order to determine the impact of home background. The science teachers/educators were used in order to find out those science process skills that are fundamental to science learning in secondary school science classes.

The last publication (1993) of Statistics Unit, Planning and Research Division of Ministry of Education, Enugu reveals that Enugu State has about 290 secondary schools in its 3 Education Zones as shown in Table 1:

Table 1: Showing Number of Secondary Schools per Education Zone of Enugu State of Nigeria

Education Zone	No of Male Schools	No of Female Schools	No of Mixed School	Total
Abakaliki Zone	16	7	26	49
Enugu Zone	36	47	59	142
Nsukka Zone	31	25	43	99
Total	83	79	128	290

3.4 Samples and Sampling Technique

Out of the three (3) education zones in Enugu State with their numerous secondary schools, only one education zone was randomly sampled. The randomly sampled education zone is Abakaliki. Within Abakaliki education zone, eight (8) secondary schools were sampled by means of stratified random sampling. Stratified random sampling was used to ensure that male secondary schools, female schools and co-educational (mixed) schools were used in equal proportions to avoid bias.

Eight Secondary Schools were considered ideal because the study also involved observation of the students. In order to get meaningful observation results, a relatively small number of schools had to be used.

In each secondary school, a total of ten (10) students were used for the study. The students were randomly composed to avoid bias. This random selection was done by balloting without replacement. Within the eight (8) secondary schools, a total of eighty (80) Senior Secondary I students were used for the research. All the parents of the 80 randomly composed students were used for the study. Eight (8) science teachers (educators) of the secondary schools h who teach SS I students were also used for the researeh work. The secondary schools within

Abakaliki education zone used for the study are as follows: Abakaliki High School (PRESCO) Abakaliki; Girls' High School Azuiyiokwu Abakaliki, Model Comprehensive Girls Secondary School, Abakaliki; Command Secondary School, Abakaliki; Boys' Secondary School, Ezzamgbo; Ntezi Community Secondary School, Ntezi in Ishielu L.G.A.; Izzi Girls Secondary School (Holy Child Sharon) - Inyimagu and Special Science School, Igbeagu Izzi.

The table below shows the number of students selected randomly from each school.

Table 2: Showing the Number of Students randomly Composed from the Randomly Selected Secondary Schools.

Schools	Abakaliki (Boys) High School (PRESCO) Abakaliki	Boys' Sec. School Ezzamgbo	Special Science School, Igbeagu Izzi	Girls High School Azuiyiokwu Abakaliki	Model Comprehensive Girls Sec. School Abakaliki	Izzi Girls Sec. School (Holy Child Sharon) Inyimagu	Command Sec. School, Abakaliki	Ntezi Community Secondary School Ntezi	Total
Male	10	10	10	-	-	-	5	6	41
Female	-	-	-	10	10	10	5	4	39
Total	10	10	10	10	10	10	10	10	80

The table below illustrates the distribution of schools by location (that is Urban and Rural Secondary Schools.

Table 3: Randomly Sampled Urban Secondary Schools in Abakaliki Education Zone

	Abakaliki High School (PRESCO) Abakaliki	Girls High School Azuiyiokwu, Abakaliki	Model Comprehensive Girls Secondary School, Abakaliki	Command Secondary School, Abakaliki	Total
Type of School	Male School	Female School	Female School	Mixed (Co-educational	
Male	10	-	-	5	15
Female	-	10	10	5	25
Total	10	10	10	10	40

Table 4: Randomly Composed Rural Secondary Schools in Abakaliki Education Zone

	Boys Secondary School, Ezzamgbo	Special Science School, Igbeagu Izzi	Izzi Girls Sec. School, Inyimagu (Holy Child Sharon)	Ntezi Community Secondary School Ntezi	Total
Type of School	Male School	Male School	Female School	Mixed (Co-educational	
Male	10	10	-	6	26
Female	-	-	10	4	14
Total	10	10	10	10	40

3.5 Instrumentation

For this research three types of instruments were used. One type is a form of rating scales which the researcher refers to as Science Process Skill Scale. This instrument indicates the presence or absence of a skill. If the skill is present, the scale measures the extent to which it is present. Hence the instrument combines the characteristics of rating scale and checklist.

Furthermore, in order to be more objective in scoring across secondary schools, there was a need to develop a test which was used to measure the extent of acquisition of process skills by the students. The rating of the students acress schools was based on this test. The researcher refers to the test as Test of Science Process Skills (TSPS). Questions were drawn from the test and the students were rated based on their responses.

Another type of instrument used for the study was questionnaire. Two questionnaires were used. On questionnaire was constructed for parents to elicit responses about the family background of the students so as to enable the researcher relate family background variables to science process skill acquisition among SS I students. The rationale behind using questionnaire for parents' responses was due to the fact that the researcher was

unable to go from house to house to interview the parents, so in order to get information about family background variables there was, therefore, a need to use questionnaire. This method of data collection was considered easier and less time consuming since a great number of the parents lived far distances away from the school and it was considered very difficult to search for the parents of the students.

The researcher was aware of the fact that some parents are illiterates and as such may be unable to comprehend the questionnaire or answer objectively. Based on this awareness, the language of the questionnaire was simplified to enable interpreters make proper interpretation of the information in the questionnaire.

Another instrument used for the study was the Determination of Science Process Skill Questionnaire which was constructed for SS I science teachers. The rationale behind the use of this questionnaire was to find out those science process skills that are fundamental to science learning in secondary school classes.

Instrument Construction: Three separate instruments were used in collecting the data for answering research question and testing hypotheses. These instruments are as follows: Science Process Skill Scale, Test of Science Process Skills, and Questionnaires for students' parents and science teachers.

Science Process Skill Scale was used to find out the presence or abscence of a skill, and the extent to which a skill is present. Test of science process skills was used to measure the extent of acquisition of process skills by the SS I students. The questionnaire for parents was constructed to elicit responses about the family background of the students so as to enable the researcher relate family background variables to science process skill ecquisition among SS I students. The rationale behind the construction of questionnaire for science teachers was to find out those science process skills that are fundamental to science learning in secondary school classes.

(i) Science Process Skill Scale (SPSS): This instrument (SPSS) was constructed for observational purposes. The instrument uses a 4-point scale for each process skill. In order to be more objective in the observation, some areas of concentration were mapped out for each process skill. The reason for this was that an observer had to base on certain dimensions in rating the students so as to create uniformity across secondary schools.

(ii) Test of Science Process Skills (TSPS): The researcher was aware of the fact that since she was not going to observe all the 80 (eighty) students by herself alone, the science teachers who assisted might fake some answers. Based on this assumption, a need arose that there should be

a test which the students should answer in order to rate them objectively. Such a test was constructed based on the process skills the researcher wanted to concerntrate on. The science process skills used for this research were observing, classifying, experimenting, measuring, communicating, using space/time relations, inferring and predicting. In constructing the test, all the dimensions of the skills under study were taken into consideration. Each item of the test had to base on the dimensions so as to rate the students accordingly.

(iii) Questionnaires: Two questionnaires were constructed. One questionnaire was constructed for students' parents and the other was constructed for science teachers/educators. From the parents' questionnaire, the researcher wished to investigate the relationship between home environment and the students level of acquisition of science process skills. In order to do so, the parents' level of education, their work sectors, annual incomes and home treatment of their children were considered. These were done in order to elicit responses concerning the educational status of the parents of the children, their socio-economic status and their level of motivation.

From the questionnaire for science teachers, the researcher wanted to find out those science process skills that are fundamental to science learning in secondary school science classes.

(iv) Response format and Weighting of the Questionnaires

Likert response format (4-Point Scale of Likert instrument) was used for the two questionnaires. The two questionnaires had four response format weighting. The weighting of the parents' questionnaire was:

Strongly Agree (SA) - 4 points

Agree (A) - 3 points

Disagree (DA) - 2 points and

Strongly Disagree (SD) - 1 point.

However, the weighting for science teachers' questionnaire was:

1 - least useful process skill

2 - useful progess skill

3 - very useful process skill and

4 - most useful process skill.

(v) Reliability and Validity of the Instruments:

Test - retest method was used to establish the reliability of the test of science process skills and the questionnaires using secondary schools in Abakaliki Local Government Area. Utilizing Pearson's Product Moment Correlation Co-Efficient (r), the test of science process skill was of a coefficient of 0.78 whereas the questionnaires were of the coefficient of 0.86 indicating that the two instruments were of high reliability.

The validity of the instruments was established by determining their face validity. This was done by giving the instruments to science teachers and science education experts to validate. Through validation, seven items of the test of science process skills were rejected and replaced by new items. The questionnaire items were also validated by science education experts. Only the accepted items of the questionnaires were used for the final study.

3.6 Data Collection Procedure

The researcher was fully involved in the observation of the students used for this study but she could not reach to the eighty (80) students who were used for the research. This was due to limitation of time. For this reason, the services of some colleagues were employed and the SS I science teachers in the different schools were consulted to help test and observe the students whom the researcher could not reach. The observation did not take place during teaching, rather the exercise was carried out when the students were tested using the test of science process skills. Students were rated based on their ability to respond to the items of the test.

Before the students were rated, they were given questionnaire to give to their parents to fill. Each student was given two copies of the questionnaire to give to his/her father and mother. Some copies of the parents'

questionnaire were not returned and some copies were returned unfilled. Out of the eighty (80) families that were given the questionnaire, sixty eight (68) families returned them. This indicates that only twelve (12) families failed to return their filled questionnaire.

The researcher also administered questionnaire on science teachers. All the eight science teachers involved in the study responded. The length of data collection (which included testing, observation and rating of the students as well as the administration of the questionnaires on the parents and science teachers) varied substantially from school to school depending on the co-operation of each secondary school. After the field work, the instruments were hand collected by the researcher.

3.7 Method of Data Analysis

Descriptive and inferential statistics were used in the analysis of the data. The research questions were answered by means of descriptive statistics using means and standard deviations (S.D).

The first research question was answered by computing the mean scores of each science process skill and judgement was made based on them.

The second research question was answered by computing the mean scores of the means in all the eight selected science process skills. Judgement was made based

on the comparison of the mean scores of the students in the eight selected process skills. Also the mean scores of the questionnaire were computed and judgement was made based on them.

The four research hypotheses were tested by the use of t-test for independent samples. The mean scores of the students were computed. Using the mean scores, the first, second, third and fourth hypotheses were tested at 0.05 (5%) level of significance. The formular for the t-test is:

$$t = \frac{\bar{X}_1 - \bar{X}_2}{\sqrt{\frac{\sum f x_1^2 + \sum f x_2^2}{n_1 + n_2 - 2}\left(\frac{1}{n_1} + \frac{1}{n_2}\right)}}$$

where

$\bar{X}$ = mean

X = Deviation scores

n = Number of cases (Students)

$\sum$ = Summation.

CHAPTER FOUR

RESULTS OF THE STUDY

This chapter deals with data organisation, analysis and results of the study.

Six research questions were asked and four hypotheses were formulated to guide the research. In order to answer the research questions and test the hypotheses, this chapter has been divided into six sections namely:

Section 1: This section one answered the first research question. This research question intended to investigate the process skills that are necessary for learning science in secondary schools.

Section 2: This section answered the second research question. This research question intended to find out the process skill out of eight selected process skills that the senior secondary school science students demonstrate greater acquisition.

Section 3: This section tested the first hypotheses (H_{o1}) at 0.05 significant level to find out whether there is any significant difference between boys and girls in the acquisition of science process skills.

Section 4: This section tested the second hypothesis (H_{o2}) at 0.05 significant level to find out whether there is any significant difference in the acquisition of science process skills as a result of socio-economic status.

Section 5: This section tested the third hypothesis (H_{03}) at 0.05 significant level to find out whether there is any significant difference in the level of acquisition of science process skills between the students in Urban Secondary Schools and those in Rural Secondary Schools.

Section 6: This section tested the last hypothesis (H_{04}) at 0.05 significant level to investigate whether there is any significant difference in the acquisition of science process skills due to family (Parental) educational status.

Research Question One:

Research question one asks what science process skills are necessary for learning science in secondary schools. The data testing this question is presented in Table 5.

Table 5: Mean Rating by Science Teachers on Science Process Skills and their Classification or Interpretation.

S/No	Science Process Skills	Mean Rating	Remarks
1.	Experimenting	3.90	Most Useful
2.	Observing	3.63	Most Useful
3.	Interpreting Data	3.25	Very Useful
4.	Communicating	3.00	" "
5.	Manipulating Instruments	3.00	" "
6.	Predicting	2.75	Useful
7.	Questioning	2.63	Useful
8.	Measuring	2.63	Useful
9.	Using Space/Time Relations	2.63	Useful
10	Formulating Hypothesis	2.63	Useful
11	Inferring	2.50	Useful
12	Classifying	2.40	Least Useful
13.	Making Operational Definitions	2.25	Least Useful
14	Controlling Variables	2.13	Least Useful
15.	Formulating Models	2.13	Least Useful
16.	Counting	1.75	Not useful

However, included by some science teachers as being useful in learning of science in secondary schools are preparation of chemicals/specimens, carefulness, curiousity and students' attentiveness in class during science lessons.

