

**AN ASSESSMENT OF SCIENCE TEACHERS' CAPACITY FOR  
TEACHING INTEGRATED SCIENCE PROCESS SKILLS**

*A Case of Morogoro Municipality Secondary School Biology Teachers*

**By**

**Jamal Jumanne**



**A Dissertation Submitted in Partial Fulfillment of the Requirements for Degree of  
Master of Arts in Education of the University of Dar es salaam.**

**University of Dar es Salaam  
September, 2010**

**CERTIFICATION**

The undersigned certify that I have read and hereby recommend for acceptance by the University of Dar es Salaam a dissertation entitled: *An Assessment of Science Teachers' Capacity For Teaching Integrated Science Process Skills: A Case of Secondary School Biology Teachers in Morogoro Municipality*, in fulfillment of the requirements for the degree of Master of Arts (Education) of the University of Dar es Salaam.



Dr. EUGENIA J. KAFANABO  
(Supervisor)

Date: 04/10/10

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## **DEDICATION**

This work is dedicated to my daughter Nuria and my son Haarith for allowing me to pursue this Masters programme at the expense of their well being.

## ABSTRACT

This study was conducted to establish a base level of information on science teachers' capacity to teach science process skills as one of the competences strongly advocated by the newly introduced Competence Based Curriculum (2005) in Tanzania. Specifically, the study intended to; (i) determine the knowledge level of integrated science process skills of Biology teachers in Morogoro Municipality (ii) examine the self efficacy of Morogoro Biology teachers towards teaching of science process skills (iii) assess the influence of teachers' self-efficacy, level of qualification, work experience, and gender on teaching integrated science process skills, and finally (iv) explore the effectiveness of school laboratories as a vital resource in the teaching of integrated science process skills.

Science process skills approach by Chiappetta & Koballa (2002), and Bandura's (1977) self efficacy theory, formed the conceptual and theoretical framework of the study respectively. A Form II test of Integrated Process Skills developed by Mungandi (2005) was used to measure the knowledge level of science process skills among 63 sampled biology teachers in Morogoro Municipality. Science Teaching Efficacy Belief Instrument (STEBI) developed by Riggs and Enochs (1990) was employed to determine teachers' self efficacy for teaching science process skills. The results indicated that irrespective of years of teaching, qualification, or gender, Morogoro teachers have unsatisfactory capacity to teach integrated science process skills. The study recommends an urgent need to refocus on science teachers' training and professional development.

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**LIST OF ABBREVIATIONS AND ACRONYMS**

<b>AEST:</b>	Agricultural and Environmental Science and Technology
<b>ANOVA:</b>	Analysis of variance
<b>CBC:</b>	Competence Based Curriculum
<b>DED:</b>	Education for Self Reliance
<b>ESR:</b>	Education for Self Reliance
<b>GPA:</b>	Grade Point Average
<b>NECTA:</b>	National Examination Council of Tanzania
<b>PSTE:</b>	Personal Science Teaching Efficacy
<b>SAPA:</b>	Science A Process Approach
<b>SSP:</b>	School Science Project
<b>STEBI:</b>	Science Teaching Efficacy Belief Statement Instrument
<b>STOE:</b>	Science Teaching Outcome Expectancy
<b>TIE:</b>	Tanzania Institute of Education
<b>TIPS I:</b>	Test of Integrated Science Process Skills I
<b>TIPS II:</b>	Test of Integrated Science Process Skills II (TIPS II)
<b>URT:</b>	United Republic of Tanzania

## **CHAPTER ONE**

### **INTRODUCTION**

#### **1.1: Background to the Problem**

During the 1960s and 70s, science curriculum innovations and reforms were characterized by attempts to incorporate more inquiry oriented and investigative activities into science classes (Mungandi, 2005; Dillashaw and Okey, 1980). As a result, science curricula started to emphasize the acquisition of science process skills as one of the major goals of science instruction (Padilla, 1990). The intention was to expose students into the world of science especially the world of research and investigation so that as future scientists, they acquire scientific investigation skills (Padilla, 1990).

