A STUDY OF THE RELATIONSHIP BETWEEN THE ACQUISITION OF SCIENCE PROCESS SKILLS AND PROBLEM SOLVING ABILITY AMONG PRIMARY SCHOOL PUPILS IN URBAN AND RURAL SETTING IN KENYA.

A RESEARCH PROJECT SUBMITTED IN PARTIAL FULFILLMENT FOR THE DEGREE OF MASTER OF EDUCATION, IN KENYATTA UNIVERSITY.

BY

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DECLARATION

"This Research Project is my original work and has not been presented for a degree in any other University".

GRACE OSODO OGONDA

"This Research Project has been submitted for examination with my approval as University Supervisor".

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DEDICATION

To my husband Henry, my best friend and roommate,

To my daughters and son
Truphena, Agnetta, Nereah and John Reuben
the delights of my life

and

To my mother Judith and my late father Jacob whose
prayers and encouragement have kept me going.
ACKNOWLEDGEMENT

No such work can be produced entirely by any one person. I am therefore indebted to a number of people whose assistance, support and cooperation made the production of this work possible.

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I am equally grateful to the District Education Officer - Kisumu, in particular Mr. F. Oketch for his timely assistance; and to the Nairobi City Education Office through Mrs. Koinange for granting me permission to carry out the study in a number of Nairobi Schools.

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ABSTRACT

This study was designed to investigate the relationship between the acquisition of science process skills and problem solving ability among standard seven pupils in a rural and an urban environment (Nyakach division of Kisumu district and Nairobi Province).

The subjects involved in the study were 528 pupils - 279 boys and 249 girls. A science process skill test and a problem solving test designed to measure the acquisition of science process skills and problem solving ability respectively, were administered to these subjects.

It was found that a high and positive relationship ($r=0.89$) existed between the acquisition of science process skills and problem solving ability. It was also observed that urban pupils performed better than rural pupils in both tests. Another observation made was that boys did better than girls in both tests. It was interesting to note that pupils of relatively better educated parents obtained significantly higher scores in both tests than those from less educated parents.

The findings of this study indicate the need for more use of inquiry method of teaching, especially in the rural areas, and an improved professional input from the area Teacher Advisory Centre (TAC) Tutors in order to improve the quality of science instruction and have better development of science process skills and problem solving ability among our Kenyan primary school pupils.
"Without education, development will not occur. Only an educated people can command the skills necessary for sustainable economic growth and for a better quality of life".

World Bank, 1988

The importance placed on education in general as a tool for economic growth and specifically in skill development as a means for sustaining economic growth has been seen in the trend education has taken since the late 1950s. The trend worldwide has been to improve the quality of education. This trend which gained prominence in America and Europe in 1957 - after the Russians had launched Sputnik I, called for a new direction in science education in Western Countries in general and in North America in particular. The launching of Sputnik I was a great challenge to the Americans; consequently they responded by channelling large sums of money and talents into efforts to upgrade all aspects of scientific enterprise (Lee, 1967 1). This scientific effort was put on historical record by Husen Torsen (1979) in the following words:

"The late 1960s and early 1970s marked a turning point with regard to expectations about formal education as an instrument of economic growth and development". 2

In Britain too, similar progress as was going on in America was experienced, and the period between 1960 and 1980 saw veritable explosions of activity
in curriculum development. A great deal of time, effort and money was expended in the largest cooperative venture ever, to upgrade education, especially science education (Ingle and Jennings, 1981)\(^3\)

Thus all over the world, it was a period of active development of scientific knowledge. This was evident in the development of varied types of school curricula at the time. In America such programmes as elementary science study (ESS) Under Educational Services Incorporated (ESI); Science Curriculum Improvement Study (SCIS); Science: A Process Approach (SAPA) among others were launched. In Britain there was the Nuffield Programme among others. In these programmes there was a deliberate effort to move away from the traditional content based programmes encouraging rote learning to the discovery/enquiry/activity approach in which the development of the process skills were encouraged. In this context Eugenia Poporad Variek and John Montean (1977) noted that:-

"during the past fifteen years there has been much activities in revising school curricula. The trend has been to change the emphasis from science content to the processes of scientific investigation. The child is no longer seen as a passive learner receiving information from the teacher or from the text book instead, he is actively manipulating materials developing his own hypothesis, ......." \(^4\)

Thus, the emphasis in science education has been on the acquisition of science process skills.
These changes in Science Education which were taking place in America and Europe, where the acquisition of process skills were being stressed other than the acquisition of knowledge, were soon taken up in Africa and other developing countries where parallel developments soon began. Professor Oke (1977) thus noted:

"The pattern of education established in Africa followed the English system, science teaching was based on the general assumption that science is science in Africa and in Europe. Science is the same everywhere." 5

Corresponding to 'the science in Europe and in America' such programmes as the African Primary Science Programme (APSP) and its successor, the Science Education Programme for Africa (SEPA), as well as the New Primary Approach (NPA) among others came up in Africa and Kenya in particular. The major aim of these changes was to introduce the science process skill (SPS) approach in our educational system. The approach which these new programmes were to take was expressed at a SEPA meeting at Njala University in 1978. It was reported that science education should take the view that science is a medium through which a child might develop his natural curiosity, his powers of observation and enquiry and constructive attitudes to problem solving and decision making (SEPA, 1978 6).

Some of the programmes emphasizing the use of science process skills and problem solving, particularly
the NPA was operative in Kenya as early as in the late 1950s, first in special schools in Nairobi, and was later extended to the African schools by the early 1960s (Waichungo, 1978).

In these new programmes, the child was to be responsible for his own learning by actively participating in the learning process through various activities organized by the teacher. Waichungo (1978) while writing about the NPA, noted that:

"In all lessons, the child will not just sit and receive information from the teachers, but he or she will actively take part. The child will be given a chance to find out for himself rather than getting the teacher to tell him all the answers." 9

It is worth noting that, in the quest to upgrade education for economic development, the Kenyan government has been engaged in a long term project which reached a climax in 1984 with the launching of the 8-4-4 system of education. In this system, the emphasis is on the development of practical skills and independent learning (Dr. Oluoch, 1984; Kenya National Examination Council, 1987).

What the 8-4-4 system of education emphasizes and that which is relevant to this study is the acquisition of practical skills which can be used in solving practical problems. The definition of science process skills (SPS) shows that practical skills are actually part of SPS. Thus one of the things that the 8-4-4 system of education stresses...
is the acquisition of the science process skills. The 8-4-4 document released in 1984 by the Ministry of Education Science and Technology stated that:

"The 8-4-4 system will ensure that students graduating at every level have some scientific and practical knowledge that can be utilized for either self employment, salaried employment or further training". 12

In this respect, the practical scientific knowledge offered in the 8-4-4 programme should enhance national development by equipping the youth with the essential knowledge and skills necessary for development. Thus, broadly speaking science education is being seen as a tool for national development; but specifically how does the acquisition of the science process skills come into this argument? The 1984-88 Development plan has the answer to this question. It says:

"Development demands people trained in Science and ... Maths occupation and manual skills much more than arts based occupation, hence more effort will be put in teaching science and maths so as to graduate adequate numbers and to making syllabus provide more functional skills to assist the majority of school leavers obtain self employment in the economy". 13

Again, the functional skills and manual skills in science and mathematics mentioned here, as the ones which will aid development in general are non other than the science process skills. It is not surprising then, that one of the aims of science education in primary schools points directly at the development of these skills. It states that science education
embracing children acquire certain manual and thinking skills which are useful in solving practical problems. 14

1.2 Rationale for the Problem

It is evident that the development and acquisition of the science process skills is a very crucial issue in the educational system. But what is surprising is that, despite all these emphases on the development of science process skills, researches on skill acquisition in the Kenyan Schools and elsewhere are very few. Alvin Pettus (1980) commented that:

"with the recent emphasis on development of science process skills in science education, it is surprising that assessing performance levels relative to these skills has not received more attention than it has to date". 15

The researcher therefore intends to look into this area and try to find out how well some of these skills which are very much emphasized in our educational system are acquired by pupils. Secondly, since our primary school syllabus and other authors (see literature review) maintain that the skills acquired should help pupils to deal with problems effectively/or be useful in solving practical problems , the researcher intends to investigate if there is actually any relationship between the acquisition of science process skills and problem solving ability on the part of the pupils.
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problem solving ability on the part of the pupils.
Thirdly, apart from the emphasis placed on science education vis-a-vis process skills acquisition in our education system, the researcher has been greatly perturbed by the low rank science as a subject has continued to occupy as compared with other subjects done in the Kenya Certificate of Primary Education (KCPE) since the inception of the 8-4-4 system. The new trend in science education emphasizing the acquisition of practical skills has demanded a parallel change in the setting of science examinations. A shift from items testing recall to items testing application of knowledge, problem solving and a wide range of skills has been realized (KCPE Newsletter, 1986) 16

Of all the subjects examined in KCPE, performance in science as a subject has been the poorest so far. The 1985 and 1986 results show the following mean standard scores and ranks for all the subjects examined in KCPE. 

<table>
<thead>
<tr>
<th>Subject</th>
<th>1985 Mean</th>
<th>1985 Std &amp; Score</th>
<th>Position</th>
<th>1986 Mean</th>
<th>1986 Std &amp; Score</th>
<th>Position</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kiswahili</td>
<td>47.96</td>
<td></td>
<td>1</td>
<td>49.69</td>
<td></td>
<td>2</td>
</tr>
<tr>
<td>G.H.C.</td>
<td>47.73</td>
<td></td>
<td>2</td>
<td>50.10</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>English</td>
<td>47.45</td>
<td></td>
<td>3</td>
<td>49.69</td>
<td></td>
<td>2</td>
</tr>
<tr>
<td>Art, H/Science &amp; Music</td>
<td>46.27</td>
<td></td>
<td>4</td>
<td>49.20</td>
<td></td>
<td>4</td>
</tr>
<tr>
<td>Mathematics</td>
<td>46.05</td>
<td></td>
<td>5</td>
<td>48.93</td>
<td></td>
<td>5</td>
</tr>
<tr>
<td>Science &amp; Agriculture</td>
<td>45.28</td>
<td></td>
<td>6</td>
<td>48.36</td>
<td></td>
<td>6</td>
</tr>
</tbody>
</table>

Source: KNEC NEWSLETTER 1986 and 1987
It is also gathered from the same source that, the performance on science questions as compared to the sister-subject Agriculture has continued to be relatively poor (KCPE Newsletter, 1987) ¹⁷

The general poor performance in science coupled with the fact that the science paper now stresses and tests science process skills problem solving and other higher capabilities like application of scientific knowledge, is really disturbing. An analysis of the questions appearing in KCPE 1985 reveals that one third \((1/3)\) of all the questions out of sixty \((60)\) were on SPS and nine \((9)\) other questions were on problem solving.

The disturbing question in the mind of the researcher was, could it be that the pupils in primary schools are not exposed to enough practical work based on SPS and problem solving that makes performance in science to be that poor? This question can only be answered by setting a separate test that measures the acquisition of science process skills and problem solving ability in pupils. Hence the need to carry out this research.

