EFFECT OF SEX DIFFERENCES UPON THE ACQUISITION OF SCIENCE PROCESS SKILLS IN ZARIA-KADUNA AREA

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APPROVAL

This study has been read and approved as meeting the requirements of the Department of Education, Ahmadu Bello University, Zaria.

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DEDICATION

This study is dedicated to the everlasting memory of my late brothers Ambrose, Richard and Okoh Ameh, who have contributed immensely to my upbringing and education. It is a pity that they are not here to see the end of what they have initiated. To them I can only say; "odo a'a no họ lipu ebọ,nmla yi a glañ".

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CHAPTER 1.

THE PROBLEM.

INTRODUCTION.

Nigeria and some other African, Asian and South American Countries have been called developing nations. In such countries technological development is taking place at a fairly rapid speed. Rural areas are being connected to cities and towns by highways and express ways. In many cases the life-style of village communities is being altered as pipe borne water, electric light and improved communications are introduced. All of these innovations have been brought about by the Nigerian government in the belief that they will benefit Nigerian society as a whole. In many cases the major development projects are executed by foreign firms employing expatriates. Soon these people will leave and Nigerians will be needed to maintain existing projects and carry out further development work in the future.

It has been stated that in the existing technological era, ever increasing change is the order of the day. In science, the student becomes accustomed to change in the physical world around him (Federal Ministry of Education, Grade II Sylabus 1974). By teaching children science and about the changes that have taken place as a result of science and technology, the idea of change is more understandable and hence more acceptable. In this way, future changes which will help to improve the standard of living for the average Nigerian will be seen for what they are and not as forces causing the erosion of the national culture (Jegede and Brown, 1980).

By teaching science to children every Nigerian can be given a basic knowledge and understanding of some of the innovations that are taking place around him. Scientific development and national development go hand in hand and hence, the teaching of science will help in the achievement of national objectives. In both developed and developing countries, science is seen as a sine qua non for development. For this reason most education planners and educators believe that science should feature prominently as part of the primary and secondary school curriculum. Recommendations have been made in the third national policy on education (1977) on the laying of sound basis for scientific and reflective thinking in the primary school and the equiping of students to live effectively in the modern age of science and technology.

Much emphasis had been laid on the word science. Conferences have been held, reports issued, projects established and materials produced yet little meaningful science teaching appear to be going on in the schools. These coupled with the fact that the Soviet Union launched an artificial satelite into the orbit in in 1957, challenged the American scientists and it triggered off an unprecedented reaction in the field of science education. Resources were made available on an unmatched scale for the development of new science curricula materials and equipment. As a result, many science programmes were developed in America. Among some of these popular science programmes was the Science - A Process Approach (SAPA), developed by the Commission on Science Education of the American Association for the Advancement of Science (AAAS) 1963-1968, based on the guideline suggested by Robert Gagne.

The distinguishing features of SAPA as an educational experiment includes emphasis on acquisition of skills in the processes as the primary objective. Ideally science in the classroom should reflect the multidimensionality of science. That is, the science curriculum should include knowledge, the attributes displaced by scientists engaged in inquiry, the history and philosophy of science, and finally the social consequences of scientific discoveries (Nay, 1971).

The Process Approach is predicated on the fact that science is more than product (the facts of science) and of equal, if not greater, value is the acquisition of the processes (the intellectual activities) of science (Nay, 1971). The process of science are observing (using the five senses), classifying, measuring, communicating, quantifying, Space/time Relationship, inferring, and predicting, they are called the basic processes and are structured from the simplest skills to the more complex skills in a definite prescribed instructional hierarchy. Integrated skills are introduced later in life which give "warp and woop" to the basic processes. These processes are, making operational definitions, formulating hypothesis, controlling variables, interpreting data, and experimenting.

To achieve the nation's aims of education in both primary and secondary schools with regard to science teaching as stipulated in the third national development plan (1977), science should be taught as a process which embodies all the process skills mentioned above.

Sex differences have been noted in a number of research variables in psychology and education e.g. Graybill (1975) discovered that boys are better at activities requiring manipulation than girls. The present researcher thinks that Nigerian females have limited experiences in this area. They are raised in much more restrictive environment than males and are, for the most part, discouraged in this important phase of intellectual exploration. In Nigeria young females are not usually rewarded for independence and non-conformity. Females are not as many as males in occupations involving science like medicine, engineering, etc.

It may later be discovered that these differences are insignificant when they are compared to the more common life experiences of females, but it does provide some foundation for the belief that females are limited in manipulative experiences during the early stages of their lives.

The differences in social milieu, aspirations, and rewards for males and females in the society may have some effect on their respective performance in science process skills, and the relúctance of the majority of females to actively deal in the so-called masculine areas of endeavour may have an effect upon the ease with which they acquire skills in science. This study is undertaken to examine possible sex differences in the acquisition of science process skills.

1.2 STATEMENT OF THE PROBLEM

There is characteristic division of labour in the adult community. Men carry on the physically more strenous, mentally more stimulating, socially more directive, and administrative types of work. Women are assigned the more personally serviceable, more sedentary, more routinized and passive occupations (Mead, 1935). Men dig, build, harvest and manufacture. Women care for children, the sick, the unfortunate, and the old; they train youth. There is essential necessity and essential merit in both types of activity. Men through their occupation more often achieve distinguished leadership and fame. Women achieve the personal, maternal satisfaction tion that come. Sex contrast in adult occupational, professional and creative achievement has sometimes been attributed to sex differences in variability (Monroe 1952). Are there really sex differences in academic performance?

Graybill (1975) in New Jersey studied sex differences in problem-solving ability with children between the ages of 9 and 15. The sample consisted of three pairs of boys and girls of about 9, 11, 13, and 15 years of age and found that there were subtle differences in performance that might have some bearing on subsequent mental development. Boys always appeared more confident in handling the equipment and more sure in their movements. Graybill, discovered that boys had little difficulty in hitting the various targets while the girls found it an almost impossible thing to do. Girls performance exceeded that of boys in an experiment that require a minimum of manipulation.

It is further conceived that because of the aggressive nature of boys towards their laboratory work, sex differences should be noticeable in acquisition of science process skills.

Specifically the study is undertaken to identify sex differences, if any exists, in science process skills based on Wideen's (1971) "Science Process Measure for Teachers". The test was conducted using boys and girls in Kaduna state of Nigeria.

1.3 HYPOTHESES

1. There will be no significant difference in the acquisition of science process skills between boys and girls (α = 05).
2. There will be no significant difference in the acquisition of science process skills among boys in urban schools and boys in sub-urban schools in Zaria - Kaduna area (α =.05).
3. There will be no significant difference in the acquisition of science process skills among girls in urban schools and girls in sub-urban schools in Zaria - Kaduna area (α =.05).
4. There will be no significant difference in the acquisition of science process skills between boys and girls in Zaria - Kaduna area based on the "Basic Processes" of <u>Science - A Process Approach</u> (α =.05).
5. There will be no significant difference in the acquisition of science process skills between boys and girls in Zaria-Kaduna area based on the "Integrative Process Skills" of <u>Science - A</u> Process Approach (α =.05).

1.4 NEED FOR THE STUDY

The present explosion of knowledge in science makes it impossible for scientists themselves to "keep-up" with all the sciences. New answers to old questions are being formulated everyday. It is impossible to teach a child all the "available knowledge" in science during his years of schooling. Even if this is done, many facts taught now may become unimportant a few years from now. A promising alternative is to equip the child with skills and processes which he can use to find solutions to science problems which he may encounter in the future.

Children may need to be scientifically literate to exercise good judgement as adults in a society which is so largely influenced by scientific and technological progress. Observation and communication, for instance, are two process skills which are absolutely essential if an individual is to relate to the physical world, be able to "identify" with his fellow men, and feel a sense of personal worth.

Moreover, there has been mass drift of Nigerian students to foreign countries to study science and technology. This shows the immense interest of the

Federal Government in science and technology. Nearly all scientists, science teachers and science educators agree that science teaching must develop more than rote memorization of scientific knowledge. Much money and efforts have been spent on science but little is achieved in the schools. Science is taught in Nigerian schools but this teaching lacks emphasis on process skills. Most teachers teach science as it was taught to them. Unless one had had the opportunity of conducting a personal investigation into some problem in science, however small, one may find it difficult to sit back while children plan and carry out an investigation. It may even seem a little unusual or uncomfortable to assume the role of guiding and supporting children in their work, rather than telling and demonstrating at every turn.

The study aims at finding out the extent to which science process skills are acquired in secondary schools, in Zaria - Kaduna area. Furthermore it is conceived that because of the general aggressive nature of boys toward their laboratory activities, sex differences should be noticeable in the acquisition and demonstration of science process skills.