The following interpretations are given the mean rating of science process skills namely:

Below 2 = not useful

2.00 - 2.49 = Least useful

2.50 - 2.99 = Useful

3.00 - 3.49 = Very useful

3.50 - 4.00 = Most useful

As shown in Table 5, "counting" is regarded as not being useful in learning of science in secondary schools. However, "experimenting" and "observing" are included in the category of most useful skills. Those science process skills which are regarded as being very useful include "interpreting data", "communicating" and "manipulating instruments." The rest science process skills are included in the category of useful and least useful.

Research Question Two

In which of the selected eight process skills do the Senior Secondary Science students demonstrate greater acquisition?

In order to answer this research question, all scores obtained by the students in each of the selected process skills were added up. The mean scores of the students for each of the science process skill were computed.

Judgement as regards the selected process skills which the students demonstrated greater acquisition was made based on the computed means.

Table 6: Mean Scores of Students for the Selected Science Process Skills

SCHOOLS	Number of Students	Observing	Classifying	Measuring	Experimenting	Using Space/ Time Relations	Communicating	Inferring	Predicting	Total
Abakaliki High School (PRESCO) Abakaliki	10	12	28	10	11	14	11	0	24	110
Girls High School Azuiyiokwu, Abakaliki	10	20	20	5	27	16	10	0	8	106
Model Comprehensive Girls' Sec. School, Abakaliki	10	28	28	14	20	21	9	12	12	144
Command Sec. School, Abakaliki	10	16	34	12	21	26	25	0	26	160
Boys Secondary School, Ezzangbo	10	27	17	12	8	16	8	4	9	101
Special Science School Igbeagu	10	21	29	12	9	19	16	4	17	127
Izzi Girls Secondary School, (Holy Child Sharon) Inyimagu	10	13	19	16	14	18	6	2	14	102
Ntezi Community Secondary, SSchool, Ntezi	10	27	20	16	7	17	7	4	13	111
Total	80	164	195	97	117	147	92	26	123	961
Mean ($\bar{X}$) Scores	-	2.05	2.44	1.21	1.46	1.84	1.15	0.33	1.54	12.02

H_{01} (Hypothesis One):

There is no significant difference ($P < 0.05$) in the acquisition of science process skills between boys and girls as measured by their mean process skill scores.

In order to test this hypothesis the mean scores of the boys as well as that of the girls were computed. Comparing the mean score of the boys with that of the girls, it was found that the mean score of the girls was greater than that of the boys. To ascertain whether the mean scores were significantly different, the hypothesis was tested at 0.05 significant level using t-test for independent samples.

Table 7: Data Showing t-ratio Comparison of Mean Significance between Boys and Girls

Gender	N	Mean	S.D	Calculated t-ratio	Critical t-value CV	P	Decision
Males	43	11.37	3.35	0.33		0.05	Null Hypothesis is accepted
Females	37	11.54	3.07		2.000		

C.V. = Critical value of t

The data in table 7 indicate that 43 male students and 37 female students were involved in the study. From the table, the male students had a mean of 11.37 with a standard deviation of 3.35. However, the female students had a mean of 11.54 with a S.D. of 3.07. By mere

observation, the two means are different but to determine whether there was any significant difference in the two means, the hypothesis was tested at 0.05 significant level. The calculated t (0.33) was less than the critical value of t (2.000) and based on that, the hypothesis was accepted. This means that there was no significant difference in the acquisition of science process skills between boys and girls as measured by their mean process skill scores.

Hypothesis Two (H_{02})

There is no significant difference ($P < 0.05$) in the acquisition of science process skills between the students from families of average/high socio-economic status and those from families of low socio-economic status as measured by their mean process skills scores.

In order to test this hypothesis, the mean score of those students from families of average/high scoio-economic status was computed. The mean score of those from famibies of low socio-economic status was also computed. The two means were compared. By comparison it was found that the mean score of students from families of average/high socio-economic status was greater than that of those from families of low socio-economic status. To ascertain whether the mean scores were significantly different, the hypothesis was tested at 0.05 significant level using t-Test for independent samples.

Table 8: Data Showing t-ratio Comparison of Mean Significance between the Scores of Students whose Families are of average/high Socio-Economic Status and those whose Families are of low Socio-Economic Status.

Socio-Economic Status	N	Mean	S.D	Calculated t ratio	CV (Critical t-value	P	Decision
Average/ High	28	14.64	2.59	8.09	2.000	0.05	Null Hypothesis Rejected
Low	40	9.75	2.37				

The data of Table 8 indicate that 28 students came from families of average/high socio-economic status while 40 came from families of low socio-economic status. From the table, the mean score of the students from families of average/high socio-economic status was 14.64 with a standard deviation of 2.59. On the other hand, the mean score of those students from families of low socio-economic status was 9.75 with a standard deviation of 2.37.

The families were divided into two by the researcher. Those families whose income ranged from ₦8,000 to ₦16,000 were considered as families of average socio-economic status. However, those families with an annual income more than ₦16,000 were regarded as families of high socio-economic status. On the other hand those families with annual income less than ₦8,000 were taken as families of low socio-economic status. These divergent families were broadly divided into families of average/high socio-economic status and families of low socio-economic status.

From the data of Table 8, it can be seen that the means of the students from these two families groups were different. The hypothesis was tested at 0.05 significant level in order to determine whether the two means were significantly different. Since the calculated t (8.07) was greater than the critical value of t (2.000), the null hpothesis was rejected and the alternative hypothesis accepted. This means that there is sighificant difference in the acquisition of science process skill between the students from families of average/high socio-economic status and those from families of low socio-economic status.

Hypothesis Three (H_{03})

There is no significant difference ($P < 0.05$) in the acquisition of science process skills between the students in urban secondary schools and those in rural secondary schools as measured by their mean process skill scores.

In order to test this hypothesis, the mean score of the students in the urban secondary schools was computed. Also the mean score of the students in rural secondary schools was computed. To ascertain whether the difference in the two mean scores of the urban and rural secondary school students were significantly different, a t-test for independent samples was calculated using the mean scores of urban and rural secondary school students. The result is shown in table 9 below.

Table 9:. Data Showing t-ratio Comparison of Mean Significance between the Scores of Urban and Rural Secondary School Students.

Location	N	Mean	S.D	Calculated t value	CV	P	Decision
Urban	40	12.85	3.17	2.77	2.000	0.05	Null Hypothesis is rejected
Rural	40	10.85	3.30				

The data of Table 9 indicate that 40 students were drawn from urban secondary schools and also 40 students were drawn from rural secondary schools. Students of the urban secondary schools had a mean of 12.85 with a S.D. of 3.17. On the other hand, the rural secondary school students had a mean of 10.85 with a standard deviation of 3.30. The two means by inspection are not the same in magnitude. In order to determine whether the difference between the two means were significantly different, the hypothesis was tested at 0.05 significant level. The calculated t was 2.77 and the critical value (CV) for t at 0.05 level of significance was 2.000. Therefore, since the calculated t was greater than the cirtical value of t, the hypothesis was rejected. This means that these was significant difference in the acquisition of science process skills between urban and rural secondary school students as measured by their mean science process skill scores.

Hypothesis Four (H_{04})

There is no significant difference ($P < 0.05$) in the acquisition of science process skills between the students whose parents are fairly/highly educated and those whose parents are not/little educated as measured by their mean process skill scores.

In order to test this hypothesis, the mean score of those students whose parents are fairly/highly educated was computed. The mean score of those whose parents are not/little educated was also computed. The two means were compared. By comparison it was found that the mean scores of the students whose parents were fairly/highly educated were greater than the mean scores of those whose parents were not/little educated. In order to ascertain whether the mean scores were significantly different, the hypothesis was tested at 0.05 significant level using t-Test for independent samples.

Table 10: Data Showing t-ratio: Comparison of Mean Significance between the Scores of Students whose parents are fairly/highly educated and those whose parents are not/little educated.

Parents' Education	N	Mean	S.D	Calculated t	C.V	P	Decision
Fairly/ Highly Educated	23	14.35	2.42	5.02	2.000	0.05	Null Hypothesis is rejected.
Not/Little Educated	45	10.51	3.25				

The data of table 10 indicate that the parents of 68 students who submitted (returned) their parents' filled questionnaires were from families of different educational backgrounds. Those parents regarded as fairly educated are those who went to secondary school as well as those who attained other educational level little above the school certificate level. Parents categorised as highly educated were those who attained up to first degree level or its equivalent. However, parents regarded as not educated were those who did not attend primary school; and those considered as little educated were parents who attained nearly and up to First School Leaving Certificate level.

The students whose parents were fairly/highly educated had a mean of 14.35 with a standard deviation of 2.42. On the other thand, those students who parents were not/little educated had a mean of 10.51 with a standard deviation of 3.25. By mere observation, the two means are different but to determine whether there was any significant difference in the two means, the hypothesis was tested at 0.05 significant level. The calculated t (5.02) was greater than the critical value of t (2.000) and based on that, the null hypothesis was rejected. This means that there is significant difference in the acquisition of science process skills between the students whose parents are fairly/highly educated and those whose parents are not/little educated.

Summary of Data Analysis

The following constitutes the summary of data analysis and the results of the data analysed. The first research question intended to find out those science process skills that are fundamental to science learning in secondary school science classes. Table 5 shows that "Counting" is regarded as not being useful in learning of science in secondary schools. However, "experimenting" and "observing" are included in the category of most useful skills. Those science process skills which are considered as being very useful include "manipulating instruments", "interpreting data" and "communicating". The rest science process skills are included in the category of useful and least useful.

The second research question intended to find out the process skill out of the eight science process skills that the SS I science students demonstrate greater acquisition. Table 6 answered the research question and shows that the process skill of "classifying" had the highest mean score which indicated that SS I science students demonstrated greater acquisition of it. However, the process skill of "inferring" had the lowest mean score and was the least demonstrated by the students.

The result of the first hypothesis was summarized in Table 7. The table shows that the calculated t (0.33) was less than the critical (table value of t (2.000) and based

on that, the hypothesis was accepted. This means that there was no significant difference in the acqusition of science process skills between boys and girls as measured by their mean process skill scores.

The result of the second hypothesis was summarized in Table 8. According to this table, the mean score of the students from families of average/high socio-economic status was 14.64 with a standard deviation of 2.59. On the other hand, the mean score of those students from families of low socio-economic status was 9.75 with a standard deviation of 2.37. At the probability level of 0.05, the result showed that students from families of average/high socio-economic status acquired more science process skills than those from families of low socio-economic status indicating that there is significant difference in their mean scores. Therefore, the null hypothesis was rejected.

The result of the third hypothesis was summarized in table 9. The data show that students in urban secondary schools within Abakaliki education zone of Enugu State acquired more science process skills than those in the rural secondary schools. The mean score of process skills of the students in urban secondary schools was 12.85 with a standard deviation of 3.07. On the other hand, the mean score of process skills of students in rural secondary

schools was 10.85 with a standard deviation of 3.30. At the probability level of 0.05, it was found that there is significant difference in the acquisition of science process skills between urban and rural secondary school students.

The result of the fourth hypothesis was summarized in table 10. The mean score of students whose parents are fairly/highly educated was 14.35 with a standard deviation of 2.42. However, the mean score of those students whose parents are not/little educated was 10.51 with a standard deviation of 3.25. The hypothesis was tested at a probability level of 0.05. At this probability level, calculated t (5.02) was greater than the critical value of t (2.000), thus the null hypothesis was rejected. This means that there is significant difference in the acquisition of science process skills between the students whose parents are fairly/highly educated and those whose parents are not/little educated.

CHAPTER FIVE

DISCUSSION OF RESULTS, CONCLUSIONS, IMPLICATIONS AND RECOMMENDATIONS

In this chapter, the results of the study were discussed and conclusions were presented while their educational implications were examined. The limitations of the study were stated while recommendations and suggestions for further studies were made.

5.1 Research Question 1

The analysis and interpretation of research question one revealed that science process skills like "experimenting" and "observing" are the most useful skills for learning science in secondary schools. Process skills such as "manipulating instruments", "interpreting data" and "communicating" are very useful. However, Table 5 revealed that the process skill of "counting" is not useful for learning science in secondary schools because it has the least mean rating by science teachers.

Research Question 2:

This research question intends to investigate the process skill out of the eight science process skills which the SS I science students demonstrate greater acquisition. Table 6 indicated that the students had demonstrated highest acquisition of the skill in "classifying" of objects. At the formal operations stage, students normally attain the level of the classification of objects based on their

feature characteristics. Piaget regards this stage as the last stage of development during which the child develops propositional thinking and that starts from the age of eleven or twelve years onwards.

Table 6 revealed that on the whole, students performed on the average for all the skills. This means that our senior secondary school students are really acquiring science process skills. However, SS I students demonstrated the least acquisition of the process skill of "inferring". This means that more efforts should be made to improve on the level of acquisition of this skill.