In Tanzania for example, the emphasis and the incorporation of science process skills in the education curriculum dates back to 1967 with the announcement of Education for Self Reliance (ESR) policy (Osaki, 2007). The policy according to Ishumi & Nyirenda (2004) placed much emphasis on merging theory and practice, critical thinking and experimentation. As a result, in 1968 the school science project (SSP) which was an inquiry and activity based curriculum was adopted from Nuffield science materials (Osaki, 2007). The curriculum and its material covered Physics, Chemistry, and Biology subjects and it placed much emphasis on the need for learners to acquire science process skills such as skills in experimenting. Science process skills have also been articulated in the newly introduced Competence Based Curriculum (CBC) of 2005 as one of the basic competences to be acquired by science learners in secondary schools (URT, 2005).

It has to be noted that, science process skills are activities that scientists execute when they study or investigate a problem, an issue or a question. Chiappetta and Koballa (2002) define science process skills as a set of broadly transferable abilities appropriate to many science disciplines and reflective of the behaviour of scientists. They are hierarchically organized, ranging from the simplest to the more complex higher order ones, called integrated science process skills (Padilla, 1990; Dyer, Myers & Washburn, 2004). Integrated science process skills include skills in formulating hypotheses, identifying and controlling variables, defining operationally, experimenting, and interpreting data (Chiappetta and Koballa, 2002; Hamilton & Swortzel, 2007). Basic science process skills on the other hand, are designed to provide a foundation for the learning of integrated process skills (Dillashaw and Okey, 1980; Dyer *et al.*, 2004). They include skills in observing, measuring, using numbers, classifying, seriating, predicting, and inferring (Brotherton and Preece, 1995; Hamilton & Swortzel, 2007).

Mungandi (2005) maintains that terms such as scientific method, scientific thinking, scientific inquiry and critical thinking have been terms that were used at various times to describe science process skills. However, the use of the term science process skills in place of other terms was popularized by the American curriculum project known as *Science-A Process Approach* (SAPA) which sought to change the emphasis of school science from a mastery of a body of knowledge to a more proper way that science was done by scientists (Padilla, 1990). Scientists are expected to look out for issues or problems, then hypothesize them, experiment and finally communicate their findings.

From a learning point of view, science process skills are the necessary means by which learners engage with the world and gain intellectual control of it through the formation of concepts and development of scientific thinking (Harlen, 2000). Chiappetta and Koballa (2002) strongly argue that, the acquisition and frequent use of these skills can better equip students to solve problems, learn on their own, and appreciate science.

In schools, science process skills can be well taught and developed during laboratory, research and other investigative activities such as project assignment works (Dyer and Myers, 2006). According to Roth and Roychoudhury (1993), laboratory experiences provide students with freedom to perform experiments of personal relevance in authentic context. Through experiments students learn to, (a) identify and define pertinent variables, (b) formulate testable hypotheses to guide investigations, (c) plan and design experiments, and (d) analyze, transform, and interpret data (Roth and Roychoudhury, 1993). These are essential and basic activities which are necessary for students' acquisition of science process skills.

Mechling, Bires, Kepler, Oliver, and Smith (1985) accord that, if science process skills have to be learnt well, they should be combined with science contents enabling students to learn them with contents at the same time in a seamless learning experience. The authors further argued that in teaching science process skills whether in a classroom or in the laboratory, there must be competency indicators which have to be spelt out clearly as to what students should be able to do to achieve a mastery of a scientific skill.

### **1.1.1: Science Process Skills in the 2005 Competence Based Curriculum (CBC)**

In 2005, the government of Tanzania through the Tanzania Institute of Education (TIE) decided to revise the curriculum of primary, secondary, and teacher education levels from that of Content Based to Competence Based paradigm (URT, 2005). According to the United Republic of Tanzania (2006:19), the Ministry of Education planned not only to review the existed curriculum but also to orient teachers on the requirements of the new curriculum and strengthen the provision of teaching and learning materials.

The new 2005 Competence Based Curriculum was streamlined to address the needs of developing analytical and market-oriented skills (URT, 2008). Moreover, the curriculum has been reviewed in the spirit of constructivism to enhance participatory and inquiry approaches of teaching (Tilya & Mafumiko, 2008). Constructivism teaching approaches require learners to be actively engaged in classroom activities so as to construct meaning out of the lesson (Kelly, 1991).