1.3 Statement of the problem

This study sought to find out whether there was any relationship between the acquisition of the science process skills and problem solving ability in science among standard seven pupils.
More specifically the study tried to answer the following questions:-

i) Does the acquisition of the science process skills necessarily presuppose a higher level of performance in problem solving by standard seven pupils?

ii) Is sex related to performance in the science process skill test and problem solving activities?

iii) Is there any significant difference in performance in science process skills and problem solving ability among urban and rural pupils?

iv) Are there skills at which girls are better than boys?

v) Are there skills at which boys are better than girls?

vi) Does the education of the parents have any bearing on pupil performance in the science process skill test and problem solving activities?

1.4 Objectives of the study.

In order to be able to fulfill the aim of the study in trying to find a relationship if any, between the acquisition of the science process skills and problem solving, the following objectives guided the researcher:-

i) To find out whether the acquisition of science process skills leads to a higher attainment in problem solving ability among standard seven pupils.
ii) To determine the type of skills best acquired by pupils in class seven in both an urban and a rural environment.

iii) To find out if there is any significant difference in the acquisition of SPS and problem solving on the basis of:

(a) Sex
(b) rural and urban environments
(c) parental level of education.

1.5 Hypotheses

The following null hypotheses were tested in the study. In this connection the alpha level chosen was 0.05.

i) Main hypothesis

$H_0^1$: There is no significant difference in pupil performance in SPS and problem solving tests.

ii) Sub hypotheses

$H_0^2$: There is no significant difference between boys' and girls' performance in SPS and problem solving tests.

$H_0^3$: There is no significant difference between rural and urban pupils in their performance in both SPS and problem solving tests.

$H_0^4$: There is no significant difference in performance in the SPS and problem solving tests among children of parents with various educational qualifications.
that they can develop materials that will emphasize both SPS and problem solving skills.

1.7 Limitations of the study

The following are some of the limitations of the study:

i) The main limiting factor in this study was time. Due to insufficient time, the researcher could not
   a) administer the instrument to the pupils on an individual basis, even though that could have been the best way to do it.
   b) cover a bigger population than five hundred pupils.
   c) test all the science process skills. The researcher concentrated only on three of the basic skills, namely classification, quantification and prediction. Hence the results are generalized to the acquisition of these three basic science process skills.

ii) External validity or the generalizability of the results from this study is limited only to the standard seven pupils of Nairobi as an example of an urban environment and Nyakach division of Kisumu district as a representative of a rural setting. It cannot be generalized to all pupils in primary schools from standard one (1) to eight (8).
iii) The funds available for this research was only Shs. 3,000/=.
This was a bit on the lower side and could therefore not allow
the researcher to cover a more representative population for the whole country.

1.8 Definitions of Key terms.

Science: Science may be defined as follows:

a) an organized body of information about
natural phenomena and the generalizations
that grow from this information.

b) specialized methods used to acquire this
information which are often referred to as
processes of science/scientific method/science
process skills.

Science Process Skills

These are mental and motor manipulative operations
used for obtaining information (or investigating the
physical world), as is done by scientists or students
of science. There are two categories of Science Process
Skills. These are:-

i) Basic Science Process Skills. These include
such activities as - observation, classification,
measuring quantification, using numbers. Using
spatial and temporal relations, predicting
communicating and making inferences.
ii) **Integrated Science Process Skills:** It includes activities like experimenting, controlling variables, using operational definitions, hypothesizing, formulating and using models and interpreting data.

**The Skill of Classification**

This is the ability to form groups having some common specified observable properties. When objects, events, people, are put together because they are alike, they are being classified. It is a very important skill especially in this era of knowledge explosion, especially since facts, concepts and generalizations become vague and excessive unless order is brought out of them. We can say that one is able to classify if he/she can carry out the following activities:— sorting out; serializing according to type or properties like colour, size or number, if he/she can use given properties to group objects or observe groups of objects then identify the characteristic(s) used to classify them.

**The Skill of predicting.**

This is an acquired ability to use one or more rules from the same or different rule classes to determine the outcome of an event or series of events without prior observation of that event or series of events. It involves fore-telling of events in the future based on observation or analysis of given situations.
There are three kinds of predictions. These are:

i) pattern prediction - whereby a known set of relations is extended to include new ones.

ii) Extrapolation - as a special case of pattern prediction.

iii) Hypothesizing - as a process of stating relationship between dependent and independent variables.

Indicators of the presence of the skill include interpolation and extrapolation in graphic data, foretelling future events from observable data.

The skill of Quantification.

Quantification is the presentation of information to other people using quantitative data. Indicators for quantification is when a pupil can: count, order information, add, multiply, divide, use decimals use powers of ten, show position of positive and negative integers on a number line, name natural numbers in an exponential form using base 10 and show how to find products of two neutral numbers.

Science process skill test

This is a test which measures the acquisition of the science process skills. It is composed of items based on science process skills - like classification, quantification and prediction. In this study, the score on this test is used as an indicator of the acquisition of the science process skills.
Problem solving

A situation where pupils apply previously learnt knowledge/skill and manipulate various cues in order to arrive at a given goal which is often obscured by the cues, is problem solving in nature.

Problem solving test

This is a test which measures problem solving ability. It is composed of items which require manipulation of several cues in order to arrive at a solution to the problem presented. In this study, the score on this test is used as an indicator of problem solving ability.

Syllabus.

An outline of course of study.

Science curriculum.

Is a programme or a series of courses in science, offered by the school system.

1.9 Organization of the Project.

The presentation of this work has been organized into five chapters. Chapter one is the introductory chapter while the second chapter deals with the literature review. Methodology of the survey forms the content of the third chapter and the fourth chapter is concerned with data presentation, analysis and interpretation. The last chapter (five) summarizes the findings of the study and proposes some recommendations for further study.
References and footnotes.


6. SEPA. (1978). A report of Integrated follow up and Training Workshop for ex-participants of Science Education Course (University of Sierra Leone) and educational evaluation course (University of
7. In the colonial era, there were schools exclusively for white children—these were the schedule C schools, there were also schools for the Asian children—schedule B and schools for the Black children—schedule A.


9. Ibid.


2.1 Theoretical framework

The education of an individual includes his becoming familiar with skills in addition to his knowing how to solve problems using these skills. Educators have noted that an educated or a learned person is one who "knows how" (Gagne, 1975). That is, one who is skillful in carrying out certain activities and can command these skills in solving practical problems and thus enhance economic development in the quest for a better quality of life. Without education in general and in the absence of these learned/skillful people, development will not occur (World Bank, 1988). Therefore, for some years, science educators (Gagne, 1975; Piaget 1971; Henson and Janke, 1984; Alan Ward, 1983; Jegede and Brown, 1984) have come to agree that the acquisition of science process skills should be a major goal of science instruction. Fitzpatrick, (1960) also observed this to be so;

he wrote that:—

"a school system would be neglecting the chief contribution of science if it did not designate as a primary purpose the development of skills and methods of enquiry by which verifiable knowledge about the world is obtained". 8

Thus, a lot of emphasis has been placed on the teaching and use of science process skills in various educational system (Bloom, 1971). Acceptance of this view
emphasizing the acquisition of the science process skills (SPS) is reflected in the curriculum developments which have occurred in recent years. As a result of this, programmes such as Science: A Process Approach (SAPA), Science Curriculum Improvement Study (SCIS), Intermediate Science Curriculum Study (ISCS) and in Kenya, the 8-4-4 Programme, have come up.

The educational emphasis on Science Process Skills has gained prominence on every level of education from Primary to the University (William Bluhn, 1979) 10 Unesco (1980) has also put it using the following words:-

"The main purpose in teaching science to young children should not be the provision of knowledge—while we have asserted that the body of Scientific Knowledge must be a secondary concern for teachers of young children, Scientific Process although neglected in the older curricula makes a vital contribution to the education of students of any age". 11

The new courses coming up, especially in primary Schools, have been found to be organized around processes of scientific enquiry (B. Bloom, 1971) 12, processes of scientific enquiry (B. Bloom, 1971) 12, of which our 8-4-4 programme is not an exception.

These new courses in science not only stress the acquisition of the science process skills but also, developing more recently has been an interest in problem solving. Primary School Science has been frequently presented as an opportunity for pupils to act as problem solvers (David Symmington, 1979 13; Henson and Janke, 1984 14). In other words
primary science is now seen, above all as an approach to problem solving and involves practising the skills of observing, classifying, investigating through experiments, appreciation of variable factors which affect a problem and forming conclusion based on evidence (Alan Ward, 1983).

The shifting of emphasis from science content based programmes to processes of science and problem solving in the elementary science courses has come about through a number of reasons; these are:

(i) There was a realization that the traditional approach to teaching of science as a body of organized knowledge learned by acquisition of predetermined facts was no longer seen as a logical basis on which to organize the curriculum. This is because traditional science courses were found to be outdated, organized in a particular patchwork manner, too massive and too technical and also because they failed to involve the students in the real activities of science (Bloom, 1971). Programmes which fail to involve pupils in the learning activities are often seen to lean towards passivity, leading pupils to engage in rote learning and mere acquisition of inert ideas. An education programme which provides pupils with inert ideas has been criticized for not only being useless but above all harmful (Whitehead, 1967).
Piaget (1971) observed this to be the case:

"If the aim of intellectual training is to form the intelligence rather than mere erudition, then traditional education is manifestly guilty of a grave deficiency". 18

Those pupils who have been exclusively exposed to traditional science courses are denied the experience of real science and most of them leave primary schools when "science is still absent from their lives (savory, 1972 19). In support of practical science Jagede and Brown (1984) have categorically pointed out that:-

"Science unlike some other subjects will demand much more than memorization of facts. In order to pass them to children. The teacher must know how to apply the teaching of skills of observation, classification, inference and prediction to appropriate lesson situations". 20

(ii) Traditional science courses based on content, have not only been found to encourage passivity, rote learning and acquisition of inert ideas on the part of the pupils, but also, the content or the scientific knowledge on which these courses are based have been found to be tentative and fallible. In the light of new findings, what is true today may not be so tomorrow. Hence emphasis should not be placed on the content or subject matter which can become outdated or in need of modification in the light of new discoveries (Romolla Showell, 1983) 21

With these criticisms, suggestions have come strongly in support of science process skill acquisition
and problem solving as an area on which to base primary school science education (Piaget, 1971). Henson and Janke (1984) have recommended that educators should place special emphasis upon the processes of science such as observation, measurements and classifying, as being skillful in these processes will help the pupils better understand their natural environment. Thus, the new idea about primary school teaching should be to focus less on facts or concepts for their own sake and more on the activities of scientific finding out, decision making, problem solving and logical thinking (Alan Ward, 1983).