Hypothesis One (H_{o1})

The results of the data of table 7. reveals that there was no significant difference in the acquisition of science process skills between boys and girls. This is because the calculated t (0.33) was less than the critical value of t (2.000) and based on that, the null hypothesis was accepted. This means that the sex of the students - male or female had no influence on their acquisition of science process skills. Any observed difference in their achievement in science is due to chance.

The findings of this study regarding sex of students are in line with the findings of Zaongo (1971); Okeke (1975) and Brown (1978) who found no difference between the achievement of male and female students in science.

The subjects (SS I students) used in this study ranged in age from 12 to 16 years. Both boys and girls at this age tend to acquire science process skills at the same rate. This finding contradicts with the findings of Chauhan (1978), Graybill (1975), Keeves (1973), Kelly (1978) Bajah (1979), Bajah (1982), Obio a (1982) and Deluca (1981) who found the boys to be superior to the girls in their science achievement. The result does not also support the findings of Nigeriama (1979), Nwosu (1987) and Wozencraft (1963) who found the girls to be superior to the boys in their school achievement.

Hypothesis Two (H_{o2})

The result of the data in table 8 reveals that students from families of average/high socio-economic status had a mean of 14.64 with a standard deviation of 2.59 whereas those students from families of low socio-economic status had a mean of 9.75 with a standard deviation of 2.37. By mere inspection, it was found that these is difference between these two means. When the hypothesis was tested at the probability level of 0.05, a significant difference was found between both groups of students in favour of students from families of average/high socio-economic status. Marjoribanks (1980) in his study pointed out that the family may act as a critical substratum variable that

influences the relations between children's attitudinal and cognitive attributes and their academic performance. In their investigation of family background variables, Schibeci and Riley (1986) pointed out that economic status of the parents and the conditions of the home in general have impact on the learning of students.

The result of table 8 indicate that socio-economic status of the family is a factor in the acquisition of science process skills by the students. This finding corresponds with the findings of Walberg and Marjoribanks (1976) who maintained that family socio-economic status was a factor in skill acquisition by the children. This means that those students from high socio-economic famililies have some advantages over those from families of low socio-economic status.

Hypothesis Three (H_{03})

The result of the data in table 9 reveals that there is significant difference in the acqusition of science process skills between urban and rural secondary school students. On the issue of school location or environment, Piaget (1972) pointed out that "the formation of operations always requires a favourable environment". In other words, the environment must be favourable to enhance learning.

The findings of this study regarding school location reveal that students in urban secondary school within Abakaliki education zone of Enugu State acquired more science process skills than those in the rural secondary schools. This finding on the issue of environment corresponds with that of Piaget who maintained that environment was a vital factor in learning. This finding that students in the urban areas performed better than those in the rural areas is supported by the findings of Dale and Miller (1972), Nwachukwu (1982) Anunobi et. al (1984) when they carried out research studies with the sole aim of comparing different environments and their effects of learning.

Differences in achievement between urban and rural students are said to be due to differential environmental stimulation. The urban secondary school students are said to be exposed to the modernising effects of science and technology and so perform better. On the other hand, the students in school in the rural areas have no such experiences on which to draw.

However, the finding of this study on environment is at variance with that of Jegede (1981) who found that the rural pupils performed better than the urban pupils. This research finding also contradicts with the finding of Ofoegbu (1984) who found that no difference exists in the performance of both urban and rural pupils.

Hypothesis Four (H_{o4})

The data of table 10 reveal that there is significant difference in the acquisition of science process skills between the students whose parents are fairly/highly educated and those whose parents are not/little educated. In their study, Schibeci and Riley (1986) considered parents' education as one of the most influential family background variables. Also Coleman et. al (1982) in their study identified educational status of the parents as one of the family variables that induce students' learning and consequent acquisition of process skills.

The results of table 10 indicate that parents' level of education determine the level of process skill acquisition by the students. This finding corresponds with the findings of Coleman et. al. (1982); Schibeci and Riley (1986) who maintained that parents' level of education was a factor in skill acquisition by the students. This means that those students whose parents are fairly/highly educated will acquire more skills than those whose parents are not/little educated.

5.2 Summary of Discussions

The discussions were based on the results of the analysis of data. A total of two research questions and four hypothesis were investigated. From the investigation, discussions were made based on the findings.

It was found that those science process skills which are fundamental to science learning in secondary schools are "experimenting", "observing", "manipulating instruments", "interpreting data", and "communicating."

It was also discovered that the process skill which the senior secondary I students demonstrated the greatest level of acquisition was classifying of objects. However, the process skill of "inferring" had the lowest mean score and was the least demonstrated by the students. On the whole, the SS I students are acquiring the science process skills.

The analysis of data involving the first hupothesis indicate that there was no significant difference in the acquisition of science process skills between boys and girls. It then means that the sex of the students - male or female had no influence on their acquisition of science process skills. Any observed difference in their achievement in science is due to chance.

The result of the second hypothesis indicates that socio-economic status of the family is a factor in the acquisition of science process skills by the students. This means that those students from high socio-economic families have some advantages over those from families of low socio-economic status.

It has also been found through the analysis of the data for the third hypothesis that the location or environment of the school is an important factor in the acquisition of science process skills. This is because students in urban secondary schools within Abakaliki education zone of Enugu State acquired more science process skills than those in the rural secondary schools.

The level of parents' education has been identified as a factor in the acquisition of science process skills by the students. The extent to which a student acquires specific skills is dependent on the level of education of the parents. In other words, students whose parents are fairly/highly educated acquire more process skills than those whose parents are not/little educated.

5.3 Conclusions from the Study

The following conclusions were drawn from the results of the study:

1. Some science process skills like experimentation, observation, manipulation of instruments, interpreting data and communication are considered to be the most

important skills for science learning in secondary schools.

2. Students' attitude to science subjects have much to do with school activities. Students who live in urban areas perform better than those who live in rural areas.

3. Students whose parents have higher educational background acquire more science process skills than others whose parents have low educational background.

4. Students who have materials that are science related at home perform better than those who do not have. Furthermore, students who have time to study at home acquire more science skills than those who engage in private trading after school.

5.4 Educational Implications of the Study

From the study carried out by the researcher and based on the results got from the analysis some vital educational implications have been highlighted namely: the result of the first research question revealed that students acquired process skills of "experimenting", " "observing", "manipulating instruments", "interpreting data" and "communicating". Since these science process skills are fundamental to science learning in secondary schools, teachers should ensure that students acquire more of them as these skills would help them to carry out scientific activities efficiently.

The result of the second research question indicated that the students have demonstrated the highest acquisition in classifying of objects. However, the process skill of "inferring" had the lowest mean score and was the least demonstrated by the students. The educational implication of this result is that science teachers should encourage students to acquire more skills in inferring as this would assist them to draw meaning from scientific practicals or experiments.

Location of the schools has been identified as a factor in the acquisition of science process skills by the students. The educational implication of this is that both State and Federal governments should ensure adequate supply of audio-visual aids or scientific equipments to rural secondary schools. Also government should embark upon intensive electrification of rural areas or installation of electric generators in rural secondary schools so that science equipments for subjects like physics, chemistry and biology that require the use of electricity can be manipulated so as to enable students acquire process skills especially manipulative skills. Science teachers should be encouraged to teach in rural secondary schools by giving them more science allowance and incentives than their counterparts in urban schools.

The result of the second hypothesis indicates that socio-economic status of the family is a factor in the acquisition of science process skills by the students. The students who come from families of high socio-economic status are provided with different learning materials and science textbooks which help to improve their learning capabilities unlike students from families of low socio-economic status who are always handicapped. The government should assist the secondary school students by providing them with learning materials, for instance, science textbooks free of charge. This will help students from families of low socio-ecohomic status to acquire more science process skills.

5.5 Recommendations

Having considered the results of this study and the implications thereof, it becomes imperative that the following recommendations should be made in order to help in improving our educational system namely:

1. Curriculum designers should identify skills to be inculcated into the students for specific topics. This will make it easier for teachers to teach science emphasizing the process aspect of it.
2. Concept-free tests of science process should be developed and standardized so as to enable teachers use them in testing students' level of proficiency in science process skill acquisition.

3. Pre-science teacher training should involve training teachers in methods of acquiring of and inculcation of science process skills. They should also be trained in methods of guiding students in an inquiry oriented learning situation.

4. Career education is very important to students for career choice. The teacher should relate whatever he/she is teaching in science to career so as to help to spur students to choosing some careers. The use of role models or mentorship is very essential for assisting students in choosing science-based careers.

5. Construction of motorable roads as well as rural electricity schemes should be encouraged in order to help bridge the gap in skill acquisition between those students living in the urban and rural areas of Abakaliki Education Zone of Enugu State.

6. More efforts should be made to ensure that our students acquire skills in inferring, measuring and predicting because without them, meaningful scientific achievements will not be made.

7. The Government should give to our secondary school students learning materials such as science textbooks free-of-charge

This will help in bridging the dichotomy between those students from families of high socio-economic status and those from families of low socio-economic status.

Limitations of the Study:

In carrying out this study, some limitations were encountered. These are:

1. Due to limited financial resources, this study was carried out only in one education zone out of the three education zones in Enugu State and as such the findings of this study cannot be generalised.

2. The time used in testing, observing and rating the students was too short to make a convincing conclusion. For example, in order to observe objectively and make a conclusive remark, a considerable length of time has to be used.

3. Since the study was observational, only eighty (80) students were used for objective results. Hence one may not be very certain in using them to generalise for thousands of students in Enugu State.

4. Because of shortness of time, the researcher involved other people to help her observe the eighty students. The science process skills are so inter-related that the

assistants might have experienced some difficulty as to when to record for a particular skill. For instance, experimenting is a process skill. In a science class, it is difficult to distinguish it from observation, measurement and manipulation all of which are related to experimentation. Therefore, one cannot for sure say that all the skills were appropriately and accurately recorded by each of the observers.

Suggestions for Further Research:

The following suggestions are made for further studies:

1. Research should be carried out to find out if there is any relationship between intelligence and acquisition of science process skills.

2. Measurement and evaluation experts should develop standardized test in science process skills for testing students in order to make a conclusive judgement.

3. This study should be carried out again by other researchers to cut across all the education zones of Enugu State as well as other States of Nigeria.

Summary of the Study:

Scientific and technological achievements are the determinants of the status of a nation vis-a-vis other nations, in terms of strength of economy, agricultural output, health and communication facilities as well as political power. However, the poor rate of scientific and technological growth in Nigeria has prodded the government in making new educational policies which emphasize science in schools. This awareness has led the government to embark on developing innovative science curricula for schools. These curricula are expected to enable students develop science concepts and skills so that they understand the world around them.

One of the aims of this study is to find out those factors that militate against the acquisition of science process skills by senior secondary school students. In conducting the investigation, the following research questions were therefore posed.

1. What science process skills are necessary for learning science in secondary schools?

2. In which of the selected eight process skills namely observing, experimenting, measuring, classifying, using time (space relations), communicating, inferring and predicting do the Senior Secondary School (SSS) students

demonstrate greater acquisition?

3. Which gender differ significantly in their achievements of science process skills tasks?

4. Are there any significant differences in the acquisition of science process skills between students from average/high socio-economic status and those from families of low socio-economic status?

5. Are there any significant differences in the process skill achievements of urban and rural Senior Secondary School students?

6. Are there any significant differences in the acquisition of science process skills between students whose parents are fairly/highly educated and those whose parents are not/little educated?

Four null hypotheses were tested in order to answer the questions that were posed. These guided the data collection and analysis. Related literature was reviewed. The factors militating against acquisition of science process skills by students were explained.

The population of the study were the Year I Senior Secondary School students in Enugu State. Stratified random sampling was employed to ensure that male and female subjects

were equally drawn as sample. A total of eighty (80) subjects were used because the study involved observation of the students. The subjects were randomly composed from eight secondary schools in Abakaliki education zone.

The parents of the students were given questionnaires to fill in order to elicit responses concerning home background of the students. The teachers of these students were also given questionnaires to fill in order to find out which science process skills are necessary for learning science in secondary schools.

Based on the scores of the students, the responses of their parents and teachers the research questions were answered and the hypotheses were tested at 0.05 significant level. The findings of the research were as follows:

1. Some science process skills like experimentation, observation, manipulation of instruments, interpreting data and communication are considered to be the most important skills for science learning in secondary schools.
2. Some of the process skills, for instance, inferring and prediction were poorly developed by the students.
3. School location was observed to be a determining factor in terms of acquisition of process skills among

the subjects who were used for the study.

4. The difference between the process skill achievement scores of boys and those of girls was not significant.

5. Students from families of high socio-economic status acquired more process skills than those from families of low socio-economic status.

6. Parents' education level is not a factor in the acquisition of science process skills by the Senior Secondary School students.

Conclusions were drawn from the result of the study, implications of the result were stated and recommendations made. Suggestions were also made for further studies. Lastly, the limitations of the study were outlined.