The revised secondary school science syllabuses explicitly state and emphasize the need for science learners to acquire competence in science process skills. The new ordinary level secondary school Biology syllabus of 2005 for example, has the following competence objective statements;

- (i) Students should be able to plan, record, analyze and interpret data from scientific investigations using appropriate methods and technology to generate relevant information in biological science.

- (ii) Students should be able to develop necessary biological practical skills.
- (iii) Students should be able to apply scientific skills and procedures in interpreting various biological data (p.ii-v).

All these objectives are putting emphasis on learner centered method of learning where students should directly be involved by doing, observing, hypothesizing, experimenting, analyzing, and interpreting data. While doing these activities, students will develop the necessary biological practical skills which culminate to science process skills. In addition, the syllabus (p.1) stipulates that science process skills should start as early as from form one, when a learner has just started secondary education. The Biology syllabus for example states that, at the end of the year, a form one student should be able to; (i) develop and apply basic knowledge and skills on scientific processes of studying Biology and (ii) develop mastery of carrying out experiments on various biological processes (p.1).

Science process skills also reappear in the list of objectives of higher classes and in the list of other science subject syllabuses. For example, a new secondary Chemistry syllabus of 2005 maintains that students should be able to, (i) think critically and evaluate scientific procedures (ii) synthesize, analyze, and communicate scientifically (iii) design and carry out experiments to prove a mastery of scientific procedures, etc (URT, 2005: v). All these learning abilities and competences to be acquired by learners are collectively known as science process skills (Chiappetta and Koballa, 2002).

## 1.2: Problem Statement

The newly revised Competence Based Curriculum of 2005 in Tanzania had placed a heavy emphasis on the need for learners to acquire science process skills. However, no education system can rise above the quality of its teachers (Ojo & Sola, 2007; Osaki, 2007). Teachers' knowledge, beliefs, and practices are key to a successful implementation of any educational reform. Bybee (1993) for example is convinced that;

*“...the decisive component in reforming education is the classroom teacher. Certainly, there is need of books, reports, and recommendations for new policies, and we need new materials, projects, and programs. However, unless the classroom teachers move beyond the status quo in teaching, the reform will falter and eventually fail”* (p. 144).

According to Berliner (1984), a classroom teacher is the main implementer of the designed curriculum and is the final arbiter of what, how, and when the content gets taught. Hence, teaching of science process skills to students will depend very much on teachers' knowledge level of science process skills, their self efficacy and the availability of teaching and learning resources. On the basis of this fact, it becomes vital to assess science teachers' capacity in the area of science process skills.

A review of literature failed to identify a research that has investigated knowledge level of science teachers in the area of science process skills in Tanzania. Little is also known about teachers' self efficacy towards the teaching of science process skills. The researcher remains convinced that there is a serious educational gap in this area both in bringing these scientific skills into the classroom and in the training of science teachers to teach these skills. This follow up study, intended to fill this research gap.

### **1.3: Objectives of the Study**

#### **1.3.1: General Objective of the Study**

The general purpose of this study was to assess the capacity of biology teachers in Morogoro Municipality for teaching integrated science process skills as one of the competences emphasized by the Competence Based Curriculum of 2005 in Tanzania.

#### **1.3.2: Specific Objectives of the Study**

Specifically the research intended to;

- (i) Determine the knowledge level of integrated science process skills of secondary school Biology teachers in Morogoro Municipality.
- (ii) Examine the self-efficacy level of Biology teachers in Morogoro Municipality towards the teaching of science process skills.
- (iii) Assess the influence of selected teacher variables (self-efficacy, education qualification, work experience, and gender) on the capacity of Morogoro Biology teachers to teach integrated science process skills.
- (iv) Explore the effectiveness of school laboratories as a vital resource in the teaching of integrated science process skills in Morogoro Municipality.

#### **1.3.3: Assumption of the Study**

The study was based on the assumption that, there is a close relationship between teachers' knowledge of integrated science process skills and their capacity to teach these skills. When teacher's knowledge level of integrated science process skills is low, then his/her capacity to teach these skills will also be low, and vice versa.