1.5 DELIMITATION OF THE STUDY

This study was confined to post primary institutions offering science in Zaria - Kaduna environs of Kaduna State. The schools were selected on the bases of all schools offering physics, chemistry and biology with fifth form enrolment of 150 or over. The total numbers of schools qualified for selection were eight but Barewa College opted out on the grounds that the period of conducting the research was not convenient for the students. By this process of selection five of the schools were in urban centres of Zaria - Kaduna whereas two were in sub-urban areas.

A total of three hundred and twenty-three students were sampled. Out of this number ninety-eight were females. The subjects were distributed in four boys secondary schools and three girls secondary schools. The coverage tends to be limited. This of course makes for a more convenient work as well as minimizing travel difficulties were it otherwise.

1.6 DEFINITION OF TERMS

The meaning of some abbreviations and terms which may not be familiar to the reader are included in this section.

NERC - Nigerian Education Research Council. A Federal body centred in Lagos which advises the Government on educational matters.

SAPA - Science - A Process Approach. An elementary school science programme developed in U.S.A.

SCIS - Science Curriculum Improvement Study. An elementary school Science Programme developed in U.S.A.

AAAS - American Association for the Advancement of Science. A body responsible for the development of Science Curriculum centred in America.

Process Skills - These are the mental 'skills' which the scientist uses in attempting to solve a science problem.

Urban - Schools located in the metropolitan Zaria and Kaduna townships.

Sub-Urban - Schools located outside metropolitan Zaria and Kaduna townships.

1.7 A BRIEF DESCRIPTION OF THE PROCESSES

SAPA is different from the more traditional elementary science curricula. In most of the elementary classes, programs in science have included more or less separate units in which children learn something about spiders, or magnets, or birds or many other things. The philosophy underlying such a programme is that by the end of the first, third or sixth year of school, the child will have learned facts about the world of science which constitute of valuable part of his intellectual inventory. (SAPA 1965)

The philosophy underlying SAPA is different. The assumption made by SAPA is that "Science is much more than an encyclopedic collection of facts, and even children in the primary grades will derive much more from the study of science if they learn the behaviour of scientists". Although the behaviours of scientists are complex, they have been classified into a number of process skills, some simple and some more complex. These intellectual activities of scientists-the processes, form the core of SAPA.

Science skills for the primary grades stresses the basic skills of: observing, classifying, using space/ time relations, using numbers, communicating, measuring, inferring, predicting, skills in applying these basic processes provide the foundation for the more complex or integrated processes which were the fundamental elements of SAPA in the intermediate grades. The integrated processes were, formulating hypothesis, controlling variables, interpreting data, defining operationally and experimenting.

OBSERVATION.

In SAPA the process of observing has a much broader meaning. Observing means perception using all the senses - sight, touch, sound, taste and odour. In order for a student to demonstrate competence in using the process of observation, he should be able to demonstrate an operational knowledge of the physical properties of objects; identify and describe the objects which interract in a system; list the observable characteristics of a given phenomenon. Tannenbaum (1971)

CLASSIFYING.

Classifying consists of sorting objects into groups on the basis of observable properties of the objects. In order for a student to demonstrate competence in using the classifying process, he should be able to group objects or systems of objects according to a given property; select and justify an appropriate property and group objects or systems of objects according to that property and group objects or systems of objects according to two simultaneous properties.

USING SPACE/TIME RELATIONS.

These terms are used in only relatively simple situation and ways not 'space' and 'time' suggesting space exploration and landing man on the moon. In order for a student to demonstrate competence in using the process of space/time relations, he should be able to make a two-dimensional representation of a three-dimensional object and visualise and describe a three-dimensional object from two-dimensional representation of it.

USING NUMBERS.

Using numbers requires the recognizing and using numbers and number relations. In order for a student to demonstrate competence in using the process of using numbers, he should be able to show that two sets have the same number of members or that one set has a greater number of members than another, by using one-to-one correspondence.

COMMUNICATING.

Communicating requires many skills like writing, speaking, etc. In SAPA, communicating embodies such things as verbal communication in class, using two-dimensional graphs etc. In order for a student to demonstrate competence in the process of communicating he should be able to exchange ideas and information occuring in the classroom and construct two-dimensional graphs.

MEASURING.

Measuring is the simplest process of knowing how short or long a thing is. Volume is also measured and in SAPA measurement is done using the metric system. In order for a student to demonstrate competence in using the process of measuring, he should be able to suggest and use "home-made" units for measuring the properties of objects; demonstrate an operational knowledge of units of measure, the function of widely accepted units, the names and approximate sizes of the most common units, such as inch, foot, centimeter, meter, pound, quart, gram, kilogram, litre, second, degrees celsius etc; represent and recognise the special relationships among two or more objects by a scale diagram (maping); represent and recognize an object or a system of objects by a scale diagram; and measure the rate of change of a property of an object or a system of objects.

EXPERIMENTING.

Experimenting is one of the intermediate processes. In order for a student to demonstrate competence in using the process of experimenting, he should be able to use suitable experimental procedures in seeking solutions to problems, including designing an investigation appropriate to the problem; select, clarify, and state in testable terms (perhaps as an answerable question) the primary variable to be investigated; control the variables appropriately so that logical conclusions may be drawn with regard to the primary variable; distinguish between dependent and independent variables employ the processes of observation, comparing, quantifying, classifying, and measuring to gather data; utilize the processes of inferring and predicting to interpret the data collected, answer the original problem, and lead to the posing of new problems and the design of new experiments to investigate them.

INFERRING.

Inferring is drawing out one's opinion about something. In order for a student to demonstrate competence in using the process of inferring, he should be able to draw warranted generalization from a body of data; identify the factor most likely to have caused a given change in a system; identify and specify observations which would be needed to justify a particular generalisation; distinguish between a statement based directly on observation and one which is an inference or a generalisation. Be able to draw more than one inference in situations where the data allows this; test an inference by collecting further data; recognise which data are necessary and sufficient to support an inference or a generalization.

PREDICTING.

Predicting in the scientific sense of the word is expressing one's confidence that the universe is not capricious. In order for a student to demonstrate competence in using the process of predicting, he should be able to detect or demonstrate trends to predict by extrapolation and/or interpolation; devise and use simple means of checking the accuracy of the predictions made;

recognise and use pertinent arguements, reasons, or principles to justify a prediction; demonstrate an operational knowledge of the necessity for multiple and reliable observations prior to prediction and an unwillingness to offer predictions in the absence of such observations.

FORMULATING HYPOTHESIS.

In order for a student to demonstrate competence in formulating hypothesis he should be able to distinguish between inferences and hypothesis; identify data from a test which support or do not support a hypothesis; conduct a revision of a hypothesis on the basis of data collected from a test of the hypothesis.

DEFINING OPERATIONALLY.

In order for a student to demonstrate competence in using the process of defining operationally, he should be able to identify variables or words for which an operational definition is needed, given a hypothesis, inference, model, question, graph, or table of data; distinguish between operational definitions and non-operational definitions of the same object, event or idea.

CONTROLLING VARIABLES.

In order for a student to demonstrate competence in using the process of controlling variables, he should be able to identify variables which may influence the behaviour or the properties of a physical or biological system; identify variables which are held constant, manipulated or responding in an experiment; describe an experiment using correctly the terms variable constant variable, responding variable, and manipulated variable; construct a test to determine the effects of one or more variables on a responding variable.

INTERPRETING DATA.

In order for a student to demonstrate competence in using the process of interpreting data, he should be able to describe in a few sentences the information shown in a table or graph; construct one or more inferences or hypothesis from a comparison of the information in two or more related tables of data graphs; construct inferences or hypothesis from pictorial data.

FORMULATING MODELS.

In order for a student to demonstrate competence in using the process of formulating models, he should be able to identify a model consistent with a set of observations, inferences, or hypothesis; construct a representation of a model; construct an expected outcome (inference or observation) based on a model; demonstrate the use of a model to explain a set of observations.

CHAPTER 2

REVIEW OF RELATED LITERATURE

In this chapter, relevant literature concerning process skills in general are reviewed. The first part deals with purposes of teaching science process skills to children and the best approach or method for teaching process skills. The development of process skill tests and their application were further examined. The results of some of these tests were also dicussed. Finally, the chapter discusses some literature on sex differences.

PURPOSES OF TEACHING SCIENCE AS PROCESS.

Science educators believe that there is excitment in seeing, however limited, the working of the physical and biological world; there is intellectual power to be gained in learning the scientist's approach to the solution of human problems. According to the authors of Science - A Process Approach (SAPA), the first task and central purpose of science education is to awaken in the child, whether or not he will become a professional scientist, a sense of joy, the excitment, and the intellectual power of science.

The nature of science teaching has changed considerably over the past several decades. Theories of instrution, the design of curricula and views on the nature of science and science teaching have gone through a variety of modifications. Throughout this period however, there has remained nearly unanimous agreement that learning in young children is likely to be more efficacious if the child is involved in first hand direct manipulative experiences. This concern for active pupil participation in the learning experience was advocated in the early years by educators such as Montessori and Dewey, and in more recent years by the authors of the experimental science curriculum projects such as Science - A Process Approach (SAPA), and Science Curriculum Improvement Study (SCIS). The theoretical foundation is also supportive of this notion. Developmental psychologists, such as Piaget, Suchman, Bruner and Gagne suggested that this active pupil participation and direct manipulation of concrete objects is important in the development of learning in young children.