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REFERENCES

AAAS (1967). Science - A Process Approach. Washington, D.C. American Association for the Advancement of Science

Abdullahi, A. (1976). "Towards A Philosophical Basis for Science Teaching in Nigerian Schools," Journal of the Science Teachers Association of Nigeria, 15(1) 6-10.

Abdullahi, A. (1982). Science Teaching in Nigeria. Ilorin. Atoto Press Ltd.

Adey, P.S. and Harlen, W. (1986). "A Piagetian Analysis of Process Skill Test Items," Journal of Research in Science Teaching, 23 (8), 707-726

Ajakaiye, D.E. (1987). "Problems and Solutions of Science and Technology in Nigeria," in Okoye, S.E. and Onuoha, K.M. (ed), Basic Science Development in Nigeria: Problems and Prospects. Ibadan: Evans Brothers (Nig. Publishers) Ltd.

Ajeyalemi, D. (1990) (ed). Science and Technology Education in Africa: Focus on Seven Sub-Saharan Countries. Lagos: University of Lagos Press.

Alexander, W.M. and Halverson, P.M. (1963). Effective Teaching in Secondary Schools. New York: Holt, Rhinehart and Winston Inc.

Aleyideino, S. (1989). "Science and the Background of Nigerian Children," Journal of the Science Teachers Association of Nigeria, 26(1), 100-104

Ali, A. (1981). "The Effect of Manipulating Science Materials and Equipment on Science Process Skills by Nigerian Secondary School Students," Jos Journal of Education 1(1) 1-4.

Ali, A. (1985). A Handbook of Science Method for Science Secondary School Teachers. Nsukka: University of Nigeria.

Ali, A. (1986). "The Teaching of Secondary School Science: Methods and Problems." A Paper presented to the Annual Publication by the Science Education Students, UNN, Vol. 4, No. 1, pp. 9-30.

Amidon, E. and Hunter, E. (1967). Improving Teaching: The Analysis of Classroom Verbal Interaction. New York: Holt, Rhinehart and Winston Inc.

Anderson, H.O. (1971). "Developing Favourable Attitudes Towards Science," Science Teacher, 38, 41-45

Anunobi, A.I. et. al. (1984). "A Comparative Study of the Performance of the Urban and Rural Secondary School Students in English Language in WASC Examinations in Enugu Education Zone from 1979-1982." Unpublished B.Ed. Thesis, UNN.

Ashley, J.P. and Butts, D.P. (1972). "A Study of the Impact of An In-Service Education Program on Teacher Behaviour," In Butts, D.P. (Ed), Research and Curriculum Development in Science. University of Texas Publication.

Ausubel, D.P. (1961). "Learning by Discovery: Rationale and Mystique," Bulletin of National Association of Secondary Principles, 45, 18-58

Averch, H.A. et. al (1974). "How Effective is Schooling?" A Critical Review of Research. Eaglewood Cliffs, N.J; Educational Technology Publication.

Bajah, T.S. (1977). "The Place of Formal Education in Special Reference to popularising Science with Teacher Education," Journal of the Science Teachers Association of Nigeria, 16 (1), 6-13.

Bajah, T.S. (1979). "Correlates of Students' Extrinsic School Environmental Factors with Level of Attainment in a Standardised Test in Chemistry," Journal of the Science Teachers Association of Nigeria, 18(1), 49-63.

Bajah, T.S. (1983). Teaching Integrated Science Creatively. Ibadan: Ibadan University Press.

Beveridge, W. (1950). The Art of Scientific Investigation. New York: W.W. Norton.

Bloom, B.S. (1984). "The Search for Methods of Group Instruction as Effective as one to one Tutoring," Educational Leadership, 4(8), 4-7

Boehm, A.E. and Weinbert, R.A. (1977). The Classroom Observer, A Guide for Developing Observational Skills. New York: The Teachers College Press.

Boocock (1980). Sociology of Education: An Introduction. 2nd Edition. Houghton Mifflin Co., Boston, U.S.A.

Bovert, M.C. (1973). "Cognitive Process Among Illiterate Children and Adults." In J. W. Berry and P.R. Dasen (Eds). Culture and Cognition. London: Methuen.

Bridge, R.G. et. al. (1979). The Determination of Educational Outcomes. Cambridge, M.A. Balinger.

Bruner, J.S. (1961). "The Act of Discovery," Havard Educational Review, 31(1), 21-32

Bruner, J.S. (1977). The Process of Education. Havard University Press, Massachusetts.

Chauhan, S.S. (1978). Advanced Educational Psychology. Vikas Publishing House, P.V.T. Ltd.

Centra, J.A. and Potter, D.A. (1980). "School and Teacher Effects: An Inter-Relational Model,", Review of Educational Research, 50, 273-291.

Cochran, W.G. (1977). Sampling Techniques. New York: John Wiley and Sons.

Cohen, T.B. (1949). Science, Servant of Man. Boston: Little Brown.

Cohen, Y. (1971). The Institutional Framework. Chicago: Aldine-Atherton.

Coleman, J.S. et. al. (1982). High School Achievement: Public, Catholic and Private Schools Compared. New York: Basic Books.

Combert, K.C. and Keeves, J.P. (1973). Science Education in Nineteen Countries, New York: John Wiley and Sons.

Conant, J.B. (1947). On Understanding Science, New Haven: Yale University Press.

Conant, J.B. (1959). Science and Common Sense. New Haven: Conn, Yale University Press.

Cross, K. and Gaier, E. (1955). "Techniques in Problem Solving as Prediction of Educational Achievement," Journal of Education Psychology, 44, 193-206.

Dale, L.G. (1970). "The Growth of Systematic Thinking Analysis of Piaget's First Chemical Experiment," Australian Journal of Psychology, 22, 277-288

Dale, R. and Miller, P. (1972). "Urban and Rural Background of First Year University Students in Relation to their Academic Performance," British Journal of Educational Psychology, Vol. XIV.

Dasen, P. (1973). "The Influence of Ecology, Culture and European Contact on the Cognitive Development in Australian Aborigines," In T.W. Berry and P. Dasen (Eds). Culture and Cognition. London: Mcthuen.

Davis, F.B. (1964). Educational Measurements and their Interpretations. Wadsworth, Belmont, California.

DeBoer, G.E. (1984a). "A Study of Gender Effects in the Science and Mathematics Course-taking Behaviour of a Group of Students who graduated from College into the Late 1970's," Journal of Research in Science Teaching, 21, 95-103.

DeBoer, G.E. (1984b). "Factors Related to the Decision of Men and Women to continue taking Science courses in Colleges," Journal of Research in Science Teaching, 21, 325-329.

DeBoer, G.E. (1987). "Predicting Continued Participation in College Chemistry for Men and Women," Journal of Research in Science Teaching.

Deluca, F. (1981). "Application of Cluster Analysis to the Study of Piaget an Stages of Intellectual Development," Journal of Research in Science Teaching, 18(1), 51-59.

Durojaiye, M.A.O. (1976). A New Introduction to Educational Psychology. Evans Bros Limited.

Ehindero, O.J. (1982). "The Effects of Cultural Factors in Operational Thought Among some Nigerian Adolescent," Journal of Research in Science Teaching, 19(16), 451-457.

Epistein, J.L. (1984). "Effects of Teacher Practices of Parents Involvement for change in Student Achievement in Reading and Mathematics". Paper presented at the Annual Meeting of the American Educational Reading Association, New Orleans, L.A.

Erickson, E.H. (1950). Childhood and Society. New York: Norton.

Ernest, J. (1974). Mathematics and Sex. Santa Barbara, CG: University of California.

Fafunwa, Babs (1967). New Perspective in African Education. Macmillan Education Ltd., London and Basing Stroke.

Federal Republic of Nigeria (1981). National Policy on Education. NERC Press, Yaba - Lagos.

Federal Ministry of Science and Technology (1986). National Policy on Science and Technology. Ibadan: Nihort Press.

Fennema, E. and Sherma, J. (1977). "Sex-Related Differences in Mathematics Achievement, Spatial Visualization and Affective Factors," Journal of American Educational Research, 14, 51-71

Ferguson, G.A. (1981). Statistical Analysis in Psychology and Education. Tokyo, McGraw-Hill International Book Company.

Finley, F.N. (1983). "Science Processes," Journal of Research In Science Teaching, 20(1), 47-54.

Fisher and Yates (1953). Statistical Tables for Biological, Agricultural and Medical Research. Longman Publishers.

Gabel, D.L. and Sherwood, R.O. (1983). "Facilitating Problem Solving in High School Chemistry," Journal of Research In Science Teaching, 20(2), 163-177.

Gagne, R.M. (1963). "The Learning Requirements for Enquiry," Journal of Research in Science Teaching, 1(3), 144-153.

Gagne, R.M. (1965). The Psychological Bases of Science - A Process Approach. American Association for the Advancement of Science (A.A.A.S) Miscellanous Publication.

Gagne, R.M. (1970). The Conditions of Learning. (2nd Edition). New York: Holt Rinehart and Winston.

Genero, E.O. (1986). "A Science Learning Experience Involving Adults and Preadolescent Children," Science Education 64(3), 209-218.

Good, R.G. (1977). How Children Learn Science: Conceptual Development and Implications for Teaching. New York: Macmillan Publishing Co. Inc.

Goodlad, J.I. (1966). The Changing School Curriculum. New York: Fund for the Advancement of Education.

Graybill, L. (1975). "Sex Differences in Problem Solving Ability," Journal of Research in Science Teaching, 12, 341-346.

Haertel, G; Walberg, H; Junker, L. and Pascarella, E. (1981). "Early Adolescent Sex Differences in Science Learning: Evidence from the National Assessment of Educational Progress," American Educational Research Journal, 18, 329-341.

Haladyna, T; Olsen, R. and Shaunessy, J. (1983). "Correlates of Class Attitude Toward Science," Journal of Research in Science Teaching, 20(4), 311-324.

Harmschfer, A. and Wiley, D.E. (1976). "Achievement Scores Drop. So What?" Educational Researcher, 5(3), 5-12.

Hasan, O. (1975). "An Investigation into Factors Affecting Science Interest of Secondary School Students," Journal of Research in Science Teaching, 12, 255-261.

Herron, J.D. (ed) (1970). Preservice Science Education for Elementary Teachers. Washington D.C. American Association for the Advancement of Science.

Hess, R.D. and Holloway, S.D. (1984). "Family and School As Educational Institutions." In Parke, R. D (ed). Review of Child Development Research. Chicago: University of Chicago Press.

Hess, R.D; McDevitt, T.M. and Chils-Mei, C (1987). "Cultural Variations in Family Beliefs about Children's Performance in Mathematics: Comparison Among Peoples Republic of China, Chinese-American and Caucasian-American Families," Journal of Educational Psychology, 79(2), 179-188.

Howard, A.W. (1968). Teaching in Middle School. International Textbook Co., Seranton Pennysivania.

Howe, A.C. and Shayer, M. (1981). "Sex-Related Differences on A Task of Volume and Density," Journal of Research In Science Teaching, 18(2), 169-175.

Hunt, B. (1979). Improving Science Teaching. New York: Nash Publishing Co.

Ikoku, Chimere (1975). "An Assessment of the Present Productivity of the Nigerian Scientists," Bulletin of the Science Association of Nigeria, 1(2), 305-325.

Inomesia, E. (1989). "Sex and School Location as Factors in Primary School Science Achievement," Journal of the Science Teachers Association of Nigeria, 26(1), 82-88

Ivowi, U.M.O. (1978). "Trends in Secondary School Science and Mathematics Curricula," Journal of Science Teachers Association of Nigeria, 17(3), 132-145.

Jegede, O.J. (1981). "Evaluation of Nigerian Integrated Science Project", Unpublished Ph.D. Thesis, University of Wales.

Karaker, R.J. (1972). "Increasing Academic Performance Through Home-Managed Contigenty Programs," Journal of School Psychology, 10, 173-179

Karl, J.A. (1961). "Common Man Boys". In Halsey, A.H; Floud, J. and and Anderson, C.A. (eds). Education, Economy and Society. New York: Fred Press.

Keeves, J.P. (1975). "The Home, The School and Achievement in Maths and Science," Science Education, 59, 439-460.

Keith, J.Z. (1986). "Parental Involvement, Homework and T.V. Time: Direct and Indirect Effects on High School Achievement," Journal of School Psychology, 78(5), 373-380.

Kelly, A. (1978). Girls and Science. International Association for the Evaluation of Educational Achievements, IEA Monograph Studies No. 9.

Kishta, M. (1979). "Proportional and Combinational Reasoning in Two Cultures," Journal of Research in Science Teaching, 16, 439-443.

Kremer, B. and Walberg, H.J. (1981). "A Synthesis of Social and Psychological Influences on Science Learning," Science Education, 65, 11-23.

Lindley, D.V. and Miller, J.C.P. (1968). Cambridge Elementary Statistical Tables. Cambridge: The University Press.

Lowell, W.E. (1980). "The Development of Hierachical Classification Skills in Science," Journal of Research in Science Teaching, 17(5), 425-433.