## **1.4: Research Questions & Hypotheses**

### **1.4.1: Research Questions**

- (i) What is the knowledge level of integrated science process skills of Biology teachers in Morogoro Municipality?
- (ii) What is the self-efficacy level of Biology teachers in Morogoro Municipality with regard to the teaching of science process skills?
- (iii) Do self-efficacy level, education qualification, teaching experience, and gender influence Morogoro teachers' capacity to teach science process skills?
- (iv) How effective are Morogoro schools science laboratories in enhancing the teaching of integrated science process skills?

### **1.4.2: Research Hypotheses**

In an attempt to answer the question *'do self-efficacy level, education qualification, years of teaching experience and gender influence the capacity of Morogoro Biology teachers to teach integrated science process skills?',* the following null hypotheses (Ho) were formulated and tested.

- Ho1: There is no significant relationship between the self efficacy of Biology teachers in Morogoro and their capacity to teach integrated science process skills.
- Ho2: There is no significant relationship between teachers' education level and their capacity to teach integrated science process skills in Morogoro Municipality.
- Ho3: There is no significant relationship between teacher's working experience and his/her capacity to teach integrated science process skills in Morogoro.
- Ho4: There is no statistical significant difference between the sex of a teacher and his/her capacity to teach integrated science process skills in Morogoro Municipality secondary schools.

### **1.5: Conceptual & Theoretical Framework**

The conceptual framework for this study was based on the science process skills approach developed by Chiappetta and Koballa (2002) in their book *Science instruction in the middle and secondary schools*. The approach focuses on the teaching of science process skills or science investigation skills which are broadly transferable abilities that are appropriate to many science disciplines and are reflective of the behavior of scientists (Padilla, 1990; Chiappetta and Koballa, 2002). The approach classifies science process skills into two major groups; Basic and Integrated science process skills.

Basic science process skills include skills in observing, inferring, measuring, classifying, and predicting. They provide a foundation for the acquisition of the higher order complex skills called integrated science process skills. The integrated process skills are the primary focus of this study, and they include skills in identifying and controlling variables, defining variables operationally, formulating hypotheses, interpreting data and in designing experiments (Chiappetta and Koballa, 2002).

According to the Science process approach by Chiappetta and Koballa (2002), in order for students to receive quality science instruction, science instructors themselves must have sufficient knowledge and competence of science process skills and inquiry participatory teaching techniques (Chiappetta & Koballa, 2002). In Table 1.1 below, the approach provides the meaning of individual/specific integrated science process skills as defined by Chiappetta & Koballa (2002).

**Table 1.1: Definitions of Individual Integrated Science Process Skills**

<b>Process Skill</b>	<b>Definition</b>
Defining Operationally	Developing statements that present concrete descriptions of an object or event by telling someone what to do or what to observe.
Formulating Models	Constructing images, draw diagrams or objects, or mathematical formulas to explain ideas.
Controlling Variables	Manipulating and controlling properties that relate to situations or events for the purpose of determining causation.
Interpreting data	Arriving at explanations, inferences, or hypotheses from the data that have been graphed or placed in a table.
Hypothesizing	Stating a tentative generalization of observations or inferences that may be used to explain a relatively larger number of events but which are subject to immediate or eventual testing by one or more experiments.
Experimenting	Testing a hypothesis through the manipulation and control of independent variables and noting the effects on a dependent variable; interpreting and presenting results in the form of a report that others can follow to replicate the experiment.