This does not mean that we should concentrate on the science process skills or the processes of science at the expense of knowledge, as it is believed that processes without knowledge becomes acquisition of skills with no apparent purpose while knowledge without processes often become memorization of information which will soon be forgotten. It means we should concentrate on processes of science to arrive at knowledge. Henson and Jenke (1984) have put it as follows:

"Using processes which generate meaningful and related knowledge - concepts meaningful to the students, should be an important goal of the elementary science curriculum". 25

In that way the two dimensions of science - which are, the body of knowledge that has been accumulated by scientists (content) and the methods used to generate this knowledge (processes/science process skills) (Unesco, 1980) will receive equal attention.
(iii) The work done by founders of childhood education like J.A. Comenius (1592 - 1670), John Locke (1632 - 1704), Rousseau (1712 - 1778), Pestalozzi (1746 - 1827), Froebel, Dewey and Montessori (1870 - 1952) and Psychologists cum educators, like Piaget and Thelde, Gagne R. and Brunner among others have helped to shed light on the direction to which childhood education should take. They have proposed that learning should emanate from the child's own interests. It should spring from within and not be imposed on him by his superiors. Thus knowledge in science can become worthwhile and can be genuinely learnt only when it is presented in some way which is meaningful to the student. An attempt should therefore be made to allow science to spring naturally from the interests and the background of the beginning student. So that the study of science should provide him with an understanding of the environment, how to control it and use it for national development (Prof. Oke, 1974)
In support of the foregoing discussion is the realization that most pupils in Primary school are at Piaget's concrete operational stage of mental development where learning become meaningful only when concrete objects are used. At this stage pupils are generally interested in manipulating things, exploring their environment, asking questions, playing, finding out things for themselves, and constructing things but are incapable of concentrating for long periods and of making reasoned conclusions (Romolla Showell, 1983). Nevertheless science cannot fail to appeal to them if only it could be introduced in the right way by making them observe things and do experiments for themselves. Some of the things listed above as would be interesting to pupils are actually part of the science process skills - for example, experimenting, observation, asking questions and manipulating things. What this discussion implies, is that primary science is best learnt by pupils if it is introduced as science process skills. In other words, "the great need, is to reveal the physical world through a scientific approach without destroying a child's sense of mystery and wonder ......... So primary school teachers cannot avoid making the whole field of science a potential source for activities". (Alan Ward, 1983)
processes of science. Processes that will logically enable the learner to arrive at meaningful knowledge about the world by engaging in problem solving activities.

2.3 The meaning of science process skills

The next question would therefore be as to what exactly are the science process skills (SPS) which are so much emphasized in our educational systems. Skills in general according to Gagne (1975)\(^\text{30}\), constitute "knowing how" as contrasted with "knowing that" of information.

They are the highest capability that can be learnt by man. And in both informal/nonformal and formal education the aim is to carry the learners through to attain skill level where they can operate without any supervision. Romiszowski (1970)\(^\text{31}\) has given a learning hierarchy whereby starting with the lowest level of learning there is the learning of facts and procedure, followed by concepts, rules and principles then reproductive skill and finally productive skill as the highest level of learning that can be attained. Gagne (1977) has put it specifically as:-

"skills are in many ways the most important types of capability learned by human beings and the essence of what is meant by "being educated".\(^\text{32}\)

Thus, skill acquisition forms a very crucial part of objectives and aims of education in
general and of science education specifically as seen in our primary syllabi. Skill acquisition implies doing something with increased refinement as indicated in the stated goals of education (Dr. Marlow, 1986).

In terms of science education, various authors and educators use various words to describe the science process skills. Some educators see it as the behaviour science students engage in during their enquiry and such behaviour are similar to the processes the scientists employ in investigating the real world in order to construct new ideas (Benjamin Bloom, 1971). According to Richard Campbell (1979) Science process skills are methods of investigations used for solving problems.

Putting the above definitions together, science process skills can be looked at as being mental and manipulative operations used in obtaining information similar to mental and manipulative operations used by scientists.

Thus a scientist searching for new knowledge about the world and a student involved in the learning activities in the classroom, both engage in several activities. These activities are what is broadly referred to as the science processes. When Unesco (1980)
defines science as "what scientists do". They are actually looking at science in terms of science process skills. That is, what scientists do are the scientific processes (Henson & Janke, 1984).

There are two kinds of science process skills (Campbell, 1979). These are the basic Process Skills and the integrated process skills. Basic skills are the simpler skills which are acquired as a prerequisite for the integrated process skills discussed herein after. Basic skills include:

- Observing, measuring, communication, classification
- Inferring, using space/time relations,
- Using number, predicting, and quantification.

Integrated skills are more complex and are designed to promote the retention and refinement of the basic skills. They include:

- Identifying variables, formulating hypothesis
- Interpreting data, controlling variables,
- Operationally defining variables and designing investigations or experimenting.

The above discussion suggests that science process skills have been a major theoretical force in science education. That is why the researcher decided to investigate how well some of these skills were acquired by primary school pupils in both an
urban and a rural environment because this is a critical foundational level for science education. The researcher concentrated on three of the basic science skills namely, Classification, quantification and prediction.

2.4 Meaning of Problem Solving

The other part of the study focused on problem solving ability among the same pupils. Problem solving is an area of prime importance in science education. The use of problem solving capabilities has come about through a realization of the complex world in which we live and the many problems that human beings encounter whose solution are crucial for the survival of mankind. Hence the need to cultivate this ability among the youth.

Thus, developing pupils problem solving ability has long been an objective of science instruction (Champagne and Klopfen, 1981), and the current emphasis in science curriculum development is the process oriented problem solving skills. Therefore, the most critical education task of current society must be to develop within the learner the ability to think and solve problems (Mike Smith & Ron Good, 1984).
According to Rappaport (1966) a problem is a particular situation in which a person encounters a blocking of mental and/or physical action in reaching a desired goal." 41

A learner encounters a problem in learning when his action to reach a desired goal is blocked. In order to reach the desired goal, the relevant cues have to be intentionally selected and manipulated by the learner himself. While the whole process of problem solving as Gagne (1977) observed is a "process by which the learner discovers a combination of previously learned rules which can be applied to achieve a solution for a novel situation." 42

In other words problem solving is a set of events in which human beings apply previously learned rules to reach a desired end (goal). It is not only reaching this desired goal that makes problem solving important but also the fact that it yields new learning (Gagne, 1977 43). That is when a learner discovers a combination of rules that fit a given problem situation, they will have not only solved the problem at hand but will have also learnt something new. This "something new" is a higher order rule which will enable the learner to solve problems of a similar type (Gagne, 1977 44). Thus problem solving is a form of learning, and learning is regarded as problem solving if it is encountered by the pupils for the first time.
However, other scholars have a different view about problem solving from that of Gagne (1977) and Rappaport (1966). For example Eniaiyegu (1983) has identified problem solving with Bloom's last three cognitive objectives namely analysis, synthesis and evaluation. He notes that these three cognitive objectives can be grouped as "highest abilities" or problem solving. To Eniaiyegu, problem solving skills include the ability to apply complex information, critical appraisal of procedures and measurements, the designing of experiments and the recognition of assumption relationships.

Terry Shaw (1983) has selected four of the integrated science process skills excluding experimenting, as problem solving skills.

Smith and Good (1984) talks of problem solving simply as skills needed by pupils to understand and apply knowledge which has not yet been discovered and solve problems which have not yet been identified. Russel and Chiappetta (1981) identify problem solving with the higher thinking abilities such as analytical, critical, productive, rational or reflective thinking. To them problem solving include the skills of interpretation of knowledge, a use of reason and an evaluation of alternatives.
Despite the differences cited in the views above, the key issue in all of them about problem solving, is 'reaching a desired goal' using either Bloom's last three cognitive objectives or higher thinking abilities or integrated process skills or subordinate (previously learned rules) skills.

Problem solving is therefore an integral part of learning. It is an area of learning which is becoming more and more important especially in these days of explosion of knowledge. In his search for more knowledge, man encounters new problems and these problems have to be solved before reaching the next stage of the search. Even a review of the stated goals of education in Kenya (primary syllabi, 1984, 49 sessional paper No. 5 50) reveals a consistent emphasis on problem solving.

2.5 Theoretical Relationship between SPS and Problem solving.

The study at hand sought to establish a relationship between problem solving and science process skills among Primary School Pupils. A relationship between problem solving and science process skills has been hypothesized by several authors. Many authors and scholars contend that pupils acquire process skills which enable them to solve practical problems more effectively. Even one of the aims of science education in Kenya is to the effect that pupils should acquire science process skills which are
useful in solving practical problems.

In other words, process skills are methods of investigation used for solving practical problems (Campbell, 1979; FitzPatrick, 1960). Peacok (1986) observed that the purpose of learning science these days is much more about solving practical problems by doing investigations. Maureen Dietz (1975) is also in agreement:

"The basic rationale of skill oriented science programme, is that one must learn to utilize skills such as observing, comparing, classifying, predicting, which will enable the individual to deal with problems effectively."  

Theoretically, this implies that those pupils who have acquired some of the science process skills will be better able to solve problems. Jegede & D.P. Brown (1984) also add that:-

"In the process approach to the teaching of sciences, the emphasis is on teaching children to develop process skills which can be used in solving problems ... . Situations and activities are devised by the teacher in which the children will be given an opportunity to use questions and to practise scientific skills to solve problems".  

There seem to be strong logical theoretical similarities between the two abilities - science process skills and problem solving and the philosophical importance of both science process skills and problem solving can therefore not be doubted. However, there is lack of research in primary schools to indicate the relationship between the two abilities.
Findings of other researches on Science process skills, problem solving and achievement in other areas.

Science process skills and problem solving abilities are not only being emphasized in our education system because of their philosophical importance but also because of their practical usefulness and applicability. Researches have shown that pupils who acquire science process skills and problem solving abilities do achieve higher in other areas. For example Riley and Westmeyer (1972) found out that students who completed a programme that taught science process skills achieved higher comprehension scores than students who were taught using a traditional textbook approach. J.P. Williams (1973) also found out that some of the requisite skills for reading relate to the acquisition of science process skills.

Padilla J., Okey J. and Garrad K. (1984) studied the effect of instruction on integrated science process skills achievements on grades six and eight pupils. They found that those students who were exposed to an intensive programme based on integrated science process skill, achieved higher scores than pupils who received content oriented instruction in the two grades.

W. Toili (1985) also studied the relationship between acquisition of science process skills and
achievement in science among standard seven pupils in Bungoma district. He used Tannenbaum's science process skill test to measure the acquisition of science process skills, and an achievement test to measure the general achievement in science content. He found a positive correlation between performance in science process skill test and science achievement test, showing that the science taught in primary schools helps in acquiring the SPS.

To investigate the relationship between science process skills and formal thinking abilities, N. Padilla, J. Okey and G. Dillashaw (1983) used 500 pupils of grades 7 - 12. They found a significant relationship between integrated science process skills and formal operational abilities. Thus teaching science process skills might not only affect science process skill abilities but also enhance pupils thinking abilities.

Hussel J.H. and Chiappatta (1981) studied the effect of a problem solving strategy on the achievement of earth science students. Their sample consisted of 287 8th grade pupils assigned to fourteen (14) groups, of which seven were control and 7 groups were for experimental purposes. Experimental groups who were exposed to problem solving activities for six weeks achieved significantly higher scores on earth science content test that did pupils in control classes.
Volk and Hungerford (1981)\textsuperscript{62} also reported useful application for teaching problem solving. They trained junior high school pupils in investigative environmental skills and found that they out-performed students in general science courses on measures of skills in problem identification. Kirkland (1981)\textsuperscript{63} found that high school physics students who used a problem solving procedure known as dimensional analysis out-performed control pupils in an achievement test.

Among studies undertaken to develop instruments for assessing pupils performance relative to specific science process skills are those by Tannenbaum (1971)\textsuperscript{64}, Molitor and George (1976)\textsuperscript{65}. Some of these tests, especially Tannenbaum's, have been used widely by different researchers to measure the acquisition of science process skills. For example Alvin Pettus (1980)\textsuperscript{66}, Munyiri (1981)\textsuperscript{67}, Toili (1985)\textsuperscript{68}, just to mention a few, have used Tannenbaum's test in their researches.