Maduka, K.N. (1980). "The Individual and National Development: A Personality Perspective". In E.C. Amucheazi (ed); Readings in Social Sciences Issues in National Development. Enugu: Fourth Dimension Publishers.

Macbeth, D.R. (1974). "The Extent to Which Pupils Manipulate Materials and Attainment of Process Skills in Elementary School Science," Journal of Research in Science Teaching, 13(5), 405-412

Maccoby, E. and Jacklin, C. (1974). The Psychology of Sex Differences. Standard Cal: Stanford University Press.

Marjoribanks, K. (1980). Ethnic Families and Children's Achievements. Sydney, Austria: George Allen and Unwin.

Marjoribanks, K. (1983). "The Evaluation of a Family Learning Model," Studies in Educational Evaluation, 9 343-357.

Modgil, S. (1974). Piagetian Research: A Handbook of Recent Studies. New York: Humanities Press.

Molitor, L.L. and George, K.D. (1976). "Development of a Test of Science Process Skills," Journal of Research in Science Teaching, 13(5), 405-412.

National Assessment of Educational Progress (1977). Summary Volume, Science Report, No., 04-5-12. Washington, D.C. US Government Printing Office.

Neive, V.E. (1972). "Verbal Predictive Ability and Performance on Selected Process Skill Tasks," Journal of Research In Science Teaching, 9(3), 213-221.

Nigeriama, K.E.K. (1974). Academic Performance of Males Versus Female Students in the UNN: A Comparative Study; Unpublished B.Sc. Ed Thesis, University of Nigeria, Nsukka.

Nnachi, K.O. et. al. (1985). "A Comparative Study of Some Factors that Affect Students in Learning Secondary School Biology." Unpublished B.Sc. Ed. Thesis, UNN

Nwachukwu, V. (1982). "The Effects of Material and Non-Material Reinforcers Upon the Level of Achievements in Certain Secondary Schools," Unpublished Ph.D. Thesis, U.N.N.

Nwana, O.C. (1981). Introduction to Educational Research. Ibadan: Heinemann Educational Books (Nig.) Ltd.

Nwosu, N.M. (1987). "The Comparative Effects of Directed-Discovery Method and Demonstration Method on Acquisition of Science Process Skills". Unpublished M.Ed. Thesis, U.N.N.

Obi, E. (1979). "Environmental Influences and Attitudes Affecting the Science Education of Secondary School Students in Rural Areas of Bendel State, Nigeria," Journal of the Science Teachers Association of Nigeria, 18(1), 15-22

Obioma, G.O. (1982). "The Development and Preliminary Validation of a Diagnostic Maths Achievement Test for Nigerian Secondary School Students," Unpublished M.Ed Thesis, U.N.N.

Obioma, G.O. (1986). "Expository and Guided Discovery Methods of Presenting Secondary School Physics Tasks," European Journal of Science Education, 8(1), 51-56

Ofoegbu, L.I. (1984). "Acquisition of Science Process Skills Among Elementary Pupils in Some Northern States of Nigeria." Unpublished Ph.D. Thesis, U.N.N.

Ohuche, R.O. (1974). "SEPA Science and Learning Theory," Science Teacher Education Monograph Series, No. 1

Okeke, E.A. (1975). A Study of the Understanding in Nigerian Secondary School Certificate Biology Candidates of the Concepts of Reproduction, Transport Mechanism and Growth," Unpublished Ph.D. Thesis, University of Leeds.

Okeke, E.A.C. (1986). "Sexual Discrimination: Attracting Women into Science-Based Occupations; Problems and Prospects," Science and Public Policy, 13(3), 147-153

Okeke, E.A.C. (1989). "Education Among Girls and Women: Review of Initiatives". in Report on the National Workshop on Promoting Science, Technology and Mathematics Education Among Girls and Women in Nigeria, organised by Federal Ministry of Education, Women Education Branch (pp. 69-76).

Okeke, E.A.C. (1990). "Gender, Science and Technology in Africa: A Challenge for Education." The Rama Mehta Lecture: Radcliffe College.

Okebukola, P.A. (1985). "Level of Process Skill Development Among Students and Implications for Sciencing in Nigeria," Journal of the Science Teachers Association of Nigeria, 26th Annual Conference Proceeding, 121-125

Okebukola, P.A. (1987). "Students' Performance in Practical Chemistry: A Study of some Related Factors". Journal of Research in Science Teaching, 24(2), 119-126.

Onwuka, U. (1981). Curriculum Development for Africa. Africana Education Publishers Ltd.

Opong, I.K. (1981). "Science Education in Primary Schools," Journal of Science Teachers Association of Nigeria, 19(2-3), 9-16.

Owen, C.B. (1956). Methods for Science Masters. London: Macmillan and Co. Ltd.

Piaget, J. (1950). The Psychology of Intelligence. London: Routeledge and Kegan Paul

Piaget, J. (1960). "Development and Learning," Journal of Research in Science Teaching, 2, 176-185.

Piaget, J. (1972). "Intellectual Evaluation from Adolescence to Adulthood," Human Development, 15, 12.

Piaget, J and Inhelder, B. (1967). The Child's Conception of Space. New York: Basic Books.

Philip, H. and Kelly, M. (1975). "Product and Process in Cognitive Development. Some Comparative Data on the Performance of School Age Children in Different Cultures." British Journal of Educational Psychology, 44, 248-265.

Piburn, M.D. (1979). "Spatial Reasoning and Formal Thought as Factors in Science Achievement for New Zealand Students". Abstract of Presented Papers, NARST, ENC/SMEAC, p. 211.

Poole, H.E. (1968)."The Effect of Urbanization upon Scientific Concept Attainment Among the Hausa Children of Northern Nigeria." The British Journal of Educational Psychology, 38, 57-63

Renner, J.W. et. al (1973). Teaching Science in the Elementary School. (2nd Edition). New York: Harper and Row.

Scott-Jones, D. (1984). "Family Influences on Cognitive Development and School Environment." in E.N. Gorden (ed) Review of Research in Education, 11, 259-304.

Schibeci, R.A. and Riley, J.P. (1986). "Influence of Background and Perceptions on Science Attitudes and Achievement," Journal of Research in Science Teaching, 23(3), 177-187.

Seginer, R. (1983). "Parents' Educational Expectations and Children's Television Viewing to School Achievement and Intelligent Quotient (I.Q)". Journal of Educational Research, 76, 294-297.

Sherma, J. (1978). Sex-Related Cognitive Difference: An Essay on Theory. Evidence Springfield, I.L., Charles C. Thomas.

Simpson, R. and Troost, K. (1982). "Influences on Commitment to and Learning of Science Among Adolescent Students," Science Education, 66, 763-781.

Steinkamp, M.W. and Maehr, M.L. (1983). "Affect, Ability and and Science Achievement: A Quantitative Synthesis of Correlational Research," Review of Educational Research 53, 369-396.

Strawitz, B.M. and Malone, M.R. (1987). "Pre-Service Teachers Acquisition and Retention of Integrated Science Process Skills: A Comparison of Teacher-Directed and Self-Instructional Strategies," Journal of Research in Science Teaching 24(1), 53-60.

Tanneubaum, R.S. (1971). "The Development of the Test of Science Processes. Journal of Research in Science Teaching, 8(2), 123-136.

Thorndike, R.L. and Hagen, E.P. (1977). Measurement and Evaluation. New York: John Wiley and Sons.

Treagust, D. (1980). Gender-Related Differences of Adolescents in Spatial Representational Thought," Journal of Research in Science Teaching, 17, 91-97

Tropp, S. (1972). "Science Education in Developing Countries," The Science Teacher, 39, 49-51

Walberg, H.J. (1984), "Improving the Productivity of America's Schools," Educational Leadership, 41(8), 19-30.

Walberg, H.J. and Marjoribanks, K. (1976). "Family Environment and Cognitive Development: Twelve Analytic Models. Review of Educational Research, 46, 527-551

Walberg, H.J. and Rasher, S.P. (1979). "Achievement in Fifty States." in J.H. Walberg (ed). Education Environments and Effects. Berkeley, C.A., McCutchen.

Walker, R. and Adelman, C.A (1975). A Guide to Classroom Observation. London: Methuen and Company Limited.

Welch, W.W.; Anderson, R.E. and Harris, L.J. (1982). "The Effects of Schooling on Mathematics Achievement," American Educational Research Journal, 19, 145-153

Welch, W. (1985). "Research in Science Education: Review and Recommendations," Science Education, 69, 421-448

Wiley, D.C. and Harnischfeger, A. (1974). "Explosion of Myth: Quantity of Schooling and Exposure to Instruction Major Educational Vehicles," Educational Researcher, 3(4), 7-12.

Witkin, H. et. al (1962). Psychological Differentiation. New York: Willey.

Woodbourn, J.H. and Obourn (1965). Teaching the Pursuit of Science, New York: The Macmillan Company.

Yeany, R.H. et. al. (1986). "Analysing Hierachial Relationships Among Modes of Cognitive Reasoning and Integrated Science Process Skills," Journal of Research in Science Teaching, 3(4), 277-291.

Yoloye, E.A. (1975). "Desired Goals in the Training of Scientists," Bulletin of the Science Association of Nigeria, 1(2), 262-275

Young, B.L. (1974). "Towards a Process Approach in Primary Science," Journal of Science Teachers Association of Nigeria, 12(4), 21-28.

Zeitler, W.R. (1981). "The Influence of the Type of Practice in Acquiring Process Skills," Journal of Research in Science Teaching, 18(3), 189-197.

SUB-DEPARTMENT OF SCIENCE EDUCATION,
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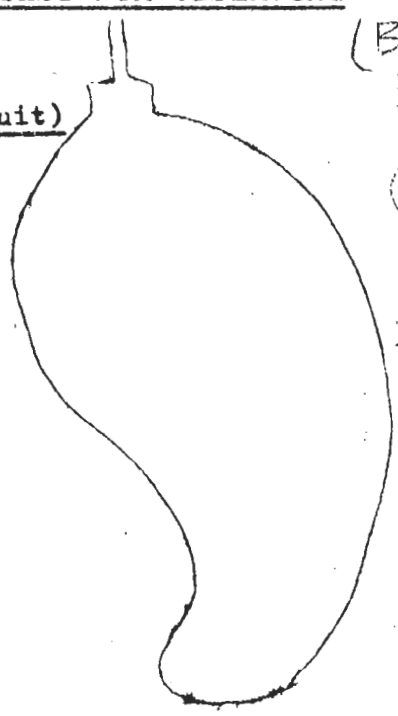
INSTRUCTION: TEST OF SCIENCE PROCESS SKILLS FOR SSI STUDENTS

This test of science process skills is geared towards finding out the factors that affect the acquisition of Science process skills among our senior secondary school students. Using the Science process skills scale, students should be rated based on their achievement in this test.

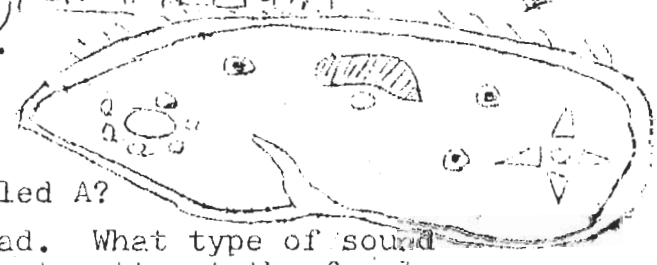
SECTION I — TEST FOR OBSERVING

(A) Ripe Manago (Fruit)



(B) Toad.

(C) Paramecium



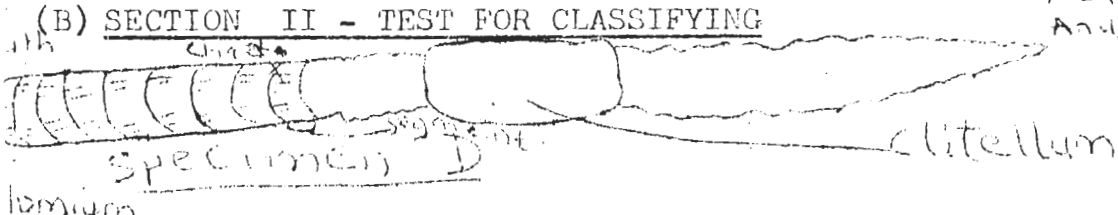
(1) What is the colour of the specimen labelled A?

(2) Specimen B is a diagram of a toad. What type of sound does the male toad make in order to attract the female during breeding in the wet season?

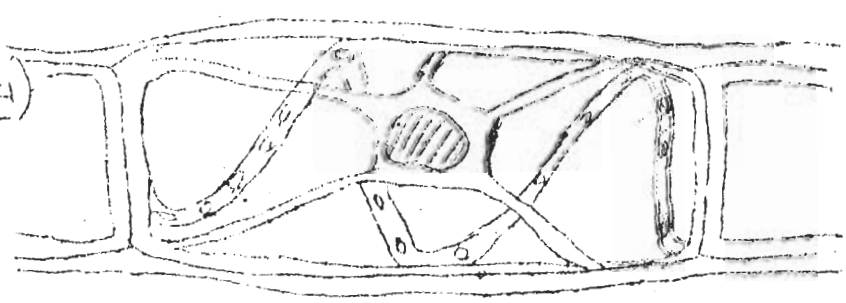
(3) Carefully watch the weight of the dead toad on the weighing balance what is the weight?