Many educators consider the development of science process skills in children to be a major objective of education (Gagne, 1965; Herron, 1970; Neie, 1972; Okey, 1972). Several educators have provided explanations for this belief. Gagne contends that the science process skills represent common elements in the scientific endeavour as well as carrying the promise of broader transferability across many subject areas.

Okey states that a major goal of education should be to teach students how to acquire and process information. He states further that "process skills that go beyond the acquisition of facts are of high value because they approximate how students will use or operate on knowledge in out of school situation".

Another major influence on the future curriculum development in science process goals was the classic National Science Teacher Association (NSTA) document - "Theory into Action" (1964) which placed process statements on a par with conceptual schemes as the framework on which science curricula should be based. The NSTA description of the major items in the processes of science are as follows:-

1. Science proceeds on the assumption based on centuries of experience that the universe is not capricious.
2. Scientific knowledge is based on observation of samples of matter that are accessible to public investigation in contrast to purely private inspection.
3. Science proceeds in a piece-meal manner even though it aims at achieving a systematic and comprehensive understanding of various sectors or nature.
4. Science is not and will probably never be a finished enterprise, and there remains much more to be discovered about how things in the universe behave and how they are interrelated.
5. Measurement is an important feature of most branches of modern science because the formulation as well as the establishment of laws are facilitated through the development of quantitative distinctions.

Subsequently, almost all statements of goals and objectives of science programmes include a considerable usage of process statements. One reflection of the status of process goals is indicatèd by their inclusion as one of the four major objectives assessed by the National Assessment of Education Progress (NAEP) studies (1969). Within the NAEP major category of the learners "ability and skills needed to engage in the procedures of Science" were the following ten skills:

1. define a scientific problem,
2. suggest or recognise a scientific hypothesis,
3. propose or select validating procedures (both logical and empirical),
4. obtain requisite data,
5. interprete data,
6. check the logical consistency of hypothesis with relevant laws, facts observations, or experiments.
7. reason quantitatively and symbolically,
8. distinguish between fact, hypothesis, and opinions, the relevant from the irrelevant and the model from the observations the model was desired to describe,
9. read scientific materials critically,
10. and employ scientific laws and principles in familiar and unfamiliar situations.

2.2 DEVELOPMENT OF PROCESS SKILL TESTS AND THEIR APPLICATION.

Many tests have been constructed in order to find out whether a child/student has acquired ability in the practice of process skills. For instance Tanenbaum (1971) developed the test of science processes. In this test an instrument to assess achievement and diagnose weaknesses in the use of science processes by students in grades seven, eight, and nine in the United States were developed. The science processes considered were: observing, classifying, quantifying, measuring, experimenting, inferring, and predicting. The instrument consisted of 96 multiple choice (five-choice) questions. It required total actual testing time of 73 minutes, and the instrument yields a Kuder-Richardson (formula - 20) reliability of .91. and eight subscores, one for each process (with reliabilities ranging from about .30 to about.80). The instrument was administered to 3,673 students from schools in the Bronx and Rockland countries, New York. The author did not report any results. The need to design instruments which will measure students progress toward the attainment of process skills is of concern to many science educators. It was not possible to gain access to this instrument and therefore it cannot be used for subjects involved in this study.

Several tests have been developed to test the effectiveness of SAPA in the acquisition of process skills. The Eastern Region Institute of Education (ERIE) Science Process Test developed by Wallace (1969), was to assess the skills associated with the S.A.P.A. Curriculum for students in fourth and fifth grades in the United States. The test was deemed to have content validity by virtue of its relationship to the listing of Science - A Process Approach processes. From the data collected with a sample of 846 students, the 55 multiple choice item test was ascertained to have a KR - 20 reliability of 0.72. Most of the items on this test were accompenied by pictoral information or graphical/tabulation of data. The author did not report the results and weaknesses. The Wallace test is considered inappropriate for the present study because the subjects of the study are much more matured than those used by Wallace.

Molitor and George (1976) developed a test to asses the performance of the processes of inference and verification of students in grades level four, five and six.

They attempted to develop a group - administered, content-free, pictorial test of specific process skills. The content of each item was chosen such as was likely to be familiar to most students. Both the stem and options of the items were presented via sketches of various situations or actions. The brief direction and questions were based on the same pictorial distractors. Their findings showed that students with four years of Science - A Process Approach instruction performed significantly better than did the group of students with no formal process instruction. From the results of the item and test statistics, they concluded that the inference subtest had low reliability because of items that were too easy for the students, while the verification subtest had acceptable psychometric qualities.

The result is expected because under normal condition somebody with formal instruction in any process will do better than somebody without the experience. This test is similar in some respects to the test used in the present study, in that they both attempt to develop a group-administered, content free, pictorial test of specific process skills. These various tests constructed to evaluate science process skills have shown the increasing interest in the skills or processes that are in involved in science.

Wideen (1971) constructed a test of Science Process Measure for Teachers. The instrument consists of a fourty item test booklet, an answer booklet, and an instruction booklet with answer key. The instrument, although openended, is objectively scored through the use of an answer key and procedures as outlined in the instructional booklet. The first twenty-seven items were designed to test the basic skills and the remaining thirteen items were designed to test the integrated skills. After examination to establish content and face validity by a panel of judges consisting of four science education staff members and three science education graduate students at the University of Alberta, it was decided that four of the twenty-seven items designed to test basic skills were really testing knowledge of the sequential nature of the SAPA Programme. These four items were grouped into a separate sub-test. It was judged that the remaining twenty-three items did measure basic process skills and the thirteen items designed for measuring integrated process skills were adequate in terms of their face and content validity. Wideen found a Hoyt reliability of 0.88. The test was judged by the investigator to be satisfactory in terms of internal consistency.

The author did not report the result of the test. In the present study, Wideen's test was adapted but ten items were left out as they were considered to be inappropriate for Nigerian students as a result of the pilot study.

It has been suggested that in order that the teaching of science be effective, the method of instruction must shift from traditional lecture method to teacher directed activities (Schwab, 1962).

Nay and his associates developed a process approach to teaching science in 1971. Nay noted that the concept of process of science is not a new one. The idea was inherent in Dewey's five-step "Scientific Method" consisting of defining a problem, forming a hypothesis, planning a test of the hypothesis, gathering data and forming a conclusion. Many modifications of Deway's model appeared in due course, owing largely to the fact that the five steps presented an inadequate description of what scientists do.

In the framework developed for Science - A Process Approach, fourteen processes have been identified. These processes as listed in the Commentary for Teachers (1965) are observing, classifying, using space/time relations, using numbers, communicating, measuring, inferring and predicting. These are called basic processes and are structured from the simplest skills to the more complex skills in a definite prescribed instructional hierarchy. Integrated skills are introduced later in life. These are making operational definition, formulating hypothesis, controlling variables, interpreting data and experimenting.

In SAPA the ability to read was not so essential as it was in many traditional curricula. Because of this the processes could start at any level, even as early as Kindergarteen. Success in SAPA did not depend on skills in reading, but on the ability to use the processes of science. This essential differences had important implications. It meant that the degree of reading skill was no longer a factor controlling science learning (AAAS, 1968). Most of the reading materials prepared are for the teachers only. Rather than reading about science in this curriculum, children learn science through the use of their senses, mental involvement, and direct manipulation of things in their immediate environment.

In this present study, the researcher noted that ability to read played a significant part in understanding the questions. From the results of the Pilot study, it was discovered that most respondents scored low due to inability to understand the questions. This led to ten of the questions being left out and some wordings rephrased to ease comprehension by the subjects used for the study.

2.3 LITERATURE INVOLVING SEX DIFFERENCES

Until about 1900, boys and girls were assumed to be alike in so far as their education was concerned and "the child in the school was thought of as relatively sexless" for most of the time. Research made before 1900 were with one or two exceptions casual, generally uncritical comparisons of small and often ill-selected and unequal groups. In 1903, Thompson made the first adequate experimental study. This was followed during the next decade and a half by a number of other critical researchers which have been reviewed by Woolley and Hollingworth (1918).

In Nigeria boys are ascribed certain roles and girls others. Boys schools are often separated from girls schools. Most people look up to maleness as masterful. A boy in any family will be expected to perform better in any involvement with a girl. Girls are looked upon as the weaker sex. Boys and girls are diverse in both biological and cultural terms, therefore one expects a difference in the acquisition of science process skills.