Alvin Pettus (1980) used the test to investigate if there is any relationship between the acquisition of science process skill—classification, and the sex, grade level, number of courses completed and interest in science careers among the high school students. He found that the acquisition of science process skills is related to sex, age, grade level,
number of courses completed and interest in science careers. The number of courses completed showed the strongest relationship to the overall pupils performance. Grade level and age ranges showed little relationship.

Munyiri (1981) also used Tannenbaum's test of science process skills in a small scale study (survey) and found a significant difference in performance based on school categories, age, sex and class level. However, she failed to find any significant difference between schools in the same category for all variables.

For studies done to determine the factors which are associated with the development of and use of science process skills, Maureen Dietz and Barufaldi (1975) used a sample of pupils from grades 1-vi to study the effect of solid objects and two dimensional representations of objects on visual observation and comparison among urban children. They failed to find significant differences between the skill of comparison and the grade level of pupils. They found out that pupils in grade one, four and six demonstrated a tendency to perform more efficiently on observation and comparison tasks employing solid objects than on tasks utilizing photographs of objects. Tasks employing photographs were relatively well done as compared to tasks based on drawings.
Among studies undertaken to relate problem solving and other areas are those by Terry Shaw (1983), Ronning and McCurdy (1982), Klopffer and Champagne (1981) Terry Shaw (1983) investigated the effect of a process oriented science curriculum upon problem solving ability among high school students. She found that a relationship existed between students being involved in the SAPA curriculum and their ability to apply problem solving skills to content not covered in the programme. The students who had the process oriented science curriculum (SAPA) thus, scored significantly higher on the test than those students who received science programmes emphasizing content.

This finding suggests that a teacher who wishes to teach problem solving processes in science should select a curriculum that has a strong and consistent emphasis on processes involved in problem solving.

Ronning and McCurdy (1982) investigated the role of instruction in the development of problem solving skills in science. They found that many junior high school students were unable to use process skills necessary to attack problems in science. They suggested that the teachers should introduce and regularly reinforce problem attack skills.
Klopfer and Champagne (1981) studied the structuring process skills and the solution of verbal problems involving science concepts. They used only a sample of 27 grade eight pupils from urban middle class homes. They found that semantic knowledge and process skills contributed to the successful solution of set membership problems but not of problems involving analogies.

William Bluhn (1979) on a study to determine the effect of science process skill instruction on preservice elementary school teachers' knowledge of ability to use and ability to sequence science process skills found out that preservice elementary school teachers exposed to activity based instruction in which they design, carry out an experiment to solve an observed problem, significantly had their ability to sequence science process skills as used in scientific problem solving improved greatly.

Leititia Graybill (1975) undertook a study to determine the existence of gender differences in intellectual development and problem solving abilities. Although she did not try to control other intervening variables, she found that boys were more successful than girls in solving science problems selected for the study. She also found that girls differ from boys at the point in which they develop logical thinking abilities.
Despite the strong logical theoretical similarities between the acquisition of science process skills and problem solving ability, the literature cited above reveals a deficiency in studies attempting to relate the two abilities in pupils. It can be noted that little research has been done in primary or elementary schools to investigate this relationship. Of the literature reviewed, it is only Terry Shaw's (1983) - even though her sample was made up of high school students, and Klopfer and Champagne's (1981) studies which are closely related to the study at hand.

Furthermore, the few studies which have been done in this area, have been undertaken in the developed countries, hence cannot so easily be applied wholesale to a developing country like Kenya. Thus the need to carry out this study in our own environment - Kenya.

The purpose of this research was to examine, the acquisition of some of the basic science process skills namely classification, quantification and prediction, and problem solving ability of standard seven pupils in both urban and rural setting, and to determine the relationship if any, between the two abilities (Science Process Skills and Problem Solving). In other words, the study's main concern was to determine whether the acquisition of science process skills helped pupils to solve problems effectively.
2.7 Summary

It has been widely accepted that science is an active process, not facts but processes of science; process that will logically allow the learner to arrive at meaningful knowledge about the world by engaging in problem solving activities. Hence more and more emphasis is being placed on the acquisition of science process skills and problem solving ability, especially at the early age of primary school education.

The literature reveals that the philosophical and practical importance of the two abilities (science process skills and problem solving), cannot be doubted or challenged.

Theoretically, there seem to be strong logical similarities between science process skill acquisition and problem solving ability. However, completed researches that relate them are few and these few ones have been done in the developed world; the third world countries such as ours cannot apply them wholesale. Hence the researcher's aim of trying to find out if there is actually any practical relationship or not between science process skills and problem solving ability among a Kenyan population.
2.8 References


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33. Dr. Marlow (1986) "Science and the learner." *Journal of the school Natural Science Society* vol. 4 No. 2 p. 8


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"The effects of a problem solving strategy on the achievement of earth science students."


65. L. Molitor and Kenneth George (1976) "Development of a test of science process skills". Journal of research in science teaching vol. 13. No.5 1976


CHAPTER 3
METHODOLOGY

3.0 Introduction

The research design used in this study is a simple survey of associative correlation. It was conducted in an urban and rural setting.

The population sample used in the study was wholly drawn from standard Seven classes. The rationale for choosing an upper Primary Class such as standard Seven is related to Harlem Wynne's (1983) observation:

"Ideas skills and attitudes take time to develop and are formed gradually through cumulative effect of many experiences." 1

That is, the researcher chose a class that had been exposed long enough to the Science Process Skills (SPS) activities such that they could apply them to solve at least some of the problems they might encounter. Standard Eight classes would presumably have been better for this study but because of ongoing Examination preparations the researcher chose not to interfere with their programme.

The design of the study included a consideration of the following:

i) the subjects (and characteristics)
ii) Sampling procedure
iii) the measuring instruments
iv) Piloting
v) Main study
   a) time of data collection
b) procedure used to administer the instruments.

vi) the variables.

3.1 The Subjects

a) Sample size and age.

The subjects (N=528) were drawn from Standard Seven Classes from Six Schools in Nairobi - an urban environment (137 boys and 124 girls), and from Seven Schools in Nyakach Division of Kisumu District - a rural environment (142 boys, 125 girls).

They ranged in age from 11 - 18 years with an overall mean of 14 years for the rural pupils and an overall mean age of 13.2 years for the urban pupils. The table below summarizes the characteristics of the sample.

<table>
<thead>
<tr>
<th>SEX</th>
<th>Characteristics</th>
<th>Rural</th>
<th>Urban</th>
</tr>
</thead>
<tbody>
<tr>
<td>GIRLS</td>
<td>Number</td>
<td>125</td>
<td>124</td>
</tr>
<tr>
<td></td>
<td>Mean age (yrs)</td>
<td>13.85</td>
<td>13.36</td>
</tr>
<tr>
<td>BOYS</td>
<td>Number</td>
<td>142</td>
<td>137</td>
</tr>
<tr>
<td></td>
<td>Mean age (yrs)</td>
<td>14.2</td>
<td>13.1</td>
</tr>
<tr>
<td>BOYS+ GIRLS</td>
<td>Number</td>
<td>267</td>
<td>261</td>
</tr>
<tr>
<td>GIRLS</td>
<td>Mean age (yrs)</td>
<td>14</td>
<td>13.2</td>
</tr>
</tbody>
</table>
b) Parental education and occupation

The subjects drawn from a rural environment were homogeneous with respect to parental educational attainment and socio-economic status. The mean education attainment for both parents (mothers and fathers) was 7.0 Years of schooling. Parents of Children in the rural Schools were mostly unskilled or semi-skilled labourers typically engaged in small Scale business. However, those fathers who were in employment formed 22.46 percent of the population. The table below shows the details.

**TABLE 3**

**PERCENTAGES OF THE RURAL FATHERS IN EMPLOYMENT**

<table>
<thead>
<tr>
<th>Profession</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Teachers</td>
<td>10.1</td>
</tr>
<tr>
<td>Civil Servants</td>
<td>4.87</td>
</tr>
<tr>
<td>Medical Officers</td>
<td>3.37</td>
</tr>
<tr>
<td>Mechanics</td>
<td>2.62</td>
</tr>
<tr>
<td>Clerks</td>
<td>0.75</td>
</tr>
<tr>
<td>Clergy</td>
<td>0.75</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>22.46</strong></td>
</tr>
</tbody>
</table>

The rest of the rural fathers comprising 77.54 percent of the population were either unemployed or doing small scale business.
Working mothers were mainly nurses or teachers; each category comprising 1.87 percent of the population while Clerks and Secretaries formed 1.498 percent of the population. Only 5.24 percent of the rural mothers were employed.

The urban parents, on the other hand were more diversified as far as educational attainment and Social – Economic status is concerned. The Educational attainment ranged from '0' years of Schooling to University Education. The mean Educational attainment for fathers was found to be 10.52 years of Schooling and for mothers was 9.34 years of Schooling.

Unlike rural parents, majority 89.4 percent of the urban fathers were employed, while 51.2 percent of the mothers were employed. The table below summarizes the above information.

**TABLE 4**

**MEAN YEARS OF SCHOOLING AND PERCENTAGES OF WORKING PARENTS**

<table>
<thead>
<tr>
<th>PARENTS</th>
<th>RURAL</th>
<th>URBAN</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fathers</td>
<td>Mean years of Schooling</td>
<td>7.30</td>
</tr>
<tr>
<td></td>
<td>% working</td>
<td>22.46</td>
</tr>
<tr>
<td>Mothers</td>
<td>Mean years of Schooling</td>
<td>6.6</td>
</tr>
<tr>
<td></td>
<td>% working</td>
<td>5.24</td>
</tr>
</tbody>
</table>
3.2 Sampling Procedure

In either area - urban or rural, stratified random sampling method was first used to select the Schools for the study. In each area, the entire population was divided into strata (Sub groups) on the basis of past K.C.P.E. performance in the last two years (1986 & 1987).

Twenty Schools which had consistently been in the top rank and another group of twenty Schools which had consistently been in the bottom rank for the last two years were selected. From these top and bottom Schools, a random sample of 6(7) Schools was drawn. In case of streamed classes in the Schools selected, random sampling was done to select the stream to be used in the study. In the stream selected all the pupils were allowed to sit for the two tests - Science Process Skills and Problem Solving Tests.

The names of the Schools selected for the study are shown in appendix D.

3.3 The measuring Instruments

It could have been desirable to have pupils individually demonstrate the various process skills and problems' Solving activities to the investigator. However, the time required to administer and evaluate hand-on tasks and the difficulty in controlling the testing situation made this option less attractive.
Hence the researcher used a paper and pencil group testing method. Two instruments were used. These were:

i) A Science process Skills test
ii) A Problem Solving test.

Attached to the two tests was a questionnaire seeking the following information about the pupils:

a) Name
b) age
c) sex
d) Parental educational attainment
e) Parental Occupation

a) The Science Process Skills Test

In order to be able to measure the acquisition of the Science Process Skills, a science process Skill test was set by the researcher. The skills to be measured were quantification, classification and prediction. The items were set in such a way that they tested all cognitive levels except evaluation (Bloom, 1971) but including even manipulative skills (Questions 17 and 18)

The test consisted of eighteen (18) items. Twelve of which were multiple questions and six were open ended items.
For each of the three skills to be measured, there were six items of varying difficulties. Appendix B gives all the details of the test. In scoring the test, each correct response was awarded one mark except for questions 16, 17 and 18 which were awarded 1½ marks each for the correct response. Half a mark was given for providing the information about themselves (pupils), thus the whole test was scored out of twenty.

b) The Problem Solving Test

This test, which appears under appendix C, consisted of five items provided by the researcher. The first item was a general reasoning problem. The second item was based on the skills of quantification, and the third item was based on the skills of classification, the fourth item was based on the skill of prediction - it required the pupils to manipulate blocks of wood and water in order to arrive at the correct answer. The last question was a crossword puzzle. The correct response earned a pupil four points. The whole paper was marked out of twenty.