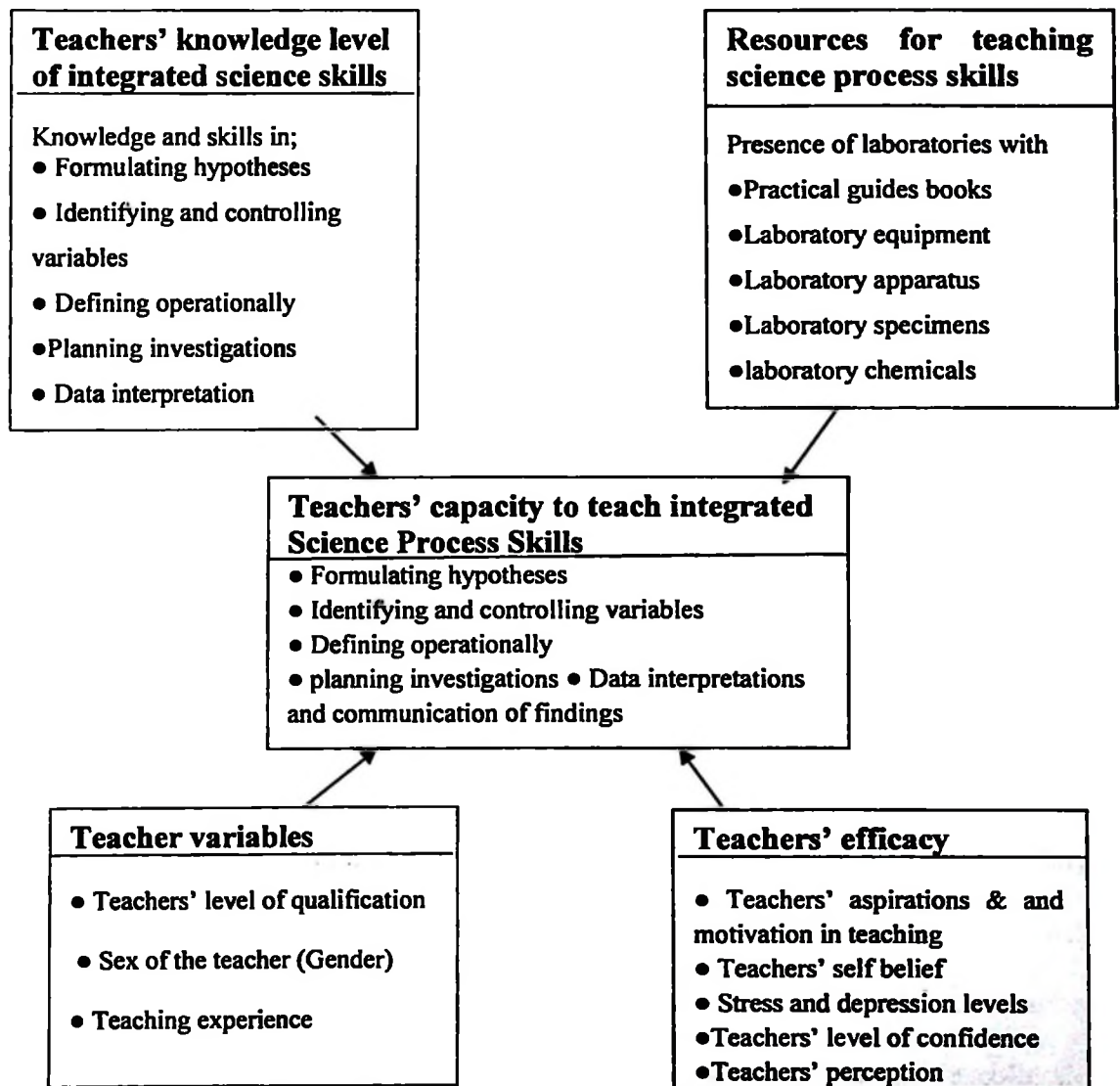
**Adapted from:** Chiappetta, E. L., & Koballa, T. R., Jr. (2002:252). *Science instruction in the middle and secondary schools* (5th ed.) Upper Saddle River, N.J: Merrill Prentice Hall.

However, as noted by several writers (Woolnough and Allsop, 1985; Roth and Roychoudhury, 1993; & Osaki, 2007), the teaching and development of science process skills is a valid aim for science laboratory work. Blosser (1998) further argues that there is much theoretical support for the value of laboratory works in helping students to understand science process skills. Laboratory exercises, according to Roth and Roychoudhury (1993), enable both students and teachers to develop questions to investigate, procedures to follow, and a means to report findings of their investigation. On this basis, the capacity of teachers to teach integrated science skills will also depend on the effectiveness of school science laboratories. This includes whether schools have science laboratories equipped with sufficient and up-to-date practical guide books, laboratory equipment, apparatuses, specimens and other necessary laboratory chemicals.