Psychological researches have shown that trainability is equal in motor and sensory performance except where male strength and endurance are primary factors. Intelligence, which as recently as the 1900 was thought to be contrasting for the sexes, is now found to display no well-defined advantage of either sex (Terman, 1916). The earliest objective studies indicated that essential equality in score average and score range is found when the tests used are constructed and validated with equal consideration of the abilities of both sexes. Terman first compared Standford - Binet scale, standardized with a view to "fairness to both sexes" and the result showed very slight differences favouring the girls at the younger ages and the boys after age thirteen. Later studies with the same scale supported the indications of sex equality in intelligence. In the standard of the 1937 revision of the Standford - Binet Scale "fairness" to both sexes was a primary aim. The result is a test in which sex differences largely cancel out.

Lincoln (1927) found that in educational pursuit girls were generally ahead of boys from the lowest grades through high school. However Rhinehart (1947) found the trend less conspicuous in college, but noticeable in large junior co-educational institutions. Lentz (1929) found that girls also tend to show general superiority on standardized achievement tests, although to a lesser extent than on teacher's grades. According to Lentz the direction of sex difference varies with specific tests. For example girls excelled in the area of the language arts, boys in arithmetic reasoning and science. The mean difference are often quite small and the overlap between the distributions for the two sexes are typically extensive.

Douglass (1937) and Rhinehart's (1947) findings regarding sex differences in secondary school achievement scores and marks bring into clear relief the contrast between girl's general better marks and boys general superior achievements in mathmatics subjects. It seems however that at the present stage of mental measurement it is not possible to give an unequivocal answer to the question "which sex is superior in intelligence." When sex differences are found on specific tests, the results may reflect opportunity for learning, cultural expectations, and attitudes toward the content of the tests. These factors may equally apply in this present study among Nigerian students.

The focus of the present study is to find out if differences exist between boys and girls in their acquisition and demonstration of process skills. The study also examined the effect of the environment (urban versus sub-urban) on the acquisition of these skills and the level of the complexity of the skills (basic versus integrative processes of SAPA).

CHAPTER 3.

3.1 DESIGN AND PROCEDURE.

The instrument used for this study is taken from the Test of Science Process Measure for Teachers, constructed in America by Wideen (1971).

Although there has been much emphasis and increasing interest by science educators in Nigeria in the skills or processes that are involved in science, there was no report that was found which describes a test based on science process skills. In this study an attempt was made to find out if differences exist between boys and girls in their acquisition and demonstration of process skills. The study also examines the effect of the environment on the acquisition of these and the level of the complexity of these skills. The test is made up of thirty (30) item questions covering thirteen of the process skills. The processes involved are communicating, using numbers, observing, inferring, predicting, space/time relationship, measuring, formulating model, controlling variables, formulating hypothesis interpreting data, operational definition and experimenting.

These processes were identified from the test items with the aid of Science - A Process Approach: Comentary for Teachers. The distribution of the test items according to the processes is shown in Table 1. The items range from communicating to operational definition. Communicating, using numbers, observing, inferring, Predicting, space/time relationship and measuring constitute the basic processes of SAPA. Experimenting, fromulating model, controlling variables, formulating hypothesis, interpreting data and operational definition constitute the integrative processes.

Wideen's test (1971) was adapted for the purpose of this study. The original test consists of fourty (40) items with a Hoyt reliability of 0.88. The Present test consists of thirty (30) items with a proportionate reliability of . 84 calculated according to Ferguson (1966).

The estimated reliability is given by

$$\gamma\text{-est} = \frac{Kr}{1+(K-1)r}$$

where K is the proportionate length of the new test and r is the calculated reliability of the original test (Ferguson, 1966).

TABLE 1

THE DISTRIBUTION OF THE TEST ITEM ACCORDING TO THE PROCESSES

PROCESSES	NUMBERS																														TOTAL NUMBER OF ITEMS/PROCESSES
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	
COMMUNICATING		✓	✓																												2
USING NUMBERS	✓						✓													✓											3
OBSERVING				✓		✓		✓	✓				✓	✓	✓															✓	8
INFERRING					✓														✓												2
EXPERIMENTING																					✓					✓					2
PREDICTING										✓																					1
SPACE/TIME RELATION											✓	✓																			2
MEASURING																✓		✓													2
FORMULATING MODEL																	✓														1
CONTROLLING VARIABLES																						✓									1
FORMULATING HYPOTHESIS																							✓	✓							2
INTERPRETING DATA																									✓		✓		✓		3
OPERATIONAL DEFINITION																												✓			1
GRAND TOTAL																															30

The thirty item questions were designed to last ninety (90) minutes . Plain answer sheets were provided for the respondents. The Wideen test is designed in the U.S. primarily for science teachers. It would have been more appropriate to use the test with science student teachers at the level of College of Education. However, the population of such student teachers in Kaduna State is very small and is not normal. Furthermore a large proportion of such teachers may have been exposed to formal science in shorter than three years. Secondary school graduates would have had four or more years of formal science and they therefore stand a good chance of having experienced some of the SAPA processes through doing them.

At any rate the SAPA processes upon which the Wideen test is based are teachable at primary, secondary and tertiary levels. The test therefore has content validity since it is based on SAPA.

3.2 THE INSTRUMENT

Answers to the items were suposed to be written on separate answer sheets. Some of the items consist of sub-units but each item scores a maximum of one point each. Several copies of these test items were made. At the beginning of each administration of the test, instructions were given that no respondent was allowed to write anything on the question paper since the same question papers were planned to be used several times and the researcher did not want respondents to be influenced by earlier respondents. To be on the safe side, the test question papers were always collected and checked. If anyone was found with pen mark, that question paper was discarded. With this strict measure taken, the same question papers were given to all the schools sampled.

3.3 THE PILOT STUDY.

A pilot study was carried out. A school comparable to those intended for the study was selected for the pilot testss. All the form four science students (67) were used. The test items were scored. All items for which 33 percent or less of the respondents got correct were considered inappropirate. On this ground ten items were left out of the instrument. Some words were considered inappropriate for Nigerian students. Such words were replaced. For instance "moisture evaporated" was replaced with "water loss"; "steel wool" was replaced by "cotton wool;" "marble" was replaced by "stone". The thirty item questions were given to "experts" for further validation. The experts were made up of two senior lecturers in science education and three post graduate science education students.

3.4 ADMINISTRATION OF THE TEST

There was no prior notification to students about the test. The test was given to all form four students who were doing science. Students were allowed to ask questions for clarification and they were to answer the questions they know first then go to the difficult ones they left. Students were instructed to answer the questions as shown in Appendix I.

3.5. SCORING THE TEST

The same marking scheme used for the pilot study was used to score all the papers. The sample answer was prepared by the researcher and compared to sample answers from two experts, one lecturer in science education and a post-graduate student in science. The items were awarded a point each for ease of scoring, though there were sub-units in some items. In item number five (5) where respondents were required to write three statements, a respondent who has at least two correct statements is awarded a point. In item number eleven (11), if a respondent gets any of the sub-units wrong, he is refused a point. In item number fourteen (14) there are six sub-units, if a respondent gets anything from four upwards, he is given a point. The items are not given equal treatment but the scoring for each item for individuals or respondents are the same.

3.6 SELECTION OF SCHOOLS

The schools selected were post-primary institutions offering science in Zaria-Kaduna environs of Kaduna State. The schools were selected on the basis of population of students in form five. Secondary schools with form five students of population of 150 or above were qualified for selection. Both urban and sub-urban schools were represented in the sample. A total of three hundred and twenty three (323) students were sampled. Out of this number, ninety-eight (98) were females. The subjects were distributed, four boys' secondary schools and three girls' secondary schools.

The instrument used was identified by SAPA to consist of two levels of science process skills. Level one consists of the Basic Processes. These are communicating, using numbers, observing, inferring, predicting using space/time relationship and measuring. While level two consists of the Integrative Processes. These are formulating models, controlling variables, formulating hypothesis, interpreting data, defining operationally and experimenting.

Test - item numbers one (1) to twenty (20) and item number thirty (30) are made up of the Basic Processes. While item numbers twenty-one (21) to twenty-nine are made up of the integrative processes.

CHAPTER 4.

RESULTS, ANALYSES AND DISCUSSION

INTRODUCTION.

This chapter contains the results, analyses and discussions of the study. The level of significance (ρ) of 0.05 was selected for the analyses.

4.1 RESULTS AND ANALYSES

The first research problem relates to sex differences between boys and girls in science process skills. The null hypothesis tested was that there will be no significant differences in the acquisition of Science Process skills between boys and girls in Zaria-Kaduna area.

The students scores were grouped into two by sex and mean scores for each group and the grand mean were calculated. A Pearson Product Moment Correlation (r) was caculated to find out the relationship between the performances of the two groups. The calculated PPM (r) value was 0.92. The t - value using Nie et al. (1975). is given by

$$t = r\left[\frac{n-2}{1-r^2}\right]^{\frac{1}{2}}$$

where r is the ppm value and n is the number of different tasks (processes involved, was calculated to be 7.77. The total number of respondents was 323. The number of girls was 98. The critical value of t at 0.05 confidence level was 2.18. The calculated t value is statistically significant and the null hypothesis was therefore rejected.