The two tests lasted a total of one hour and thirty minutes, each taking a total of forty-five minutes.
3.4 Piloting

The study was conducted in two stages - a pilot study and a major survey. Before piloting, two primary school teachers looked at the items. This was an attempt to ensure content validity. After that a pilot study was carried out in two primary Schools in Nairobi. The following were some of the reasons for Piloting:

i) to establish the suitability and ambiguity of the test items and to help the researcher identify areas which needed special remedy like readability and clarity of the questions.

ii) to test how the instrument would work when taken out for a major study

iii) to help the researcher decide on such factors as the length of the tests.

iv) to gain preliminary test administration experience prior to embarking on the final survey.

Analysis of items from the pilot study revealed very low difficulty indices for questions one and fifteen appearing in the proposal, hence these two questions were omitted in the final instrument.
3.5 **Main study**
   
a) **Time of data Collection**

   In the main study, the instruments were administered in the morning hours only. This was to help in minimizing the influences time (an independent variable extraneous to the purpose of the study) may have had on the study; as it is generally believed that pupils concentrate better in the morning hours than in the afternoon hours.

   b) **Administration of the Instruments**

   The two tests were administered in English because in Kenya the medium of instruction in upper primary (std 4 - 8) classes is English, and all the tests including the Kenya Certificate of Primary Education are conducted in English.

   A paper and pencil group testing technique was used in which each pupil was given a question booklet and the apparatus for questions seventeen and eighteen in the Science Process skills test and for questions four in the Problem solving test. The Class/Subject teacher helped in this phase.

3.6 **Variables**

   a) **Independent variables**

   These are the variables that are often manipulated by the researcher. In this study they were:

   i) Environment (rural vs urban)  
   ii) sex of the pupil  
   iii) parental level of education  
   iv) Science process skill test items and problem solving items.
b) **Dependent variables**

These are the presumed effects or consequences of the independent variables. They usually determine the effectiveness of the experimental treatment. In this study the dependent variables were factors that determined how the science process skills and problem solving abilities were acquired by the pupils as shown by their scores on the:-

i) Science Process Skill test

ii) Problem Solving test

c) **Intervening Variables**

These are variables that lie between the independent and the dependent variables. They are variables which are not under direct control of the researcher and/or may not have been diagnosed but may have effect on the research findings. In this study they included:-

i) reliability and validity of the instruments

ii) attitudes of the pupils towards Science and towards teaching

iii) Teaching/learning resources/facilities available in the Schools.

iv) Language abilities of the pupils

v) Reading abilities of the pupils

vi) The psychological factors within the pupils like their emotions, readiness and so on.

vii) Teaching effectiveness

viii) Self-concept.
It was assumed that these intervening variables did not influence the outcome of the research.

3.8 Summary

The sample for the study was made up of 528 standard Seven pupils, 279 boys and 249 girls from Nairobi province and Nyakach division of Kisumu District. They were selected through both stratified and random sampling techniques. To these subjects two tests were administered after piloting in two schools in Nairobi. The two tests were a Science process Skill test measuring the acquisition of science process skills and problem solving test, whose purpose was to measure problem solving ability. The tests written in English consisted of eighteen and five items for science process skill and problem solving respectively. The time allocated for taking each test was 45 minutes. The two instruments were administered in the morning.

3.9 References

4.0 Introduction.

The researcher has used both descriptive and inferential statistics to analyse data in this study. Descriptive statistics used include:—

(i) the mean — which as a measure of central tendency has been used to summarize pupils' performance in the two tests. It has been specifically used because it considers every score in the sample and can thus enable the researcher to generalize the findings of the study; and partly because other statistics used in the study, like the Z-test, analysis of variance, correlation coefficient and standard deviation make use of it.

(ii) Standard deviation — which as a measure of dispersion has been used to describe the variability in pupils' performance in the two tests.

For decision making, inferential statistics has been used. In this study it includes the use of:—

(i) Correlation coefficient:— It has been used to find out whether pupils' performance in the science process skill test correlate with pupils' performance in the problem solving test.
(ii) The Z-test:— This has been used to help the researcher decide whether the findings of the study were significant (to test the hypotheses) Z-test has been used here because the sample size (N=528) is big (that is, much greater than thirty) and secondly because the data collected and used in this study is parametric.

(iii) Analysis of variance (ANOVA): It has been used to test the fourth hypothesis in which a series of mean scores were analysed.

4.1. Pupils Performance in the science process skill and problem solving tests.

TABLE 5
GROUPED FREQUENCY DISTRIBUTION FOR SPST.

<table>
<thead>
<tr>
<th>SCORES</th>
<th>FREQUENCIES</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>URBAN</td>
</tr>
<tr>
<td></td>
<td>BOYS</td>
</tr>
<tr>
<td>0 - 3.5</td>
<td>20</td>
</tr>
<tr>
<td>4 - 7.5</td>
<td>44</td>
</tr>
<tr>
<td>8 - 11.5</td>
<td>45</td>
</tr>
<tr>
<td>12 - 15.5</td>
<td>23</td>
</tr>
<tr>
<td>16 - 19.5</td>
<td>5</td>
</tr>
<tr>
<td>Σf</td>
<td>137</td>
</tr>
</tbody>
</table>

The scores on SPST and PST were grouped at intervals, and frequencies worked out as shown in table 5 and 6.
### Table 6

**GROUPED FREQUENCY DISTRIBUTION FOR PST**

<table>
<thead>
<tr>
<th>SCORES</th>
<th>URBAN</th>
<th></th>
<th>RURAL</th>
<th></th>
<th>RURAL + URBAN</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>BOYS</td>
<td>GIRLS</td>
<td>TOTAL</td>
<td>BOYS</td>
<td>GIRLS</td>
<td>TOTAL</td>
</tr>
<tr>
<td>0 - 3</td>
<td>20</td>
<td>19</td>
<td>39</td>
<td>35</td>
<td>33</td>
<td>68</td>
</tr>
<tr>
<td>4 - 7</td>
<td>24</td>
<td>19</td>
<td>43</td>
<td>49</td>
<td>41</td>
<td>90</td>
</tr>
<tr>
<td>8 - 11</td>
<td>23</td>
<td>36</td>
<td>59</td>
<td>36</td>
<td>35</td>
<td>71</td>
</tr>
<tr>
<td>12 - 15</td>
<td>27</td>
<td>27</td>
<td>54</td>
<td>13</td>
<td>15</td>
<td>28</td>
</tr>
<tr>
<td>16 - 19</td>
<td>31</td>
<td>22</td>
<td>53</td>
<td>9</td>
<td>1</td>
<td>10</td>
</tr>
<tr>
<td>20+</td>
<td>12</td>
<td>1</td>
<td>13</td>
<td>0</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Σf</td>
<td>137</td>
<td>124</td>
<td>261</td>
<td>142</td>
<td>125</td>
<td>267</td>
</tr>
</tbody>
</table>

The means and standard deviations were calculated using the following formulae:

**Formula for working out:**

(a) Mean \( \bar{X} = \frac{\Sigma fd}{\Sigma f} \)

(b) Standard deviation (S.D.) = \( \sqrt{\frac{\Sigma d^2}{\Sigma f} - \left(\frac{\Sigma fd}{\Sigma f}\right)^2} \times C \)

Where \( \Sigma \) = the sum of

- \( f \) = frequency (number of times a given value occurs in a collection of figures)
- \( d \) = deviation (the difference between two values)
- \( C \) = class interval.
The following mean scores and standard deviations were found for the variables under test:

**TABLE 7**

MEAN SCORES AND STANDARD DEVIATIONS FOR SCIENCE PROCESS SKILLS (SPS) AND PROBLEM SOLVING (PS) FOR VARIOUS VARIABLES

<table>
<thead>
<tr>
<th>VARIABLES</th>
<th>No. of pupils</th>
<th>MEAN SCORES</th>
<th>STANDARD DEVIATION</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>SCIENCE PROCESS SKILL</td>
<td>PROBLEM SOLVING</td>
</tr>
<tr>
<td>The whole sample</td>
<td>528</td>
<td>7.4</td>
<td>7.24</td>
</tr>
<tr>
<td>all the schools</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Girls</td>
<td>249</td>
<td>6.77</td>
<td>6.83</td>
</tr>
<tr>
<td>Boys</td>
<td>279</td>
<td>8.04</td>
<td>7.6</td>
</tr>
<tr>
<td>Urban pupils</td>
<td>261</td>
<td>7.95</td>
<td>9.195</td>
</tr>
<tr>
<td>Urban Boys</td>
<td>137</td>
<td>8.51</td>
<td>9.78</td>
</tr>
<tr>
<td>Urban Girls</td>
<td>124</td>
<td>7.32</td>
<td>8.55</td>
</tr>
<tr>
<td>Rural pupils</td>
<td>267</td>
<td>6.69</td>
<td>5.3</td>
</tr>
<tr>
<td>Rural Boys</td>
<td>142</td>
<td>7.58</td>
<td>5.52</td>
</tr>
<tr>
<td>Rural Girls</td>
<td>125</td>
<td>5.68</td>
<td>5.12</td>
</tr>
</tbody>
</table>
4.2 The relationship between the acquisition of science process skills and problem solving

The main aim of the study was to try and find out if there was any relationship between the acquisition of the science process skills and problem solving ability among standard seven pupils in a rural and an urban environment. In order to be able to state whether there is actually any relationship or not between the two abilities, the researcher used Pearson Product-moment Coefficient of Correlation (r) formula, in which:

\[
 r = \frac{\Sigma xy - n\overline{xy}}{\sqrt{n}\sigma_x \sigma_y}
\]

Where \(\Sigma\) = the sum of
- \(x\) = scores from the science process skill test
- \(y\) = scores from the problem solving test
- \(xy\) = Product of the two scores \(x\) and \(y\)
- \(\Sigma xy\) = sum of the product of the two score \(x\) and \(y\)
- \(n\) = number of pupils who took the test
- \(\overline{x}\) = arithmetic mean of scores from science process skill test.
- \(\overline{y}\) = arithmetic mean of scores from problem solving test.
- \(\sigma_x\) = standard deviation of scores on science process skill test.
- \(\sigma_y\) = standard deviation of scores on problem solving test.

NB: '=' means 'stands for'
Thus through computation

\[ \Sigma xy = 34216.5 \]
\[ n = 528 \]
\[ \bar{x} = 7.4 \]
\[ \bar{y} = 7.24 \]
\[ \sigma_x = 3.23 \]
\[ \sigma_y = 3.9 \]

Therefore,

\[ r = \frac{34216.5 - 528 \times 7.4 \times 7.24}{528 \times 3.23 \times 3.9} \]

\[ r = 0.89 \]

The correlation coefficient \( r \) of the two abilities is positive (0.89) and reasonably high. This means that the acquisition of science process skills is associated to a greater extent with an increase in the ability of pupils to solve problems.