(4) What is the shape of the object labelled C?

(B) SECTION II - TEST FOR CLASSIFYING

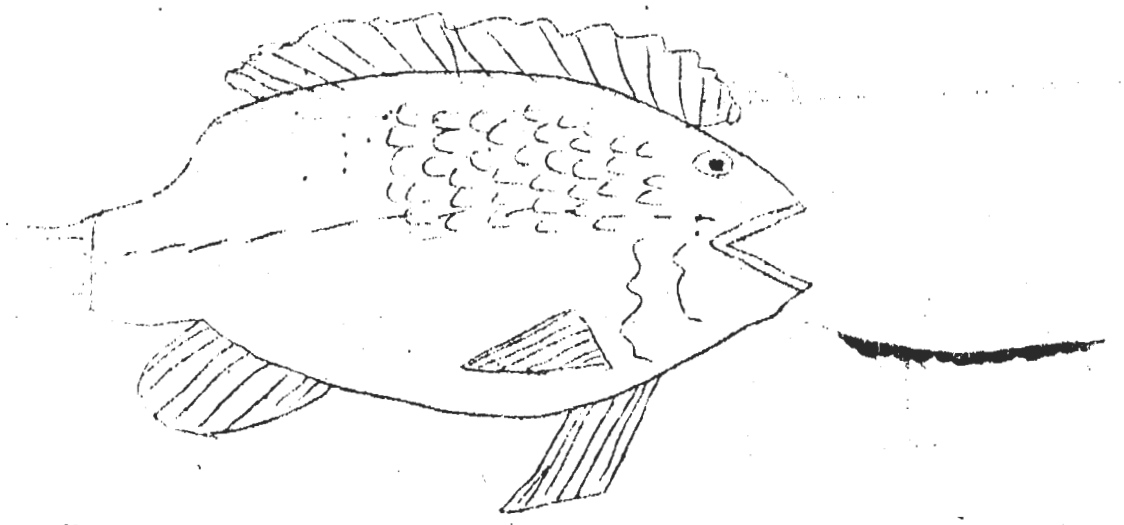


lamium



Specimen E (Spirogyra)

Specimen F (Tilapia – fish)



Specimen G

(1) What is the name of the organism labelled D?

(2) What is the colour of specimen labelled E?

(3) What shape has specimen F?

(4) The basin labelled G contains soil. Take a bit of it and crush it on your palm. How do you feel about it?

C. SECTION III - TEST FOR MEASURING

(1) Measure specimen D and find the length.

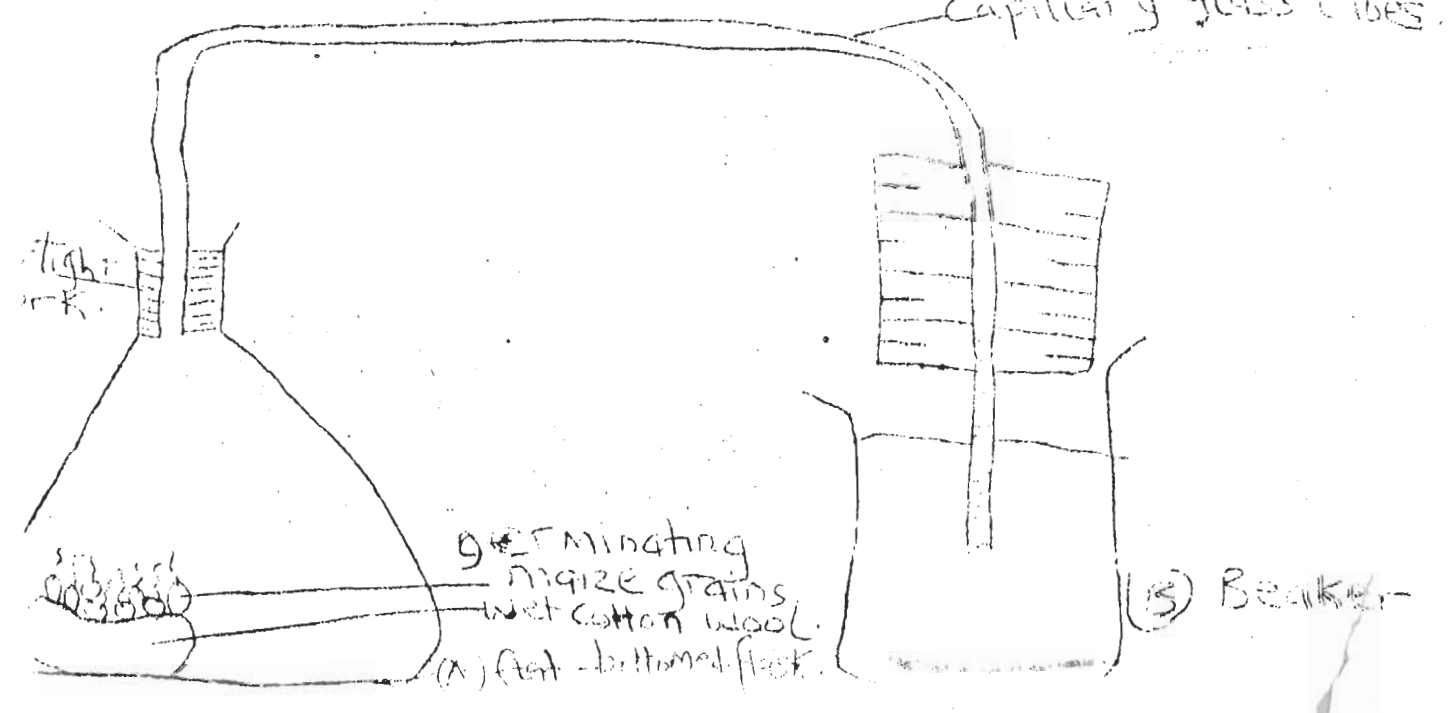
(2) What is the area of F?

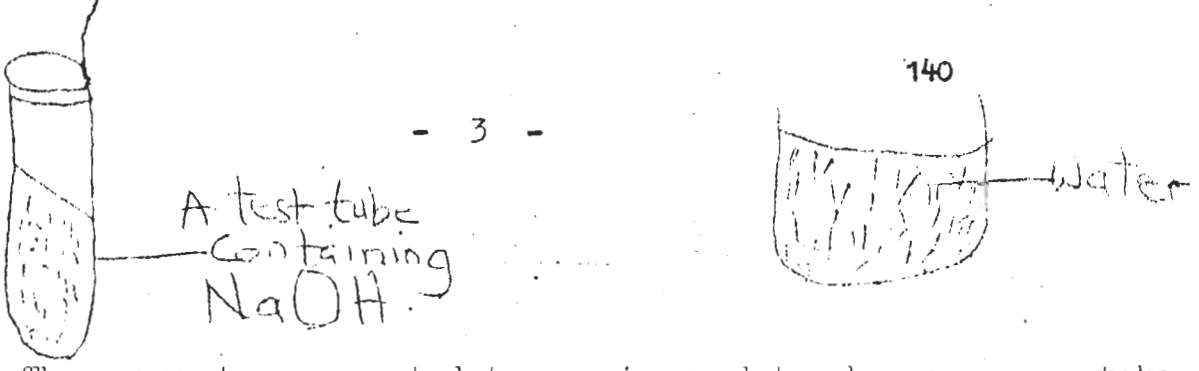
(3) Find the volume of the basin which contain the soil you have tested?

(4) Specimen B is a dead toad. Find the weight.

D. SECTION IV- TEST FOR EXPERIMENTING

D. Diagram illustrating the apparatus to show oxygen plant by germinating seeds.





The apparatus presented to you is used to show oxygen uptake by germinating seeds.

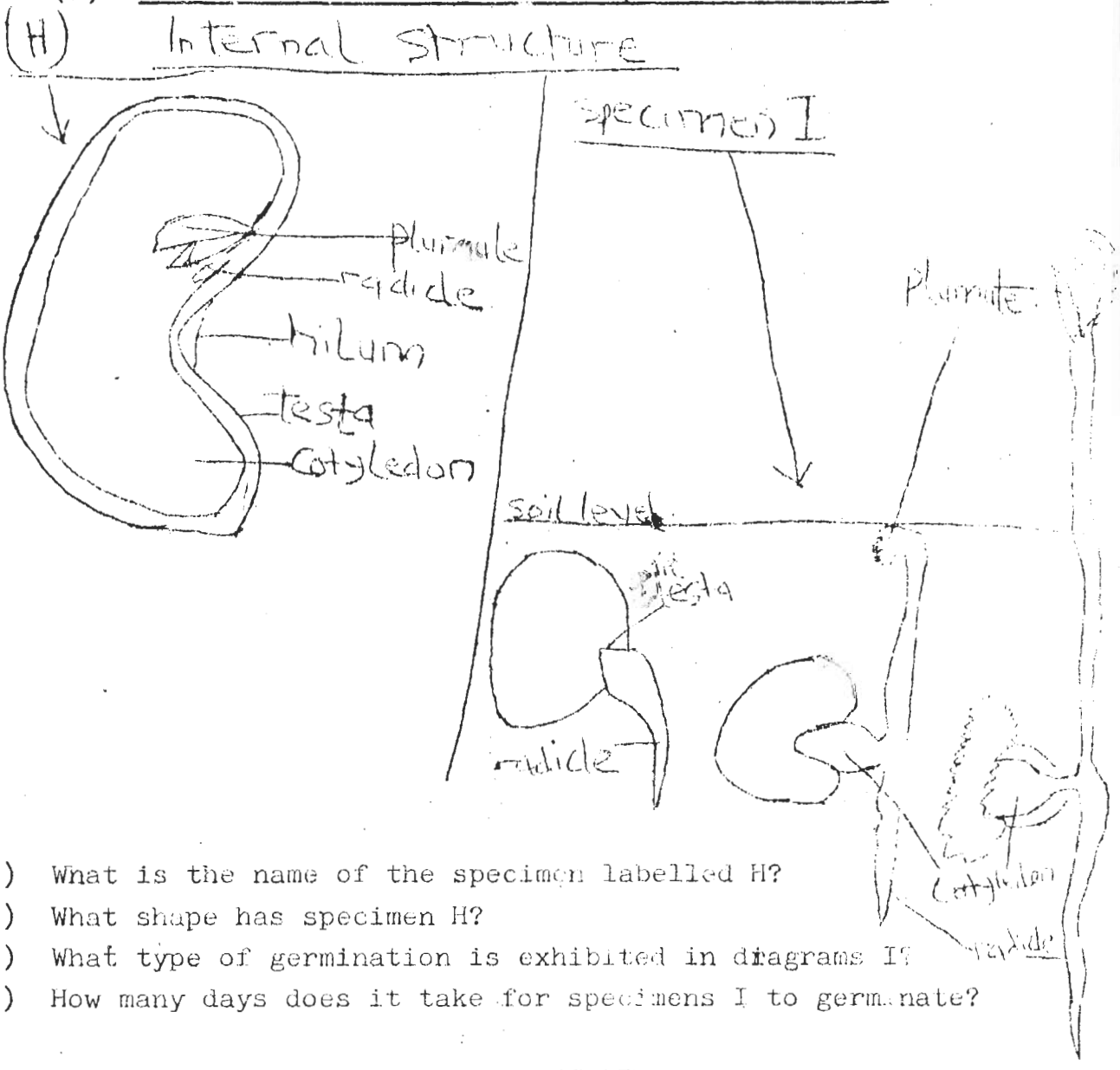
(1) In which container should we keep the test tube containing NaOH (Sodium hydroxide)?

(2) Draw this apparatus in the way you will use it to show oxygen uptake by germinating seeds.

(3) Where will you put water - Is it in the flat-bottomed flask or inside the beaker?

(4) How many hours will it take for there to be a rise in coloured water level in the glass tube of the experimental apparatus?

(E) SECTION V - TEST FOR SPACE/TIME RELATIONS



(1) What is the name of the specimen labelled H?

(2) What shape has specimen H?

(3) What type of germination is exhibited in diagrams I?

(4) How many days does it take for specimens I to germinate?

F. SECTION VI - TEST FOR COMMUNICATING

(1) What does $C_6H_{12}O_6$ stand for?

(2) Why is it that without light photosynthesis will not take place?

(3) What did we say would happen when we bend our arms?

(4) Describe what happens during the dark stage of photosynthesis.

G. SECTION VII - TEST FOR INFERRING

(1) If a food substance was tested with Fehling solution, Sudan III, iodine and Benedict's solution and there was found to be no change either in colour or in state, what does the food substance most probably contain?

(2) After performing tests with plants cell protoplasm, copper II sulphate and sodium hydroxide, the colour of the mixture was found to have changed to purple. What would you say the protoplasm contains?