The second research problem relates to differences between urban boys and sub-urban boys in science process skills. The null hypothesis tested was that there will be no significant difference between urban boys and sub-urban boys in Zaria - Kaduna area in the acquisition of science process skills.

The male students scores were grouped into two, urban and sub-urban and mean scores for each group and the grand mean were calculated. A Pearson Product Moment correlation (r) was calculated to find out the relationship between the performances of the two groups. The calculated PPM (r) value was 0.72. The t value was calculated to be 3.43. The total number of boys was 225. The number of boys in sub-urban school was 38. The critical value of t at .05 confidence level was 2.18. The calculated t value was statistically significant and the null hypothesis was therefore rejected.

The third research problem relates to differences between girls in urban schools and girls in sub-urban schools, in science process skills. The null hypothesis tested was that there will be no significant difference between girls in urban and girls in sub-urban schools in the acquisition of science process skills in Zaria - Kaduna area. The female students scores were grouped into two by environment and mean scores for each group and the grand mean were calculated. A Pearson Product Moment correlation (r) was calculated to find out the relationship between the performances of the two groups. The calculated PPM (r) value was 0.84. The t value was calculated to be 5.08. The total number of girls was 98. The number of girls in sub-urban school was 23. The critical value of t at .05 confidence level was 2.18. The calculated t value was statistically significant and the null hypothesis was therefore rejected.

The fourth research problem relates to sex differences in the basic processes. The null hypothesis tested was that there will be no significant difference in the acquisition of science process skills between boys and girls based on the basic process skills.

The students scores were grouped into two by sex and mean scores for each group and the grand mean were calculated, using PPM (r) to find out the relationship between the performances of the two groups. The calculated PPM (r) value is 0.91. The t value was calculated to be 4.96. The total number of respondents was 323. The number of girls was 98. The critical value of t at .05 confidence level is 2.45. The calculated t value was statistically significant and the null hypothesis was therefore rejected.

The fifth research problem relates to sex differences between boys and girls in the integrative processes. The null hypothesis tested was that there will be no significant differences between boys and girls in the acquisition of science process skills based on the integrative skills in Zaria-Kaduna area.

The student scores were grouped into two by sex a and mean scores for each group and the grand mean were calculated. A PPM (r) was calculated to find out the relationship between the performances of the two groups. The calculated PPM value was 0.93. The t value is calculated to be 8.99. The critical value of t at 0.05 confidence level is 2.57. The calculated t value is statistically significant and the null hypothesis is therefore rejected.

The researcher did an inter-process comparison. The mean performance per group (sex) per process was calculated. The results are in table II below

Table II.

Mean Score of Respondents in Process Skills

Processes	Boys	Girls
	(N= 225)	(N=98)
Communicating	0.43	0.46
Using numbers	0.52	0.48
Observing	0.57	0.64
Inferring	0.24	0.30
Experimenting	0.22	0.20
Prediction	0.08	0.11
Space/time relation	0.47	0.49
Measuring	0.31	0.16
Formulating models	0.26	0.36
Controlling variables	0.06	0.04
Formulating hypothesis	0.34	0.45
Interpreting data	0.14	0.17
Operational definition	0.27	0.45

Table II shows the mean score of respondents in process skills. In some of the processes like communicating, using numbers, experimenting, predicting, space/time relation, controlling variable and interpreting data the differences between the scores are not much. Girls are performing better in observing and inferring while boys are scoring better in measuring. Girls are generally performing better in the integrative processes: formulating hypothesis, formulating models, and operational definition.

Table III.

Mean Scores of Urban and Sub-urban Boys in Process Skills.

Processes	Urban boys (N =187)	Sub-urban boys (N = 38)
Communicating	0.45	0.31
Using numbers	0.52	0.50
Observing	0.56	0.64
Inferring	0.24	0.23
Experimenting	0.19	0.34
Predicting	0.06	0.15
Space/time relationship	0.47	0.47
Measuring	0.33	0.21
Formulating models	0.25	0.34
Controlling variables	0.04	0.15
Formulating hypothesis	0.30	0.56
Interpreting data	0.11	0.28
Operational definitions	0.23	0.47
Grand Mean	3.75	4.65

Table III is the mean scores of urban and sub-urban boys in process skills. The scores of urban boys and sub-urban boys are the same in processes such as using numbers, inferring, and space/time relationship. Although, no cause-effect relationship is established, certain processes appear to be performed better by sub-urban boys than urban boys. These processes are observing, experimenting, predicting, formulating model, controlling variables, formulating hypothesis, interpreting data and operational definition. Urban boys perform better in the process of measuring than sub-urban boys. The grand mean is higher with sub-urban performance than with urban performance.

Table IV.

Mean Scores of Urban and Sub-urban Girls in Process Skills

Processes	Urban Girls (N =75)	Sub-urban Girls (N =23)
Communicating	0.54	0.23
Using numbers	0.55	0.27
Observing	0.67	0.52
Inferring	0.32	0.23
Experimenting	0.22	0.13
Predicting	0.13	0.01
Space/time relationship	0.52	0.39
Measuring	0.20	0.02
Formulating model	0.37	0.34
Controlling variables	0.04	0.04
Formulating hypothesis	0.44	0.50
Interpreting data	0.20	0.07
Operational definitions	0.45	0.39
Grand Mean	4.65	3.14

Table IV is the mean scores of urban and sub-urban girls in process skills. Some processes appear to be performed better by urban girls than sub-urban girls. These processes are communicating, using numbers, observing, inferring, experimenting, predicting, space/time relationship, measuring, interpreting data and operational definition. There are no differences in the performance of urban girls and sub-urban girls in the processes of controlling variables. The grand mean shows that urban girls are performing better than sub-urban girls.

Table V.
Mean Scores of Boys and Girls in the Basic Process Skills.

Processes	Boys (N= 225)	Girls (N=98)
Communicating	0.43	0.46
Using numbers	0.52	0.48
Observing	0.57	0.64
Inferring	0.24	0.30
Predicting	0.08	0.11
Space/time relationship	0.47	0.49
Measuring	0.31	0.16
Grand Mean	2.62	2.64

Table V shows the mean score of boys and girls in the basic processes. The performances of both sexes in the basic process skills are more or less the same. The grand mean is almost the same except that there is slight difference favouring the girls.

Table VI

Mean Scores for Boys and Girls in the Integrative Process Skills

Processes	Boys (N = 225)	Girls (N = 98)
Formulating models	0.26	0.36
Controlling variables	0.06	0.04
Formulating hypothesis	0.34	0.45
Interpreting data	0.14	0.17
Operational definition	0.27	0.43
Experimenting	0.22	0.20
Grand Mean	1.29	1.65

Table VI shows the mean scores for boys and girls in the integrative process skills. There is not much difference in performance in the processes of controlling variables, interpreting data, and experimenting although boys are performing slightly better than girls in the process of experimenting. Girls performance in formulating models, formulating hypothesis and operational definition excel that of boys. The overall mean again is favouring the girls.

4.2 DISCUSSIONS

The main purpose of this study is to find the effect of sex differences upon the acquisition of science process skills. The effect of sex differences is assessed using the thirteen SAPA processes: observing, communicating, measuring, using numbers, inferring, predicting, using space/time relationship, experimenting, formulating models, controlling variables, formulating hypothesis, interpreting data and defining operationally.

From Tables II , V, and VI, boys are better at using numbers than girls. Using number in SAPA is acquiring skills in working mathematics. Boys mastery in mathematics had been reported by Douglass and Rhinehart as early as 1937 and 1947 respectively. They carried out research regarding sex differences in secondary school achievement scores and their results showed clear-ly the contrast between girls low performance and boys general superior achievements in mathematics.

Girls performance in the processes of observing and inferring excel that of boys. This finding supports Seder's (1940) finding in which he discovered the existence of sex differences in the affective domain. The evidence suggests that boys have stronger and more aggressive nature than girls. Girls are more artistic an and docile. Moreover in the Nigerian culture girls are expected to use their eyes, ears and not their mouth, that is girls should be seen not heard. It is not surprising that girls are performing better than boys in the process of inferring as in observing. In SAPA, the ability to observe goes with the ability to infer.

Boys performance in the processes of measuring and experimenting excel that of girls. This finding supports Seder's finding in which he discovered that boys are more mechanically and scientifically inclined. Lentz (1929) also found that boys excelled in the area of arithmetic reasoning and science.

From the results obtained in table III, one would have taught that boys in urban schools would perform better than boys in sub-urban schools, but the reverse is the case. Boys in urban schools are exposed to many amenities which one would have thought will enhance their performances. The possible reason could be that the sub-urban schools have better scientific facilities in their laboratory. Teaching method could be another. The girls in urban schools are performing better than girls in sub-urban schools. The researcher is attributing the reason first to amenities in the urban areas. Secondly, better and more qualified teachers prefer to remain in the urban areas. Girls are naturally more docile than boys and more strict measure is taken on them than on boys in Nigerian schools. These could be the reason why the social life in the urban area could not distract them.