Testing the main hypothesis \( H_{01} \); that there is no significant difference between pupils performance in SPST and PST at an alpha level of 0.05

Assuming normal distribution of the two attributes and that the scores were indipendent, a Z-test was used to test the \( H_{01} \), that is \( \bar{x}_1 = \bar{x}_2 \).
The Z-test formula used was:

\[
Z = \frac{\bar{x}_2 - \bar{x}_1}{\sqrt{\frac{S^2_2}{N_2} + \frac{S^2_1}{N_1}}}
\]

where
- \(\bar{x}_2\) = mean score for the SPST
- \(\bar{x}_1\) = mean score for PST
- \(S^2_2\) = standard deviation of SPST squared
- \(S^2_1\) = standard deviation of PST squared.
- \(N_2\) = Number of pupils who sat for SPST
- \(N_1\) = Number of pupils who sat for PST.

Substituting:

\[
Z = \frac{7.4 - 7.24}{\sqrt{\frac{3.23^2}{528} + \frac{3.92^2}{528}}} = \frac{0.16}{0.22}
\]

\[
Z = 0.72
\]

The alpha level set was 0.05; hence the critical value (cv) = 1.645.

\[
CV (1.645) \geq Z \text{ values (0.72)}
\]

Hence the findings were non significant at \(\alpha = 0.05\) and the null hypothesis \(\bar{x}_1 = \bar{x}_2\) has been accepted. This means that pupils performance in SPST and PST are the same.
4.3 The relationship of sex to performance in science process skill (SPST) and problem solving tests

The investigator sought to answer the question: is sex related to pupils performance in the above tests, and to test the hypothesis that "there is no significant difference between boys' and girls' performance in the two tests at $\alpha = 0.05$".

i.e $H_0$: Mean performance of boys = Mean performance of girls

$$\bar{x}_2 = \bar{x}_1$$

a) Sex and pupil performance in the SPST.

NB: The mean scores and standard deviations for all the variables are given in table 7.

Therefore,

$$Z \text{ value for SPST} = \frac{8.04 - 6.77}{\sqrt{\frac{3.32^2}{279} + \frac{2.93^2}{249}}}$$

$$Z \text{ value} = 4.669$$

The critical value when $\alpha = 0.05 = 1.645$

Hence the Z value (4.669) > critical value (1.645). The finding was significant and the $H_0$ has been rejected. This means that boys outperformed girls in the science process skill test.
b) Sex and pupils performance in the PST.

In testing the Hypothesis that the mean score for boys in the PST is the same as the mean score for girls in the same test, Z-test was used as above. The Z-value found = 2.169

The Z value (2.169 > critical value (1.645), hence the findings were significant, and the null hypothesis was rejected. What this means is that the performance of boys in the PST was better than that of girls.

4.4 Performance of urban and rural pupils in the SPST AND PST.

The purpose here was to test the null hypothesis $H_0^3$, which states that "the performance of urban pupils is the same as that of the rural pupils in the two tests".

1.e $H_0^3 : \bar{x}_1 = \bar{x}_2$

a) Comparing performance of rural and urban pupils in SPST.

Through computation of mean scores, standard deviation and sample size given in table 7, the Z-value for SPST was found to be 4.593. This value is greater than the critical value (1.645) hence the null hypothesis was rejected at 0.05 significant level of confidence. This tells us that the performance
of urban pupils in the SPST was significantly better than that of the rural pupils.

b) Comparing performance of rural and urban pupils in PST.

Substituting the mean and standard deviation values of PST given for urban and rural pupils in Table 7, the Z-value was found to be 11.58. At alpha level of 0.05, the findings were significant and the null hypothesis was rejected. This means that urban pupils performed better than the rural pupils in the problem solving test.

All the above findings are summarized in the table below.

| TABLE 8 |
|-------------------|-------------------|-------------------|-------------------|-------------------|
| A SUMMARY OF FINDINGS FROM HYPOTHESIS TESTING OF DIFFERENCES BETWEEN MEANS OF SPST AND PS USING Z-TEST AT 0.05 LEVEL OF SIGNIFICANCE FOR VARIOUS VARIABLES. | | | | |

<table>
<thead>
<tr>
<th>Variables</th>
<th>SCIENCE PROCESS SKILL TEST</th>
<th>PROBLEM SOLVING TEST</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Z-value</td>
<td>Critical value</td>
</tr>
<tr>
<td>Girls vs Boys</td>
<td>4.669*</td>
<td>1.645</td>
</tr>
<tr>
<td>urban vs rural Ps.</td>
<td>4.593*</td>
<td>1.645</td>
</tr>
<tr>
<td>urban gls vs. rl. gls.</td>
<td>4.62*</td>
<td>1.645</td>
</tr>
<tr>
<td>urban gls. urban bys.</td>
<td>2.79*</td>
<td>1.645</td>
</tr>
<tr>
<td>rural gls. rural bys.</td>
<td>5.94*</td>
<td>1.645</td>
</tr>
<tr>
<td>rural bys. urban bys.</td>
<td>2.344*</td>
<td>1.645</td>
</tr>
</tbody>
</table>

* P < 0.05
4.5 Parents level of education.

Parents were put in four categories depending on the number of years spent in formal education. Tallies of scores obtained by children belonging to parents in each category were made for both SPST and PST and frequency tables were constructed as shown in the tables below:

**TABLE 9**

FREQUENCY OF SCORES ON SPST OBTAINED BY PUPILS WHOSE PARENTS BELONG TO DIFFERENT EDUCATIONAL ATTAINMENT LEVELS

<table>
<thead>
<tr>
<th>SCORES</th>
<th>EDUCATIONAL ATTAINMENT (Year of schooling)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0 (f)</td>
</tr>
<tr>
<td>0 - 3.5</td>
<td>12</td>
</tr>
<tr>
<td>4 - 7.5</td>
<td>30</td>
</tr>
<tr>
<td>8 - 11.5</td>
<td>9</td>
</tr>
<tr>
<td>12 - 15.5</td>
<td>3</td>
</tr>
<tr>
<td>16 - 19.5</td>
<td>0</td>
</tr>
<tr>
<td>( \Sigma f )</td>
<td>54</td>
</tr>
</tbody>
</table>
### TABLE 10

**Frequencies of scores on PST obtained by pupils whose parents belong to different levels of education.**

<table>
<thead>
<tr>
<th>Scores</th>
<th>Levels of Educational attainment (in years of schooling)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0 - 4 (f)</td>
</tr>
<tr>
<td>0</td>
<td>16</td>
</tr>
<tr>
<td>4</td>
<td>16</td>
</tr>
<tr>
<td>8</td>
<td>11</td>
</tr>
<tr>
<td>12</td>
<td>6</td>
</tr>
<tr>
<td>16</td>
<td>5</td>
</tr>
<tr>
<td>20</td>
<td>0</td>
</tr>
<tr>
<td>Σf</td>
<td>54</td>
</tr>
</tbody>
</table>

Standard deviation and mean scores (\(\bar{x}\)) for each category were worked out using the formulae:

\[
S.D = \sqrt{\frac{\sum fd^2}{\sum f} - \left(\frac{\sum fd}{\sum f}\right)^2} \times C
\]

and

\[
\bar{x} = \frac{\sum x}{n}
\]

where \(f\), \(d\), \(x\), \(n\) and \(C\) are as defined on page 54, and \(n = \text{number of pupils}\).
The findings got through computation using the above formulae are summarized in table 11 below.

**TABLE 11**

**STANDARD DEVIATIONS AND MEAN SCORES OBTAINED IN SPST AND PST BY CHILDREN OF PARENTS WITH DIFFERENT EDUCATIONAL ATTAINMENT.**

<table>
<thead>
<tr>
<th>Years of education</th>
<th>science process skill test</th>
<th>Problem solving test</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>( \bar{x} )</td>
<td>SD</td>
</tr>
<tr>
<td>0 - 4</td>
<td>6.01</td>
<td>2.73</td>
</tr>
<tr>
<td>5 - 8 (7)</td>
<td>6.42</td>
<td>2.834</td>
</tr>
<tr>
<td>9 - 12</td>
<td>7.763</td>
<td>3.0385</td>
</tr>
</tbody>
</table>

For decision making, Analysis of Variance (ANOVA) was used to find out if the differences between the means for each category of parents was significant. The results are summarized in the table below.

**TABLE 12**

**ANOVA - SPST**

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>df</th>
<th>MS</th>
<th>F (ratio)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Within groups</td>
<td>501</td>
<td>8.458</td>
<td>49.38</td>
</tr>
<tr>
<td>Between groups</td>
<td>3</td>
<td>417.6</td>
<td></td>
</tr>
</tbody>
</table>
The H04: 0 - 4 = 5 - 8 = 9 - 12 = 13 +

Critical value (CV) when df1 = 3

\[ \text{df}_2 = 501 \text{ (or 00)} \]

at \( = 0.05 = 95\text{th percentile} \quad = 2.60 \)

Decision: \( F(49.38) > CV \quad (2.60) \)

hence reject the H04

The findings were significant at 0.05.

This means that parents level of educational attainment had some influence on children's performance in science process skill test.

**TABLE 13**

**ANOVA - PST**

<table>
<thead>
<tr>
<th>Source of variation</th>
<th>df</th>
<th>MS</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Within groups</td>
<td>501</td>
<td>7.256</td>
<td></td>
</tr>
<tr>
<td>Between groups</td>
<td>3</td>
<td>1366.66</td>
<td>919.94</td>
</tr>
</tbody>
</table>

H04: 0 - 4 = 5 - 8 = 9 - 12 = 13

CV when df1 = 3 at 95th percentile = 2.60

\[ \text{df}_2 = 501 \]

Decision: \( F(919.9) > CV \quad (2.60) \)

Here reject the hypothesis

The findings were significant at 0.05, meaning that educational attainment of parents had some bearing on children's performance in the PST.
Mastery of the three science process skills tested

In order to determine the mean scores obtained by pupils in each skill, the scores which were obtained for each skill were added and the sum was divided by the number of pupils in each sample. The results which were obtained are summarized in table 14.

**TABLE 14**

**MEAN SCORE OBTAINED IN EACH SKILL**

<table>
<thead>
<tr>
<th>Name of the skill</th>
<th>whole sample</th>
<th>sex</th>
<th>environment</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>boys</td>
<td>gils</td>
</tr>
<tr>
<td>Classification</td>
<td>2.4</td>
<td>2.6</td>
<td>2.2</td>
</tr>
<tr>
<td>Quantification</td>
<td>2.89</td>
<td>3.2</td>
<td>2.5</td>
</tr>
<tr>
<td>Prediction</td>
<td>2.4</td>
<td>2.6</td>
<td>2.1</td>
</tr>
</tbody>
</table>

NB: A perfect score in any one skill was 6

This table shows that the skill which was "well" mastered by everybody is quantification and predictions was the least mastered when compared to the other three skills. As compared to girls, boys performed better in all the skills.
4.7 The acquisition of the three science process skills tested in the study.