H. SECTION VIII - TEST FOR PREDICTING

(1) If we heat water, what type of gas do you think will be liberated?

(2) Why will this gas be liberated?

(3) Why is it that when we put our meat in the refrigerator it does not decompose?

(4) What do you thimk will happen if blood transfusion is carried out from one person to another without a preliminary test to determine the blood group of each person.

APPENDIX II

FACULTY OF EDUCATION
UNIVERSITY OF NIGERIA,
NSUKKA

QUESTIONNAIRE FOR PARENTS

This questionnaire is geared towards finding out some factors that influence the acquisition of Science process skills among Senior Secondary School Students in Enugu State. Any information given by you will be confidentially treated.

Name of Town/Village:----------

Please tick (✓) inside the most appropriate box that gives information about you.

Parent: (a) Father ☐ (b) Mother ☐

(1) Highest level of Education attained:
(a) O-primary 6 ☐ (b) WASC/RSA/TC II ☐
(c) NCE, OND, HND ☐ (b) Degrees (e.g. B.Sc.,M.Sc., Ph.D. etc) ☐

(2) What is your area of specialization? (a) Medicine/Engineering ☐
(b) Business ☐ (c) Teaching ☐ (c) Civil Service ☐
(e) farming E.T.C. ☐

(3) Are you a Salaried worker or not?
(a) Unsalaried ☐ (b) Salaried ☐

(4) Annual income received:
(a) Below ₦3,000.00 ☐ (b) ₦3,000 - ₦6,000 ☐
(c) ₦8,000 - ₦16,000 ☐ (d) Above ₦16,000 ☐

Please, rate the level to which you consider the following for your children:

		STRONGLY AGREE	AGREE	DIS AGREE	STRONGLY DISAGREE
(a)	I always attend to my childrer to help them in their home studies even if I have something to do				
(b)	I do ensure that my children revise their work without much rest.				
(c)	Even if my child is studying, I do not mind sending him on errand.				
(d)	Even if my child is sick, I do encourage him to go to school.				
(e)	I do not mind when my children tend to forget their studies because of watching T.V. and playing records				
(f)	Students perform well in Science subjects with what they learnt in the school only.				

	STRONGLY AGREE	AGREE	DISAGREE	STRONGLY DISAGREE
(g) Parents should encourage their children to learn Science by:				
i) Purchasing (buying) Science textbooks, Science journals, magazines, Science charts, Science video tapes ETC for them.				
ii) Taking their children to visit Science related places such as zoological gardens, Botanical gardens, industries ETC				
iii) Providing their children with Science related equipment such as Electric Iron, flower pots, Aquarium, Electric fans, Refrigerator Electric boiler, gas cooker ETC				
iv) Explaining to them those areas/ objects that will motivate their interest in Sciences.				
v) Giving children extra - lessons on Science and Science related subjects at home.				
vi) Allowing their children to operate some of the electric gadgets in the house on their own.				
vii) Encouraging their children to participate in farming and keeping of livestock in the home.				

APPENDIX III

Sub-Department of Science
Education
University of Nigeria
Nsukka

Dear Sir/Madam,

QUESTIONAIRE FOR SCIENCE TEACHERS

Attached is a list of Science process skills considered necessary for Science learning in Secondary schools. Please, you are required to rate the level of importance of each of these process skills without bias. The aim is to find out those Science process skills that are fundamental to Science learning in Secondary School Science classes. You should therefore be as objective as possible in your rating.

There are four (4) points on the rating scale and you are required to mark (X) in the column that best describes the level of importance of each skill. The categories are:-

1 = least useful
2 = useful
3. = very useful
4 = most useful

Thanks very immensely for your anticipated co-operation.

Yours faithfully,

Nwachukwu, J.C.

	Science Process Skills	Rating			
1.		1	2	3	4
1.	Observing				
2.	Classifying				
3.	Experimenting				
4.	Measuring				
5.	Using Space/Time Relations				
6.	Communicating				
7.	Inferring				
8.	Predicting				
9.	Questioning				
10.	Manipulating Instruments				
11.	Formulating models				
12.	Counting				
13.	Controlling varibles				
14.	Interpreting data				
15.	Making operational definitions				
16.	Formulating hypothesis				

N:B:- Please, kindly add more Science skills (if any) and rate them.

APPENDIX .IV.

NAME:----------

SCHOOL:----------

Guidelines and Instructions for the use of Science Process Skill Scale (SPSS).

(1) The dimensions to be observed for each skill are listed under the skill and are regarded as area of concerntration. For each skill, the observer should concerntrate on the dimensions to evaluate and rate the student.

(2) If the student does not prove to have acquired a particular skill, he/she should be rated zero. The rating should be based on the dimensions mapped out for the skill. If a student has zero for a skill, it means that he/she has acquired none of the dimensions of the skill.

(3) Skill 7 has only 2 (two) dimensions. If a student has acquired one dimensions, it means that he/she should be rated 2. If he/she scores half ($\frac{1}{2}$) of a dimension he/she should be rated 1.

(4) Scaling or scoring of the child (student) should be done by ticking (✓) the appropriate spaces provided. Please, fill all the vacant spaces provided for information required for this investigation.

PLASE NOTE:

(i) The purpose of this research is not to find the strengths or weaknesses of the teacher. The essence is to investigate into the factors that influence the acquisition of Science process skills among our students thus exploring some strategic avenues for the improvement of teaching and learning of Science.

(ii) The students should not be made to understand that they are being observed.

(iii) For this work to achieve its essence, it therefore requires honest recording of observations.

APPENDIX V.

SCIENCE PROCESS SKILL SCALE (SPSS)

CLASS: SS I Students
NAME OF SCHOOL:
TYPE OF SCHOOL: (a) Boys Sec. School (b) Girls Sec. School (c) Mixed School (Please tick (✓) where appropriate

LOCATION OF SCHOOL: (a) Urban (b) Rural

SCIENCE PROCESS SKILLS	OBSERVING	CLASSIFYING	EXPERIMENTING	MEASURING	USING TIME SPACE RELATION	COMMUNICATING	INFERRING	PREDICTING
Level of Acquisition	0 1 2 3 4	0 1 2 3 4	0 1 2 3 4	0 1 2 3 4	0 1 2 3 4	0 1 2 3 4	0 1 2 3 4	0 1 2 3 4
Area of Concentration	1. Colour 2. Sound 3. Size 4. Shape Each carries 1	1. Shape 2. Size 3. Colour 4. Texture Each carries 1	1. Design 2. Setting equi. 3. Handling 4. Calculating Each carries 1	1. Length 2. Area 3. Volume 4. Weight Each carries 1	1. identification 2. Shape 3 differentiating 4. time (duration) Each carries 1	1. Interpreting model 2. Discussing results 3. Expressing 4. Attentive listening Each carries 1	1. Drawing Conclusion 2. Basing on evidence from the experiment Each carries 2 ½ of 2 = 1 1+2=3	1. Statement of prediction 2. Enquiry into the prediction 3. Conformity to prediction 4. Continuing enquiry Each carries 1

For the Student { Name of Student:
Sex:

Student's Serial number:

The Teacher { 1. Did you do Science course? Yes..... No.....
2. Name of Science done:-
3. Period taught: (a) 0-1year (b) 1-2years (c) 2-5 yrs (d) 6-9 yrs (e) 10years and above

APPENDIX VI:

Summary of Data for Hypothesis One

A. Calculation of Mean and Standard Deviation of the scores of randomly composed male Secondary School students within Abakaliki Education Zone of Enugu State.

11, 12, 13, 6, 17, 7, 11, 11, 9, 8, 8, 9,
6, 14, 10, 11, 14, 11, 8, 15, 10, 11, 13, 10
12, 14, 12, 15, 13, 6, 18, 10, 11, 12, 16,
16, 15, 13, 18, 20.

X	f	fx	$X - \bar{X}$	$(X - \bar{X})^2$	$f(X - \bar{X})^2$
20	1	20	8.63	74.4769	74.4769
18	2	36	6.63	43.9569	87.9138
17	1	17	5.63	31.6969	31.6969
16	2	32	4.63	21.4369	42.8738
15	3	45	3.63	13.1769	39.5307
14	3	42	2.63	6.9169	20.7507
13	5	65	1.63	2.6569	13.2845
12	4	48	0.63	0.3969	1.5876
11	7	77	-0.37	0.1369	0.9583
10	4	40	-1.37	1.8769	7.5076
9	2	18	-2.37	5.6169	11.2338
8	3	24	-3.37	11.3569	34.0707
7	1	7	-4.37	19.0969	19.0969
6	3	18	-5.37	28.8369	86.5107
	43	489			471.4929

$$\text{Mean } (\bar{X}) = \frac{\sum fx}{N} = \frac{489}{43} = \underline{11.37}$$

$$\text{S.D.} = \sqrt{\frac{f(X - \bar{X})^2}{N-1}} = \sqrt{\frac{471.4929}{43-1}}$$

$$\therefore \text{S.D} = \sqrt{\frac{471.4929}{42}}$$

$$= \sqrt{11.23}$$

$$= \underline{3.35}$$

B. Calculation of Mean and Standard Deviation of the Scores of Randomly composed Female Secondary School students within Abakaliki Education Zone of Enugu State.

9, 9, 12, 11, 11, 13, 10, 10, 11, 10, 13, 12, 12, 15, 16, 15, 14, 13, 17, 11, 14, 9, 8, 6, 16, 8, 15, 8, 5, 12, 9, 14, 7, 6, 14, 13, 18, 14, 19.

X	F	FX	$X - \bar{X}$	$(X - \bar{X})^2$	$F(X - \bar{X})^2$
19	1	19	7.46	55.6516	55.6516
18	1	18	6.46	41.7316	41.7316
17	1	17	5.46	29.8116	29.8116
15	3	45	3.46	11.9716	35.9148
14	5	70	2.46	6.0516	30.258
13	4	52	1.46	2.1316	8.5264
12	4	48	0.46	0.2116	0.8464
11	4	44	-0.54	0.2916	1.1664
10	3	30	-1.54	2.3716	7.1148
9	4	36	-2.54	6.4516	25.8064
8	3	24	-3.54	12.5316	37.5948
7	1	7	-4.54	20.6116	20.6116
6	2	12	-5.54	30.6916	61.3832
5	1	5	-6.54	42.7716	42.7716
	37	427			339.1892

$$\text{Mean } (\bar{X}) = \frac{\sum FX}{N} = \frac{427}{37} = 11.54$$

$$\text{S.D} = \sqrt{\frac{\sum f(X-\bar{X})^2}{N-1}}$$

$$= \sqrt{\frac{339.1892}{37-1}}$$

$$= \sqrt{\frac{399.1892}{36}}$$

$$\therefore \text{S.D} = \sqrt{9.42} = 3.069 \quad 3.07$$

t-Test for the hypothesis concerning boys and girls' achievement in Science Process Skills.

$$t = \frac{\bar{X}_1 - \bar{X}_2}{\sqrt{\frac{\sum fx_1^2 + fx_2^2}{n_1 + n_2 - 2}\left(\frac{1}{n_1} + \frac{1}{n_2}\right)}}$$

$$= \frac{11.37 - 11.54}{\sqrt{\frac{471.4929 + 339.1892}{43 + 37 - 2}\left(\frac{1}{43} + \frac{1}{37}\right)}}$$

$$= \frac{-0.17}{\sqrt{\frac{810.6821}{78}\ (0.0232 + 0.0270)}}$$

$$= \frac{-0.17}{\sqrt{10.3934\ (0.0502)}}$$

$$\therefore \quad t = \frac{0.17}{0.52}$$

$$= -0.33$$

NB: Negative sign does not apply for the use of t-Table. Therefore, -0.33 becomes 0.33

Degree of Freedom (df) $= n_1 + n_2 - 2$

$= 37 + 43 - 2$

$= 80 - 2$

$\therefore \quad df = 78$

At 0.05 significant level, critical value (CV) of t at df (78) = 2.000. Since the calculated t (0.33) is less than the CV of t(2.000), the null hypothesis is accepted.

APPENDIX VII

Summary of Data for Hypothesis Two

A. Calculation of Mean and Standard Deviation of the Process scores of the students from Families of High Socio-economic Status.

15, 14, 12, 10, 17, 14, 19, 13, 15, 20,
12, 16, 18, 15, 18, 14, 16, 12, 15, 13,
11, 14, 17, 12, 15, 11, 14, 18.