4.3 LIMITATIONS OF THE STUDY

An assumption underlying this study is that the results could be attributed to many factors. While every attempt was made to minimise any fraud on the part of respondents, one can not ignore the possibility of uncontrolled factors accounting for the results. Three possibilities are evident to the researcher.

School Environment: Some of the schools were in urban areas which may have influenced the experiences of the respondents from those areas and vis versa for those from the suburban areas. Environmental factors represent a possible alternative explanation for the results, since the administration of the tests were carried out in different locations. Secondly, the training and ability of teachers and their method of instruction represent another possible alternative explanation for the results. Some teachers are old in the profession and may not have had the opportunity of experiencing some of the more recent science curricula while others may have just freshly graduated, equiped with the processes and skills of the new science curricula. Whichever is the case, the impact must tell on the students performance in the process skill test. Thirdly, the availability of science materials in the various schools may have enhanced the performance of the students. Some schools are introduced earlier to the manipulation and handling of science aparatus while some schools are introduced later to the same thing. This may also have effect on the performance of the students.

The researcher noted that boys complain that they are not taught practicals in science until they are in their final year. However, such complaints did not come from the girls. This could be another reason for the girls better performance than boys. Processes in SAPA include manipulation, experiments etc. Where students have not experienced these, they cannot be expected to perform well in such processes. This again may represent a further alternative explanation for the results since the test was administered to students of form four regardless of what has been taught to them.

Infact, every other condition was assumed equal, since students were all in the fourth year of secondary school and were doing science.

In a study by Brown (1978) findings and observations similar to those contained in the present study were made. Partin (1967) in Mississipi also arrived at results similar to the present results.

In a comparison of student outcomes for Science - A Process Approach, Wideen (1971) confirmed that there is a sex difference in process achievement. Although boys showed more interest in science than girls, the girls had superior achievement in the process test. The pattern of interractions found in Wideen's study suggests that high interest in science is likely to be found among low academic achievers and those scoring low on process measures. This latter suggestion could be a possible reason for girls performing better in the process measure than boys.

The results of this study have shown that there are sex differences in the acquisition of science process skills between boys and girls in Zaria-Kaduna area. The girls showed superior achievement in process tests. It is also noted that environmental locations may have effects on the acquisition of science process skills.

CHAPTER 5.

SUMMARY AND RECOMMENDATIONS

5.1 SUMMARY.

This study sets out to verify the effect of sex differences in the acquisition of science process skills in Zaria - Kaduna area.

The study was confined to post - primary institutions offering science in Zaria and Kaduna area. The study sets out to test the following hypotheses:

1. There will be no significant differences in the acquisition of science process skills between boys and girls in Zaria - Kaduna area.
2. There will be no significant differences in the acquisition of science process skills between boys in urban and boys in sub-urban area of Zaria - Kaduna area.
3. There will be no significant differences in the acquisition of science process skills between girls in urban and girls in sub-urban schools in Zaria - Kaduna area.
4. There will be no significant differences in the acquisition of science process skills between boys and girls based on the basic process skills of SAPA.

5. There will be no significant differences in the acquisition of science process skills between boys and girls based on the integrative process skills of SAPA.

Relevant literature were reviewed on sex differences. Researches on sex differences before 1900 showed that boys and girls were alike as far as their education was concerned and the child in the school was thought of as relatively sexless for most of the time. But researches made after 1900 have shown one or two exception of sex differences. For instance, Douglas (1937), and Rhinehart (1947), discovered that boys are better in Mathematics subjects than girls. Seder (1940), found that girls have stronger artistic and literary interests while boys have stronger mechanical and scientific interests.

Some research findings showed clearly that there are sex differences in achievement and interests. For instance Terman (1936), compared boys and girls on the Standford-Binet Scale and found slight differences in achievement favouring the girls.

The instrument used in the present study was taken from the test of science process measure for teachers, constructed in America by Wideen in 1971. The original test consisted of fourty items with a Hoyt reliability of 0.88. The present test consists of thirty items with a calculated reliability of 0.84.

All the five hypotheses, stated in their null form were rejected because there were no sufficient grounds not to reject them. Therefore, the alternate hypotheses may be true, that is (a) there are significant differences in the acquisition of the SAPA science process skills between boys and girls in Zaria-Kaduna area; (b) there are significant differences in the acquisition of science process skills between urban boys and sub-urban boys in Zaria - Kaduna area; (c) there are significant differences in the acquisition of science process skills between urban girls and sub-urban girls in Zaria - Kaduna area; (d) there are significant differences in the acquisition of science process skills between boys and girls based on the integrative skills and basic skills of SAPA.

The researcher has attributed these results to three factors. (1) The effect of the environment is conceived to have influenced the performance of the students. Some schools are located in urban areas where there are lots of amenities which could enhance learning while some schools are located in sub-urban areas, deprived of many amenities. All these have direct effect on the performances of students. (2) The ability and methods of instruction of the teachers are other factors that could have effect on student performances. Where the teachers are knowledgeable and use effective methods of instructions, the students are also expected to perform very well. In short, the methods of instruction is often reflected in students performance. (3) The Third factor is the availability of science materials. In schools where the laboratories are well equiped, the learning of science is facilitated, because the students are involved in direct first hand experience.

Apart from these factors, there are other difficulties which are obvious. For instance, the environment of the sexes from birth onward is essentially dissimilar. In the Nigerian society boys are brought up in the male tradition of their culture and girls in the female tradition; the education and the experience of the sexes are unavoidably diverse. Hende one can say that in attempting to evaluate acquisition of process skills with a view to discovering sex differences, one is actually measuring a product of elements themselves diverse in both physical and cultural terms. It is expected that these diversity in the individuals - boys and girls - will affect their performance. This makes the problem of sex differences greatly complex. There are two important causes of sex differences. One is the physical constitution and the second is the social tradition. Education can increase or decrease social sex differences and has considerable influence on the psychological elements, but it cannot alter the physical dichotomy.

Many research findings are in line with the present study. For instance Brown (1978) in Nigeria found girls performing better than boys after both have been exposed to the same treatment of SAPA. Partin (1967) also in Mississipi found girls performing significantly better than boys after both have been taught using SAPA.

5.2 RECOMMENDATIONS

The utilization of the two levels of science process skills - basic and integrative processes led to two results. In the first place, the hypothesis on the basic procossess led to the finding that there may be significant differences between boys and girls in the acquisition of science process skills. Secondly, that on the integrative processes, girls were performing generally better than boys. Girls are performing better in the higher or integrative processes of SAPA than boys. This result raises some question as to whether this difference is an indication of girls superiority over boys in science processes or merely a question of chance. However if a larger sample is utilized, it may give a true picture of the sexes. It is therefore recommended that more research into this area of sex differences should be undertaken to cover a wider ground and using a larger sample.

The results must be accepted with reservation since in most cases the differences were statistically significant only when the whole items were correlated. These findings however should be a source of encouragement to the many teachers and science educators and especially curriculum planners and those who participate in planning education in the ministries. Since the girls appear to perform better than boys in science process skills, the school curriculum should be planned in such a way as to lay more emphasis on the teaching of processes to boys. This of course does not mean that girls should be left out. The influence of girls may affect boys performance in these processes and therefore a co-educational system in which the girls may influence the boys performance should be encouraged.

When these findings are considered in conjunction with the popular belief in this society that boys are better than girls, and the idea that some people prefer male children to female, it seems likely that the conceived notion will have to be altered and a new step in planning for both sexes would have to be adapted.

The researcher has listed environmental location as a possible alternative reason for differences in performance of boys and girls. It is recommended that equal treatment should be given to schools in both urban and sub-urban areas, even though the findings in sub-urban and urban areas do not seem real and do not reflect the true picture of what is expected. For instance, one would have expected that boys in urban schools would have performed better because of all the available amenities, but the reverse is the case. Results obtained from comparison of performance of girls in urban and girls in sub-urban areas is more true to reality where urban girls were performing significantly better than sub-urban girls. However, good staffing system is recommended both in urban and sub-urban schools. Qualified and efficient science teachers should be employed and distributed equally between the urban and sub-urban schools.

In the supply of science materials to both urban and sub-urban schools no school should be neglected and girls should be made to work in close contact with boys so that boys could be also influenced in science skills.

Evidence from examination results, e.g. West African School Certificate and other examination bodies have shown that boys are much more superior in the content area than girls though this result has not been confirmed by any known experimental or analytical study. irls working closely with boys, will benefit from this area where they are weak. In short mutualism will result from a co-educational system of education.