The scores on SPST marked out of 20 were analysed for each pupil. This was done by tallying the number of boys and girls who got the correct response as per skill. The totals were then divided by the number of items (6) in each skill to obtain the average number of responses for each skill. And the results were as follow:

<table>
<thead>
<tr>
<th>Table 15</th>
</tr>
</thead>
<tbody>
<tr>
<td>THE NUMBER OF PUPILS WHO GOT CORRECT RESPONSES FOR EACH SKILL</td>
</tr>
<tr>
<td>Name of Skill</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Classification</td>
</tr>
<tr>
<td>Quantification</td>
</tr>
<tr>
<td>Prediction</td>
</tr>
<tr>
<td>TOTAL</td>
</tr>
</tbody>
</table>

Table 15 shows that for each skill, less than half the pupils got them correct. This means that the overall performance in all the skills was poor.
DISCUSSION AND RECOMMENDATIONS

5.1 Discussion of findings

The questions the study sought to answer were:

i) Does the acquisition of science process skill necessarily presuppose a higher level of performance in problem solving activities by standard seven pupils?

ii) Is sex related to pupils performance in the science process skill and problem solving tests?

iii) Is there any significant difference in performance in science process skills and problem solving tests between urban and rural pupils?

iv) Does the education of parents have any bearing on pupils performance in science process skill and problem solving tests?

v) Are there skills in which girls are better at as compared to boys and vice-versa?

Data analysis revealed a positive correlation \((r=0.89)\) between performance in science process skill test and problem solving activities. It is therefore evident from the findings of this study that a logical relationship does exist between the acquisition of the science process skills and problem solving ability among primary school pupils. Thus, pupils who are good at science process skills are also good at solving practical problems. Thus, science process skills are not only useful in understanding the natural phenomena but are also useful in solving problems. This confirms the theoretical relationship cited in the literature.
review that a relationship exists between the acquisition of science process skills and problem solving ability. This finding also supports the general contention of other researchers notably, Padilla, Okey and Dillashaw (1983) who found a significant relationship \((r=0.73)\) between integrated science process skills and formal operational abilities - that is, problem solving ability. Toili W. (1985)\(^1\) also found a significant difference \((r=0.70)\) between science process skills and science achievement among standard seven pupils in Bungoma district.

The relationship that exists between the acquisition of science process skills and problem solving ability was further supported by the results obtained from the hypothesis testing (using \(z\)-test) - where no significant difference was found between performance in science process skills and problem solving tests.

These findings imply that the acquisition of science process skills need to be strongly emphasized in primary education in order to inculcate in the minds of the young people the ability to solve problems. This is particularly important because problem solving ability itself is an internal process which takes place within the learner and cannot be taught (Gagne, 1977; Rappaport, 1966); however, learners can be placed in a problem solving situation through
the use of science process skills. The need to have pupils acquire science process skills in order to develop problem solving ability, rests in the fact that we are part of a very dynamic society in which rapid economic growth is being experienced, and in order to maintain this rapid growth we need to keep pace with scientific developments. Science itself, according to Khun, progresses by revolution (Chalmer, 1978), whereby the 'Crisis phase' of the progress can be taken in this case as the 'problem phase' and in order for the progress to continue the 'problem' has to be solved first. Thus problem solving is an integral part of science development/progress, which teachers and science educators cannot afford to ignore.

The z-test performed on mean scores for boys and girls on the science process skill and problem solving tests indicated significant differences, leading to the rejection of the null hypotheses. Boys out-performed girls in both tests. This finding is consistent with the findings of a research conducted by Maritim (1987) in which he investigated sex differences in class rank of primary grade children. He found a significant difference in class rank between boys and girls (using a chi-squared analyses) where there were significantly more boys than girls in the first class position, indicating that boys performed better than girls. Graybill (1975) also found significant differences between the performance of boys and girls in problem solving activities where boys outperformed girls.
The differences observed above, perhaps could be attributed to the differential upbringing of and task assignment to both boys and girls in Kenya. Boys are often assigned manipulative tasks such as helping with the fencing of the compound, fixing broken furniture, slashing grass to keep the compound tidy; for the rural community, herding is an additional task assigned to boys. In tasks like fixing of broken things, a lot of measurement and quantification skills are employed. While in herding, by studying the rainfall regime, they should be able to predict and tell the places with better pasture for their flock/herd. At the same time they get to know their animals so well that if these animals mix with others, the herdsboy can still identify and separate them and drive them home. So, long before enrolling for formal education, boys will have already been informally introduced to some of the science process skills like prediction, classification and quantification.

On the other hand, girls are often assigned the routine tasks of tending the baby, fetching water, washing dishes and other household chores and in the evening while boys are taking time off to play, girls would be either helping with the preparation of the evening meal or taking care of the baby as the mother prepares the evening meal. So girls have relatively little time to play and manipulate things and hence, poorer at mechanical and spatial skills as compared to
Therefore the latter have a headstart regarding the acquisition of science process skills.

Another possible factor which could be attributed to the observed differences in SPST and PST performance between boys and girls is the belief nursed by many students that science is a masculine subject and is not meant for girls. A similar opinion is generally held regarding mathematics. Hence some girls normally give up science education prematurely. This negative attitude hinders the progress of girls in science education, and could have partly contributed to the poor performance of girls in the two tests.

On the basis of these findings, the researcher recommends that primary school teachers should try to counsel girls out of the attitude that science is a masculine subject. They can supplement this kind of counselling with an invitation of resource people—especially women doctors, scientists, engineers and mechanics into the classroom to encourage girls to work hard in science subjects and even take up science careers in future.

Looking at the mean score and standard deviation for problem solving, even though boys did better than girls in it, when it is compared to the performance in the science process skill test it was better done by girls. The researcher suggests therefore, that there should be a balance of equal number of items
testing both science process skills and problem solving ability in the final examination given at the end of primary school education. This kind of design should give girls a fair chance of competing with boys, since, already the former are disadvantaged when it comes to the acquisition of science process skills, due to their upbringing and domestic task assignment.

It is evident from the findings of the study that the performance of urban pupils was significantly better than that of the rural pupils. The null hypothesis was thus rejected. The present study therefore supports the contention that there are possibly certain tangible achievement promoting factors present in the urban schools that are absent in the rural schools. A survey of the schools in which the study was conducted and the discussions held with the science teachers showed that urban schools had access to some learning resources which were not available in the rural schools. Such resources included the availability of science rooms, nature corners and laboratories which in some cases had standard apparatus; standard text books and other stationery for both pupils and teachers; duplicating machines and secretarial services. Most of these facilities were lacking in the rural schools, where, for examples only the teachers had access to science text books, which in most cases were of substandard quality and contained questions and answers only.
Parental level of education and occupation has been found to influence primary school achievement (Maundu, 1986). Most parents in the rural areas surveyed had very low educational attainment and it is possible that they were not in a position to understand what it means to buy textbooks and other learning facilities for their children; and even if they did they were restricted financially as most of them were unskilled or semi-skilled labourers getting meagre income which is not even enough to buy them enough food.

It was observed in this study that pupils performance in both science process skill and problem solving tests significantly improved with increasing number of years spent by their parents in school. That is, children whose parents had high educational attainment performed better in the two tests than those whose parents had comparatively low educational attainment.

From the above evidence, it may be argued that, in Kenya, educational attainment and job opportunities are quite related. This was shown to be true in another study in Kenya (Maundu, 1986). That is, those people with high educational attainment are better placed as far as job opportunities available to them is concerned when compared to the less educated group.
Furthermore, the well educated lot form part of the high income bracket and can provide well for their children's education in terms of such requirements as text books and other learning facilities. On top of this, considering that education is designed to impart knowledge and skills, it is expected that the educated parents should be more enlightened about educational requirements than their less educated counterparts; the former can, for example, understandably work hand in hand with the school for the betterment of their children's education.

It is therefore not surprising that the urban pupils and pupils whose parents had high education performed better than rural pupils and pupils whose parents had low education respectively, in the science process skill and problem solving tests.

One other fact about the rural and urban population which could have helped in bringing about the difference is the nature of the population itself. It was observed that the rural population was more homogeneous with respect to socio-economic status and level of schooling as compared with the urban population which was observed to be heterogeneous in these respects. The rural pupils were therefore disadvantaged in that, they were not exposed to different career and educational models, hence the challenge to work harder in school and strive for academic excellence could have been lacking within
them, and hence, their poor performance.

It is possible that access to learning resources, availability of career and/or educational models and financial status of the parents greatly aided in better acquisition of the science process skills and problem solving ability among urban pupils.

It is therefore recommended that workshops should be constantly held for parents, whereby they are educated and counselled on how to motivate their children to aspire for educational excellence and where they can be enlightened on the importance and advantages of buying their children textbooks and other learning materials. It is hoped that this kind of counselling would be very useful, especially to the less educated parents and consequently their children.

An analysis of the process skills acquired by the pupils showed that the mastery of the skills tested had not been fully realised and that pupils were still wanting as far as the acquisition of these skills was concerned. It was further revealed that boys dominated in the mastery of all the skills tested.

It is possible that pupils were not being exposed to enough practical work which could enable them to acquire the said skills despite the fact that they feature prominently in the 8-4-4 syllabus. Perhaps
the traditional method of chalk and talk was the usual practice in science instruction instead of the recommended enquiry approach. During her study, the researcher observed that in most of the science classes, teachers mainly taught by providing descriptions of scientific facts to the pupils, at the end of which, the learners copied notes from the chalkboard. Abidha's study (1982) supports this observation. He found out that most science teachers resort to drilling method instead of using the enquiry method.

It is actually a general fact that more often than not, and with examination pressure, goals related to the development of basic knowledge for academic preparations receive significant emphasis while goals related to personal use of science in everyday life, including the science process skills, are often ignored in our educational system. This actually does a lot of injustice to the teaching and learning of science because facts (knowledge) are being emphasised at the expense of processes of science thus leading to rote learning and memorization of facts which are soon forgotten.

One may therefore conclude that the poor performance in science observed in the Kenya Certificate of Primary Education (KCPE) examination could be due to the fact that pupils do not master the science process skills well enough as is required by the syllabus. If we
want good performance in this science examination, then teachers should use very little of the lecture method and should embark more on the enquiry method which helps pupils to acquire the science process skills. In this connection, the inspectorate should liaise with Kenya Institute of Education and the local Teacher Advisory Centre (TAC) Tutors to conduct more inservice courses to the serving teachers with an aim of enlightening them on the science process skills. Discussions held with some of the teachers involved in the study revealed that there are some teachers serving in the field who did not know what the science process skills are and could not facilitate their acquisition by the pupils.

Teachers should be inserviced too on how to improvise certain apparatus which may be lacking in their schools. Talking to some science teachers and enquiring why they were not engaging pupils in practical work, it was learnt that most teachers especially the untrained ones and those trained more than twenty years ago did not know what is meant by improvisation and as long as the schools failed to buy them Chemicals and apparatus, no practical work could be done.
Finally science curriculum developers should prepare supplementary readers to go along with the science syllabus. This can be very helpful to the untrained teachers and also to those other teachers who may fail to interpret the syllabus; and to the rural teachers who may not have access to the relevant science books.