X	F	FX	$X - \bar{X}$	$(X - \bar{X})^2$	$F(X - \bar{X})^2$
20	1	20	5.36	28.7296	28.7296
19	1	19	4.36	19.0096	19.0096
18	3	54	3.36	11.2896	33.8688
17	2	34	2.36	5.5696	11.1392
16	2	32	1.36	1.8496	3.6992
15	5	75	0.36	0.1296	0.648
14	5	70	-0.64	0.4096	2.048
13	2	26	-1.64	2.6896	5.3792
12	4	48	-2.64	6.9696	27.8784
11	2	22	-3.64	13.2496	26.4992
10	1	10	-4.64	21.5296	21.5296
	28	410			180.4288

$$\text{Mean } (\bar{X}) = \frac{\sum fx}{n} = \frac{410.}{28} = \underline{\underline{14.64}}$$

$$\text{S.D.} = \sqrt{\frac{\sum f (X - \bar{X})^2}{N-1}}$$

$$= \sqrt{\frac{180.4288}{28 - 1}}$$

$$= \sqrt{\frac{180.4288}{27}}$$

$$= \sqrt{6.683} \quad \therefore \text{S.D.} = 2.585 \longrightarrow \underline{\underline{2.59}}$$

B. Calculation of Mean and Standard Deviation of the Process Scores of the Students from Families of Low Socio-economic Status.

7, 10, 8, 11, 13, 6, 12, 9, 11, 8, 6,
9, 6, 11, 13, 6, 10, 11, 8, 12, 10,
13, 11, 10, 12, 6, 13, 9, 11, 5, 11,
7, 13, 10, 9, 13, 9, 11, 8, 12.

X	F	FX	$X - \bar{X}$	$(X - \bar{X})^2$	$F(X - \bar{X})^2$
13	6	78	3.25	10.5625	63.375
12	4	48	2.25	5.0625	20.25
11	8	88	1.25	1.5625	12.5
10	5	50	0.25	0.0625	0.3125
9	5	45	-0.75	0.5625	2.8125
8	4	32	-1.75	3.0625	12.25
7	2	14	-2.75	7.5625	15.125
6	5	30	-3.75	14.0625	70.3125
5	1	5	-4.75	22.5625	22.5625
	41	390			219.5

$$\text{Mean } (\bar{X}) = \frac{\sum fx}{n} = \frac{390}{40} = \underline{\underline{9.75}}$$

$$\text{S.D} = \sqrt{\frac{\sum f(X - \bar{X})^2}{N-1}}$$

$$= \sqrt{\frac{219.5}{40-1}}$$

$$= \sqrt{\frac{219.5}{39}}$$

$$= \sqrt{5.628}$$

$$= \underline{\underline{2.37}}$$

t-Test for the hypothesis concerning students from families of Average/High Socio-economic status and those from Low socio-economic status families.

$$t = \frac{\bar{X}_1 - \bar{X}_2}{\sqrt{\frac{\sum x_1^2 + \sum fx_2^2}{n_1 + n_2 - 2}\left(\frac{1}{n_1} + \frac{1}{n_2}\right)}}$$

$$= \frac{14.64 - 9.75}{\sqrt{\frac{180.4288 + 219.5}{28 + 40 - 2}\left(\frac{1}{28} + \frac{1}{40}\right)}}$$

$$= \frac{4.89}{\sqrt{\frac{399.93}{66}\ (0.0357 + 0.025)}}$$

$$= \frac{4.89}{\sqrt{6.0595\ (0.0607)}}$$

$$= \frac{4.89}{\sqrt{0.3678}}$$

$$= \frac{4.89}{0.606}$$

$$= 8.067$$

$\therefore$ t $\underline{\underline{0.07}}$

Degree of Freedom (df) = $n_1 + n_2 - 2$, that is $28 + 40 - 2 = \underline{\underline{66}}$ At the probability level of 0.05, CV of t at df (66) = 2.000. The null hypothesis is, therefore, rejected because the calculated t (8.07) is greater than CV of t (2.000).

APPENDIX VIII

Summary of Data for Hypothesis Three

A. Calculation of Mean and Stadard Deviation of the Process Scores of the Students from Urban Secondary Schools.

9, 9, 12, 11, 11, 13, 10, 10, 11, 10, 13,
12, 12, 15, 16, 15, 14, 13, 17, 11, 11,
12, 13, 13, 6, 17, 7, 11, 11, 9, 14,
13, 18, 14, 19, 16, 15, 13, 18, 20.

X	F	FX	$X - \bar{X}$	$(X - \bar{X})^2$	$F(X - \bar{X})^2$
20	1	20	7.15	51.1225	51.1225
19	1	19	6.15	37.8225	37.8225
18	2	36	5.15	26.5225	53.045
17	2	34	4.15	17.2225	34.445
16	2	32	3.15	9.9225	19.845
15	3	45	2.15	4.6225	13.8675
14	3	42	1.15	1.3225	3.9675
13	7	91	0.15	0.0225	0.1575
12	4	48	-0.85	0.7225	2.89
11	7	77	-1.85	3.4225	23.9575
10	3	30	-2.85	8.1225	24.3675
9	3	27	-3.85	14.8225	44.4675
7	1	7	-5.85	34.2225	34.2225
6	1	6	-6.85	46.9225	46.9225
	40	514			391.1

$$\text{Mean } (\bar{X}) = \frac{\sum fx}{N} = \frac{514}{40} = 12.85$$

$$\text{S.D} = \sqrt{\frac{\sum f(x - \bar{x})^2}{N - 1}}$$

$$= \sqrt{\frac{391.1}{40 - 1}}$$

$$\text{S.D} = \sqrt{\frac{391.1}{39}} \qquad \sqrt{10.03} = 3.17$$

B. Calculation of Mean and Standard Deviation of the Process scores of the students from Rural Secondary Schools.

6, 18, 10, 6, 7, 11, 14, 9, 12, 16,
8, 8, 9, 6, 14, 10, 11, 14, 11, 8,
14, 9, 8, 6, 16, 8, 15, 8, 5, 12, 15,
10, 11, 13, 10, 12, 14, 12, 15, 13.

X	f	fx	$x - \bar{x}$	$(x - \bar{x})^2$	$f(x - \bar{x})^2$
18	1	18	7.15	51.1225	51.1225
16	2	32	5.15	26.5225	53.045
15	3	45	4.15	17.2225	51.6675
14	5	70	3.15	9.9225	49.6125
13	2	26	2.15	4.6225	9.245
12	4	48	1.15	1.3225	5.29
11	4	44	0.15	0.0225	0.09
10	4	40	-0.85	0.7225	2.89
9	3	27	-1.85	3.4225	10.2675
8	6	48	-2.85	8.1225	48.735
7	1	7	-3.85	14.8225	14.8225
6	4	24	-4.85	23.5225	94.09
5	1	5	-5.85	34.2225	34.2225
	40	434			425.1

Mean $(\bar{x}) = \frac{\sum fx}{N} = \frac{434}{40} = \underline{10.85}$

S.D. $= \sqrt{\frac{\sum f(x - \bar{x})^2}{N - 1}}$

$= \sqrt{\frac{425.1}{40-1}} = \sqrt{\frac{425.1}{39}} = 0.09$

$\therefore$ S.D $= \underline{3.30}$

t-Test for the hypothesis Concerning Urban and Rural Secondary School students.

$$t = \frac{\bar{x}_1 - \bar{x}_2}{\sqrt{\frac{\sum fx_1^2 + \sum fx_2^2}{n_1 + n_2 - 2}\left(\frac{1}{n_1} + \frac{1}{n_2}\right)}}$$

$$= \frac{12.85 - 10.85}{\sqrt{\frac{391.1 + 425.1}{40 + 40 - 2}\left(\frac{1}{40} + \frac{1}{40}\right)}}$$

$$= \frac{2.0}{\sqrt{\frac{816.2}{78}\,(0.025 + 0.025)}}$$

$$= \frac{2.0}{\sqrt{10.46\ (0.05)}}$$

$$t = \frac{2.0}{\sqrt{0.523}}$$

$$= \frac{2.0}{0.723} = 2.766$$

$\therefore$ t ~~>~~ 2.77

Degree of freedom (df) $= N_1 + n_2 - 2$

$= 40 + 40 - 2$

$= 80 - 2$

$\therefore$ df $= \underline{\underline{78}}$

At 0.05 probability with df (78), the Critical value of t = 2.000. At 0.05 significant level, calculated t (2.77) is greater than Critical Value of t (2.000), therefore, the null hypothesis is rejected.

APPENDIX IX

Summary of Data for Hypothesis Four

Calculation of Mean and Standard Deviation of the Process Scores of Students whose parents are Fairly/Highly educated.

17, 15, 13, 11, 14, 15, 13, 11, 13, 15, 12,
14, 18, 13, 15, 11, 14, 16, 13, 20,
15, 13, 19.

x	f	fx	$x - \bar{x}$	$(x - \bar{x})^2$	$f(x - \bar{x})^2$
20	1	20	5.65	31.9225	31.9225
19	1	19	4.65	21.6225	21.6225
18	1	18	3.65	13.3225	13.3225
17	1	17	2.65	7.0225	7.0225
16	1	16	1.65	2.7225	2.7225
15	5	75	0.65	0.4225	2.1125
14	3	42	-0.35	0.1225	0.3675
13	6	78	-1.35	1.8225	10.935
12	1	12	-2.35	5.5225	5.5225
11	3	33	-3.35	11.2225	33.6675
	23	330			129.2175

$$\text{Mean } (\bar{x}) = \frac{\sum fx}{n} = \frac{330}{23} = \underline{14.35}$$

$$\text{S.D} = \sqrt{\frac{f(x - \bar{x})^2}{N - 1}}$$

$$= \sqrt{\frac{129.2175}{23 - 1}}$$

$$= \sqrt{\frac{129.2175}{22}} = \sqrt{5.8735}$$

$$\therefore \quad \text{S.D} = \underline{2.42}$$

Calculation of Mean and Standard Deviation of the Process Scores of Students whose Parents are Not/Little educated.

13, 11, 14, 7, 15, 9, 10, 6, 8, 14, 12, 9, 13,
6, 8, 10, 9, 6, 8, 18, 9, 15, 11, 14,
8, 13, 11, 6, 15, 11, 8, 16, 8, 11, 5,
10, 12, 9, 7, 10, 6, 12, 17, 10, 13

x	f	fx	$x - \bar{x}$	$(x - \bar{x})^2$	$f(x - \bar{x})^2$
18	1	18	7.49	56.1001	56.1001
17	1	17	6.49	42.1201	42.1201
16	1	16	5.49	30.1401	30.1401
15	3	45	4.49	20.1601	60.4803
14	3	42	3.49	12.1801	36.5403
13	4	52	2.49	6.2001	24.8004
12	3	36	1.49	2.2201	6.6603
11	5	55	0.49	0.2401	1.2005
10	5	50	-0.51	0.2601	1.3005
9	5	45	-1.51	2.2801	11.4005
8	6	48	-2.51	6.3001	37.8006
7	2	14	-3.51	12.3201	24.6402
6	5	30	-4.51	20.3401	101.7005
5	1	5	-5.51	30.3601	30.3601
	45	473			465.2445

$$\text{Mean } (\bar{x}) = \frac{\sum fx}{n} = \frac{473}{45} = 10.51$$

$$\text{S.D} = \sqrt{\frac{\sum f (x - \bar{x})^2}{N - 1}}$$

$$= \sqrt{\frac{465.2445}{45 - 1}}$$

$$= \sqrt{\frac{465.2445}{44}} = \sqrt{10.5737}$$

$$\therefore \text{S.D} = \underline{\underline{3.25}}$$

t-Test for the hypothesis concerning students whose parents are Fairly/Highly educated and those whose parents are Not/Little educated.

$$t = \frac{\bar{x}_1 - \bar{x}_2}{\sqrt{\frac{\sum fx_1^2 + \sum fx_2^2}{n_1 + n_2 - 2}\left(\frac{1}{n_1} + \frac{1}{n_2}\right)}}$$

$$= \frac{14.35 - 10.51}{\sqrt{\frac{129.2175 + 465.2445}{23 + 45 - 2}\left(\frac{1}{23} + \frac{1}{45}\right)}}$$

$$= \frac{3.84}{\sqrt{\frac{594.462}{66}(0.043 + 0.022)}}$$

$$= \frac{3.84}{\sqrt{9.007\ (0.065)}}$$

$$= \frac{3.84}{\sqrt{0.585}}$$

$$= \frac{3.84}{0.765} \quad \therefore\ t = 5.019 \approx \underline{5.02}$$

Degree of Freedom (df) $= n_1 + n_2 - 2$

$= 23 + 45 - 2$ $\therefore$ df $= \underline{66}$

At the probability level of 0.05, CV of t at df (66) = 2.000. Therefore, the null hypothesis (H_o) is rejected because the calculated t (6.02) is greater than CV (2.000).

APPENDIX X

List of Secondary Schools Used for the Study

1. Abakaliki High School (PRESCO), Abakaliki
2. Girls' High School Azuiyiokwu, Abakaliki.
3. Model Comprehensive Girls Secondary School, Abakaliki.
4. Command Secondary School, Abakaliki.
5. Boys Secondary School, Ezzangbo.
6. Ntezi Community Secondary School, Ntezi
7. Izzi Girls Secondary School, (Holy Child Sharon), Inyimagu.
8. Special Science School, Igbeagu-Izzi.

These secondary schools which were used for the research are within Abakaliki Education Zone of Enugu State, Nigeria.

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