From the results of this study and some other similar studies cited earlier, it seems clear that the girls are performing better than the boys on science process tests. None of the cited works nor the present study has established any cause - effect relationship. It is still not very clear what causes the boys to perform less than the girls in such process tests. Similarly, it is not clear why the boys do better than girls in cognitive tests. A causal study would enable educators to provide either sex with the missing links. It is therefore recommended that future studies should focus on the determination of causes of poor performances on process tests by boys.

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APPENDIX I.

SCIENCE PROCESS MEASURE FOR TEACHERS

TIME: 1½ hrs.

PLEASE COMPLETE EACH OF THE FOLLOWING TASKS TO THE BEST OF YOUR ABILITY. DO THE ONES YOU KNOW FIRST THEN GO TO THE DIFFICULT ONES YOU LEFT.

Write your answers on a separate answer sheet which is provided. Do not write on the paper and please return the paper at the end of this task.

1.

Draw this line in your answer sheet and mark the position of:

A. −5 B. 2 C. − 0.8

2. Here is a table of data collected during an experiment to see how water is lost out of plant during successive hourly intervals.

Hours	Volume in milliliters of water lost during each hour
1	17
2	13
3	15
4	12
5	16
6	15

Construct a graph on your answer sheet and label the axis carefully.

3. Number 2 above represented data collected during an experiment which required measuring water lost from a plant. Describe the shape of your graph.
4. Examine the object placed infront of you and describe some of its properties which you can observe. (Your description of the object should be complete, enough so that it could be used by another person to identify the object.)
5. You peeled a banana and put it and the peel in a clear plastic container and sealed it. A week later you observe fruit flies inside the container with the banana and peel. Write three statements to explain the occurence of fruit-flies inside the container.
6. A class of children was shown five identical dishes labelled A.B,C,D and E, in each of which a piece of cotton wool and a nail had been placed. The tables show what was put in some of the dishes and the results they observed.

Container	Contents	Observation
A	dry cotton wool and nail	no rust
B .	cotton wool and nail moiste-ned with water	Some rust
C	cotton wool and nail covered with water	no rust
D	cotton wool and nail moiste-ned with vinegar	much rust
E	cotton wool and nail covered with vinegar	no rust

Two conclusions were made by the class:

A. liquids cause cotton wool and nail to rust.

B. Air causes cotton wool and nail to rust.

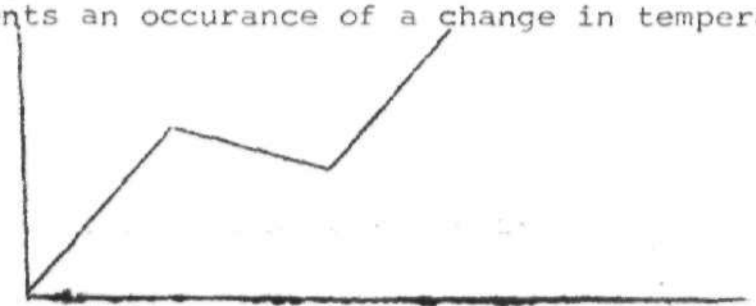
List two observations that support each conclusion.

7. A stone is 6 cm round, it takes 2.5 seconds for the stone to roll in a straight path from the starting line to the centre of a circle, a distance of 150 cm. What is the average speed of the stone in

   A. Centimeters per second?

   B. Number of revolutions per second?

8. Below is a graph. Place an 'X' over a point that represents an observation. Draw an arrow to identify any point on the curve that represents an occurance of a change in temperature



9. What will you notice if you suspend objects of the following masses from a rubber band?

A. 175 grams

B. 300 grams

10. An object was droped from a height of 20 meters and it took 2 seconds for the object to strike the ground. From a height of 80 meters it took 4 seconds for the object to fall. Based upon this information, three children predicted how long it would take the object to fall from a height of 50 meters:

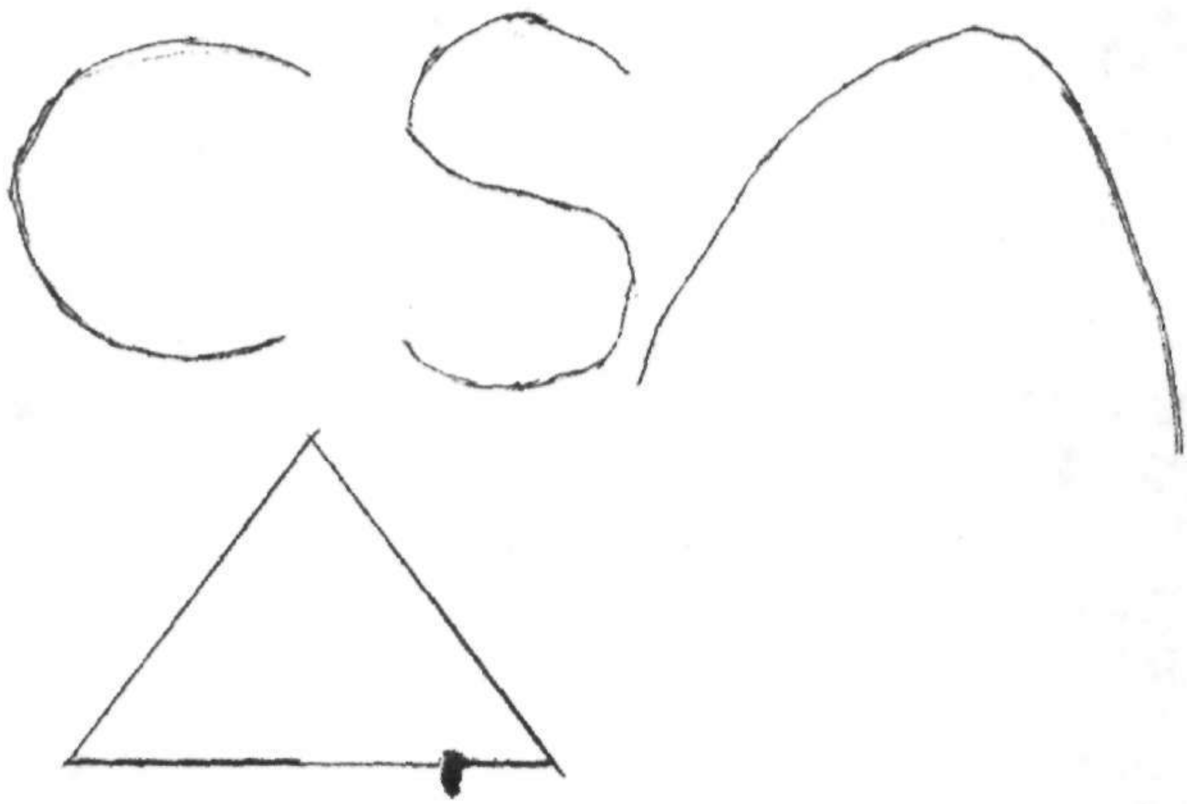
Louise predicted 3 seconds

Barbara predicted 3.5 seconds

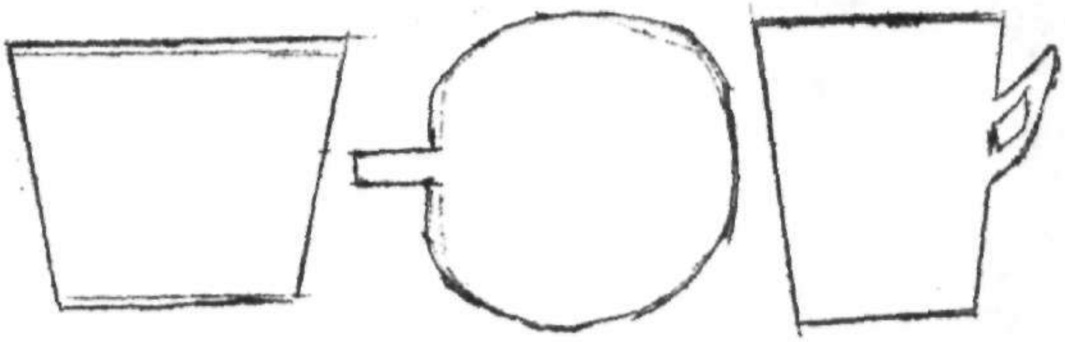
Jill predicted less than 3 seconds, but more than 2 seconds.

Order these three predictions from most to least reliable and describe the basis for your decision.

11. Draw the following figures in your answer sheet. On each figure draw lines indicating exactly similar parts on either side. If a line has no exact similar parts on either side, write the word none across the drawing



12. Here are the shadows an object makes when it is lighted from three directions perpendicular to each other:



Draw the three-dimensional object that cast these three shadows.