5.2 Recommendation for further study:

Even though an attempt was made to investigate the acquisition of science process skills and problem solving ability among standard seven pupils, the study was limited by size of population used and the number of skills tested for. So future studies on the acquisition of science process skills should attempt to fulfill the following requirements:

i) Cover a larger population in order to facilitate a wider generalization.

ii) test for all the science process skills and not just three of them as was done in this study.

iii) attempt to have pupils individually demonstrate the various process skills to the investigator in a classroom situation.
Reference


9. Ibid p. 69

APPENDIX A

Information about the pupils

Please provide the following information first:-

i) Your name: ........................................

ii) Your age: .........................................

iii) Are you a boy or a girl? .........................

iv) What do your parents do for a living and what level of education did they attain?

father
   a) My father works as a ...........................

   b) He went to school up to .......................  
      (state the class level)

Mother
   a) My mother works as a ..........................

   b) She went to school up to class ..............  
      (state the class/level)
APPENDIX B

SCIENCE PROCESS SKILL TEST (SPST)

Answer all the questions.
For Questions 1 - 12 and 16, shade the correct answer.
For questions 13 - 16 fill in the spaces provided

1. For an experiment, Ochieng bought 10 rabbits. He later realized that he did not need all of them, so he gave away 3 of them to his friend John. What percentage of rabbits was Ochieng left with?
   a) 0.7%    b) 70%   c) 30%   d) 0.3%

2. Kamau covered a burning candle with a large glass jar as shown in the diagram below.

What would happen to the candle after a few minutes?
A) The candle will burn more brightly
   b) the candle will stop burning immediately
   c) The candle will stop burning after sometime
   d) the candle will burn until all the wax is used up

3. During her study time, Monica came across the following names: frog, Newt, salamander and toad. She then grouped them in one class of amphibia
Which one of the following reasons would best explain why she put them in one class:–

a) They are all living things
b) They all live in water
c) They lay eggs which hatch out into tadpoles
d) They all spend part in their life cycle in water and the other part on land

4. Estimate to the nearest square unit the area of potato tuber drawn below

```
[Diagram of a potato tuber]
```

a) 10 square units       b) 21 square units

c) 38 square units       d) 82 square units

5. The chart below shows a simple food web

```
[Diagram of a food web with arrows indicating the flow of energy]
```

Note: The arrows point to the eater

What would be the immediate effect if all gazelles and waterbucks are killed?

a) Lions would increase in number and plants decrease
b) Waterbucks would increase and lions decrease in number
c) Lions would decrease and plants increase in number
d) Gazelles would decrease and plants increase in number
6. Soil A was found to possess the following properties:-
   i) Retains (holds) a lot of water when it rains
   ii) has very fine particles
   iii) Dries up and cracks during the dry season
   iv) is sticky and heavy when wet
Soil A can be classified as
   a) sandy soil   b) Loam soil   c) clay soil   d) Rocky soil

7. The following instructions show how a certain farm chemical should be used: Mix 500g of the chemical in 10 litres of water for one hectare of the crop. How much of this type of farm chemical and water would a farmer require in a quarter hectare of the crop?
   a) 50 g of the chemical and one litre of water
   b) 125 g of the chemical and 2.5 litres of water
   c) 500g of the chemical and 10 litres of water
   d) 2000g of the chemical and 40 litres of water

8. Mary had two pieces of ice. On one piece of ice she placed a piece of black material, and on the other she placed a piece of white material. She then placed the two experiments in the sun for a short time.
   Which material will sink into the ice faster?
   a) both will sink at the same time
   b) the white material
   c) the black material
   d) none of them
9. In an outdoor class session, Terry collected leaves and divided them into two groups,

Which of the following leaves should fit into group B?

10. In a balancing experiment, rods of wood were balanced as shown in the diagram below:

In order to keep the block balancing how far from the pivot would the log weight be placed?

a) 6cm   b) 4cm   c) 15cm   d) 10cm

11. In a science class, Jane learnt that things expand when heated and contract when cooled. But while doing an experiment, she discovered that water expands instead of contracting when it is cooled from 4°C through 0°C and that when it is heated from -4°
through O°C to 4°C it contracts instead of expanding. Starting with 10 litres of water at 4°C and cooling it upto freezing point (0°C), Which of the following diagrams would best represent the level of water at 0°C?

12. Given below is a list of different types of food:
Bread, meat, orange, beans, pawpaw, cassava, fish, ugali peas, sukuma wiki, tomatoes.
Use the order shown below to put them in the right class

<table>
<thead>
<tr>
<th>Energy giving food</th>
<th>Protective food (Vitamins)</th>
<th>Body Building (proteins)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
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</tbody>
</table>

13. Tom made 2 holes in a tin and then filled it with water.
The diagram below shows what he observed.

He then made a third hole between the first 2 holes. Show by drawing how water will flow out through the third hole.
Use the figures given below to answer questions 14-16:

An iron bar was heated through different temperatures and a change in its length recorded as follows:

<table>
<thead>
<tr>
<th>Temperature (°C)</th>
<th>Length (in Cm)</th>
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</thead>
<tbody>
<tr>
<td>10</td>
<td>100</td>
</tr>
<tr>
<td>30</td>
<td>101</td>
</tr>
<tr>
<td>50</td>
<td>102</td>
</tr>
<tr>
<td>90</td>
<td>104</td>
</tr>
</tbody>
</table>

14. What would be the length of the iron bar when it is heated at 40°C?

The length of the iron bar at 40°C would be .......... Cm

15. What would the length probably be at 100°C?

The length of the bar at 100°C would be .......... Cm

16. The best way to check the answers for the last two questions (a and b above) would be ....

a) measure the length of the iron bar at 40°C then graph it to check your answer
b) Just put your answer on the chart and see if they look correct
c) Measure the length of the iron bar at 140°C then graph the findings
d) measure the length of the bar at 40°C and at 100°C then compare what you find with your answer.
17. You have been provided with several seeds. Try to group them in as many ways as possible. And state clearly the reason you have used to group them together as shown below.

Group 1: The reason I have used to group them together is ........

Group 2: The reason I have used to group them together is ........

Group 3: The reason I have used to group them together is ........

Group 4: The reason I have used to group them together is ........

Group 5: ............

18. You have been provided with a block of wood. Hold in your hand and try to estimate its weight.

The weight of the wooden block is about ............grams.
Section B: Answer all the questions by filling in the spaces provided.

1. A man has to transport a fox, duck and some maize across a river. The boat he has can only hold the man and one other thing. Left by themselves, the fox will eat the duck and the duck will eat the maize. How can he get them all safely across the river?

2. A farmer has some hens and goats. All these animals (hens and goats) have 50 heads and 146 legs. How many animals of each kind does he have?

<table>
<thead>
<tr>
<th>Numbers of hens</th>
<th>Number of goats</th>
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<tbody>
<tr>
<td></td>
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</table>
3. The diagram below shows part of classification of invertebrates:

```
4. In which of the above groups of invertebrates does the animal drawn below belong?

Answer .............. (a) Annelida  b) Insect  c) Arachnids

   d) Millipede   e) flatworm   f) Roundworm   g) woodlice
   h) centipede   i) snail   j) slug
```
4. Given that heavy wood provides more heat than light wood. You are hereby provided with three pieces of wood and some water. Dip them in water and decide which of the three pieces of wood would provide the most heat energy.

5. This is a crossword puzzle

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
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<td>22</td>
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</tbody>
</table>

ACROSS

2. A perfectly round plane figure
6. When things are heated, they .....
8. Very small things which cause diseases in our bodies
9. A kind of vessel moved by oars or sails or an engine It is used for travelling on water. It is a .... t
11. Stoma(ta) is a small ...... found on the surface of leaves. It allows exchange of air
13. A name of an insect side used for killing insects (It is also used as a pronoun for all things except man)
14. A small bed for a child used at home or in the hospital
16. Animals do it to keep alive
17. Hearts do it all the time, it can be felt in the pulse
20. The main source of all energy
21. Is an important source of proteins, related to the bean family but smaller in size
22. The ability to do work

DOWN
1. A chopping tool(used for cutting, splitting wood)
2. A place where people live temporarily in tents or huts or smaller shelters
3. A class of invertebrates with segmented bodies, divided into three distinct parts, 3 pairs of legs
4. Short form for river dam.
5. A large powerful carnivore of the cat family found in the savannah
6. It is produced by females in their ovary: when fertilized forms a baby
7. Another name for body building food
9. Scorpions and some insects sting, but a snake ..... Jane last week
10. The length of time a person or a thing has existed
12. Is a tortoise a mammal?
15. A cold blooded animal living wholly in water; its flesh is used as food
17. Helps in pollination of flowers and makes honey
18. An organ of hearing
19. A play thing especially for children
21. In short for protein nourishment
## APPENDIX D

### SCHOOLS WHICH PARTICIPATED IN THE STUDY

<table>
<thead>
<tr>
<th>Rural Schools</th>
<th>Urban Schools</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Agai Primary</td>
<td>Kilimani Primary</td>
</tr>
<tr>
<td>2. Moro Primary</td>
<td>Nairobi Primary</td>
</tr>
<tr>
<td>3. Abwao Primary</td>
<td>Harambee Primary</td>
</tr>
<tr>
<td>4. Thur-Gem Primary</td>
<td>Baba Dogo Primary</td>
</tr>
<tr>
<td>5. Magunga Primary</td>
<td>Mahiga Primary</td>
</tr>
<tr>
<td>6. Got-ONYUONGO Primary</td>
<td>Mathari Primary</td>
</tr>
<tr>
<td>7. Bugo Primary</td>
<td></td>
</tr>
</tbody>
</table>


Nairobi: KNEC

Nairobi : KNEC.


SEPA, (1978). *A report of integrated follow up and training workshop for ex-participants of science education course*, University of Sierra Leone, and educational evaluation course (University of Ibadan), Njala University.


Symmington David, (1979) "Improving the ability of students elementary teachers to propose investigable scientific problems". *Journal of Research in Science Teaching*, vol. 16 No. 5. pp. 453.


The Headmaster,

Dear Sir,

RE: ASSISTANCE TO COLLECT SOME DATA FOR M.ED. (PTE) RESEARCH

MR/MISS/MRS. GRACE OGONDA

is a bonafide student of KENYATTA UNIVERSITY doing his/her M.Ed. (PTE). As a part fulfilment of the course, he/she is supposed to carry out a small scale research project. So, please assist him/her, in a way you can, in collecting information.

Please rest assured that the information given will be used only for educational purpose.

Thank you for your help in anticipation.

Project Supervisor
Faculty of Education
Kanyatta University.

Prof. M.M. Patel
Course Co-ordinator
M.Ed. (PTE) Programme

MMP/sf
20th June, 1988

Dear Sir/Madam,

RE: ASSISTANCE TO COLLECT SOME DATA FOR M.E.D(P.TE) RESEARCH

This is to inform you that Mrs. Grace Ogonda of Kenyatta University has permission from this office to carry out the research quoted above in your school.

Please assist her when she calls in your school.

Yours faithfully,

M. A. Keinange (Mrs)
Ag. Chief Advisor to Schools
for: City Education Officer, Nairobi
The Headteachers:

1. Obange
2. Abwao
3. Sango Buru
4. Kobonugo
5. Moro
6. Olembo
7. Bugo
8. Sigoti
9. Thurgem
10. Ndori
11. Mangungu
12. Onyuongo
13. Ng'ope
14. Kabete
15. Rakwaro
16. Chachi
17. Nyabondo
18. Agai
19. Holo
20. Odhong'o

REF: ASSISTANCE TO COLLECT SOME DATA FOR (M.E.D.(PTE)) RESEARCH

This is to inform you that the bearer of this note, Mrs. Grace Ogonda of Kenyatta University has permission from this office to carry out the above quoted research in your school.

Please render any possible assistance to her.

(M. OKEO)

For: DISTRICT EDUCATION OFFICER
KISUMU DISTRICT