13. Examine carefully the sketch below. Write a description of the sketch.

14. A child was describing an object he had played with. Indicate whether each of the child's statements is an observation or an assumption: The child's statements were:

A. it was warmer than my fingers

B. it loves me

C. it moves by itself

D. it is related to a wolf

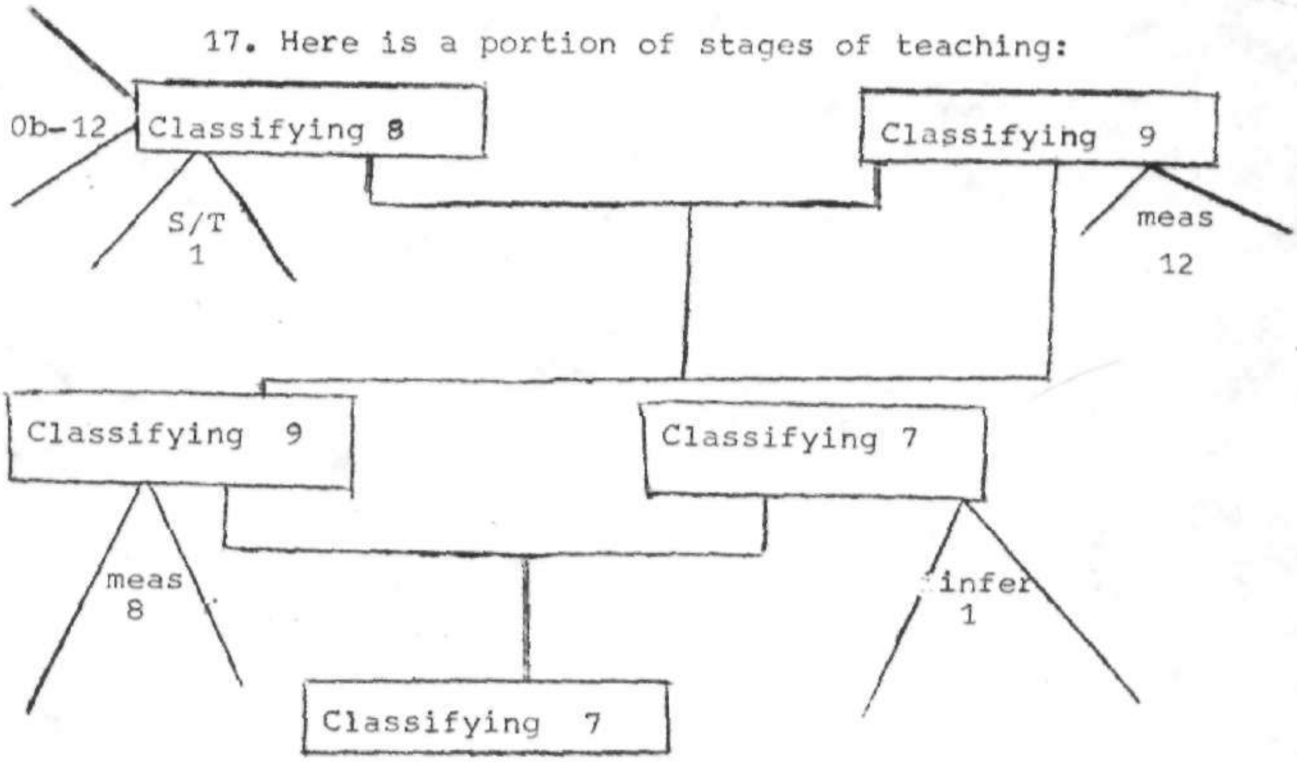
E. it was very hungry

F. it is reddish brown.

15. Take a careful look around you and write a sentence on what you can see.

16. In your answer sheet, draw a circle of any size, measure the diameter of the circle and the circumference. Record your answer.

17. Here is a portion of stages of teaching:



In your answer sheet name the exercise that should be taught before teaching classifying 8.

18. Consider the cup you use in drinking water: estimate the:

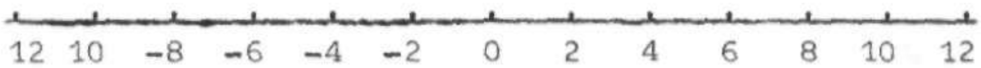
A. Diameter of the cup in centimeters

B. Height of the object in decimeter

C. Volume of water that the object could hold when filled-full, in milliliters (cubic centimets)

19. A child has been trying to grow some plants from seeds. He planted the seeds one week ago, but so far no seedlings have come through the soil. He infers that the pot of soil and seeds has been too hot. He decides to move the pot away from the sun. Another week passes, but no seedlings appear. Indicate whether the new observation supports or does not support the inference, and describe the basis for your decision.

20. From the number line below, find the sum of 4 and - 6.



21. You have observed that bread left in the open dries out and rarely develops mould, but that bread that you cover or seal in plastic does develop mould if you leave it for several days. From your observations you infer that the amount of mould that develops on bread depends on the

amount of moisture the bread retains.

Describe an experiment how you would test your inference.

22. This number refers to the experiment you described in number 21 list the variables.

23. In your answer book identify which of these statements is an inference and which is a hypothesis by placing X in the appropriate box.

INFERENCE	HYPOTHESIS	STATEMENT
		All gases expand when heated.
		Burning can take place only if oxygen is available
		Iron expands faster than brass on heating
		Candle wax changes from liquid to solid because the wax is cooled.

26. Describe an experiment that you will carry out for the following hypothesis: Four - legged animals can move faster than two legged animals.

27. Some students measured the time it took for solid cylinders to roll down an inclined plane. They used aluminium cylinders that had the same lengths but different diameters. They tried cylinders that had diameters of 6mm, 8mm, 10mm, and 12mm and found that each took the same amount of time (3 seconds to roll the same distance down) the plane from their observations, the children made this hypothesis: "The amount of time it takes for a cylinder to roll down an inclined place does not depend on its diameter". The children decided to test their hypothesis with other cylinders. The diameter of the cylinders and the time it took for each to roll the same distance down the plane are shown in the Table below.

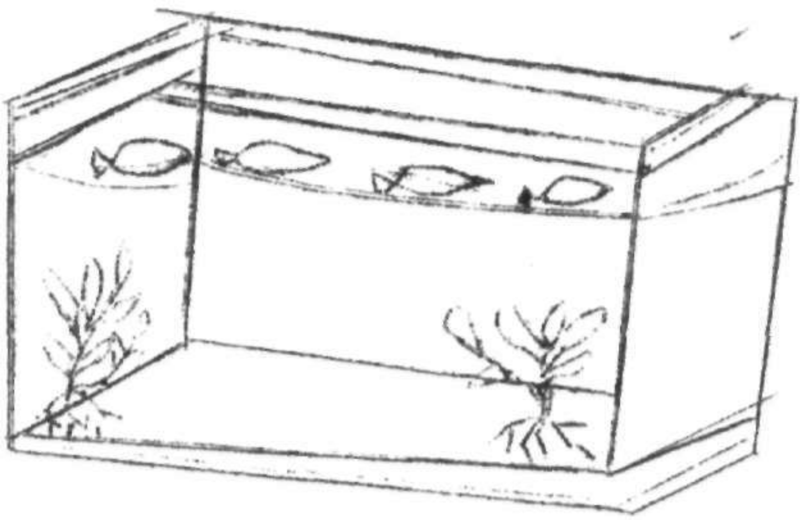
Diameter of Cylinder	Time to roll down Plane
16 mm	3 seconds
14 mm	3 seconds
4 mm	3.4 seconds
2 mm	5 seconds

In your answer sheet state a revision of the hypothesis based on the new observations.

28. Some children hold in a flame the ends of 'rods' of different materials to which clay have been attached with wax, and they observe whether or not the clay drop off and how soon. They obtain data like this:

	TIME FOR THE CLAY TO DROP(SECONDS)			
Steel rod	33	25	36	31
Spoon	40	32	50	41
Chalk	did not drop	did not drop	did not drop	-
Glass rod	did not drop	did not drop	did not drop	-

30. Look at this picture of an acquarium in a classroom. Write three statements about the picture alone.



APPENDIX II.

24th April 1980.

The Permanent Secretary,
Ministry of Education,
Kaduna State,
Nigeria.

Dear Sir,

We are writing to request your kind permission and assistance to conduct some science process tests in eight Post-Primary Institutions in Kaduna State. The acquisition of science process skills underlie most of the science curriculum projects for Secondary Schools.

This study is being conducted in the Faculty of Education in partial fulfillment of the requirements for the award of M.Ed Curriculum and Instruction (Science). The title of the study is:

> "Effect of Sex Differences on the Acquisition of Science Process Skills."

It is conceiveable that because of the generally aggresive nature of boys towards their laboratory activities, sex differences should be noticeable in the acquisition and demonstration of process skills. The object of this study is to find out if secondary school boys perform better than girls in demonstrating science process skills and to access the extent to which secondary school students in Kaduna State will perform in science process skills.

We shall appreciate whatever you can do to ease our task, with the understanding that copies of the results of our findings in this project would be made to the Ministry on request.

Thank you for your anticipated co-operation.

Yours faithfully

Dr. M.J. Shuaibu
CO-ORDINATOR, SUPERVISOR.

Catherine O. Ameh.