Self efficacy theory developed by Bandura (1977) also constructed a framework of thinking to this study. The theory defines self-efficacy as people's beliefs about their capabilities to produce designated levels of performance. Self-efficacy beliefs determine how people feel, think, motivate themselves, and behave (Bandura, 1977). Bandura's self efficacy theory classifies people's behavior into two major categories; people with a strong self-efficacy and those with a weak sense of self efficacy (doubting their capabilities in difficult situations). People with a strong sense of self-efficacy according to Bandura (1977), tend to approach difficult tasks as challenges to be mastered with assurance in themselves about their capabilities. This type of outlook is seen to produce personal accomplishments, reduce stress, and lower vulnerability to depression. On the other hand, people with low self-efficacy tend to have low aspirations and weak commitment to the goals they pursue. They easily develop stress and depression which in turn, hamper their capacity to perform actions effectively (Bandura, 1977). Hence with this theory, the higher the self efficacy of a teacher, the higher his/her capacity to teach science process skills, and the reverse is also true.

Apart from knowledge, resources and self efficacy, teacher's capacity in teaching may also be influenced by variables such as the level of qualification, teaching experience, and sometimes gender (Hamilton & Swortzel, 2007; Odeyeko, 2008; Trigwell, 1990 and Baker & Leary, 1995). Hence, to assess the capacity of secondary school teachers in teaching integrated science process skills, all the variables above should be determined. As shown in Figure 1.1 below, teachers' capacity for teaching science process skills is

determined by their knowledge level of science process skills, their self efficacy in teaching these skills, the availability of teaching resources such as laboratory facilities and variables such as qualification, work experience, and gender.



**Figure 1.1:** A conceptual Framework on Construed Determinants of Teachers' Capacity for Teaching Integrated Science Process Skills

Source: Researcher's Conceptualization with Insights from Bandura's Self Efficacy Theory (1977), and Science Process Skills Approach by Chiappetta & Koballa (2002).

### **1.6: Significance of the Study**

This study was conducted in order to establish a base level of information on science teachers' knowledge and competence to teach investigation skills (the science process skills). The findings of this study would be of use to both teacher educators and the Ministry of Education and Vocational Training for science teachers' professional development programs. The findings would also be used by the Tanzania Institute of Education (TIE) in developing science education curricula and programs that promote science process skills and a sense of self efficacy to prospective teachers. The findings of this study could also encourage other scholars to investigate the manner in which other competences addressed in the new 2005 education curriculum, apart from science process skills are taught, or could be integrated in teacher education curriculum.

### **1.7: Limitations of the study**

One of the major limitations of this study stems from the fact that it required a large amount of empirical data if generalization of the findings was to be established. Owing to time and resources constraints, it was not possible to collect data from all the teachers in secondary schools across the country although it was realized that such a collection would greatly enhance external validity of the findings. So, the study ended up by assessing only 63 Biology teachers who were available in 10 sampled secondary schools in Morogoro Municipality. Administration to teachers a test of integrated science process skills by Mungandi (2005) also posed another limitation to this study. Some teachers hesitated to undertake the test for fear of professional challenge or for fear of

failing the test that was meant for ordinary level secondary school students. The hesitation occurred despite the fact that all teachers were ethically assured on the purpose of the test and that of the study in general.

### **1.8: Delimitation of the study**

This study was conducted within the following parameters to delimit its scope;

(i) Only secondary school Biology teachers in Morogoro Municipality were involved in the study. This limited the overall magnitude of the study.

(ii) Science process skills are classified into, (i) Basic and (ii) Integrated skills. This study dealt only with assessing teachers' capacity to teach integrated science process skills. This is because integrated skills are higher order and complex than basic skills. Dealing only with integrated science process skills also limited the scope of study.

### **1.9: Operational definitions**

(i) **Science process skills:** In this study, this term was taken to mean the investigation skills or the scientific methods or procedures of generating knowledge (Padilla, 1990).

(ii) **Integrated science process skills:** means knowledge and skills in formulating hypotheses, identifying and controlling variables, defining operationally, planning investigations, interpreting data and communicating results (Padilla, 1990).

(ii) **Competence** as used in this study means abilities, skills, and knowledge attained by the learner after learning, that enable him/her to accomplish tasks (URT, 2005).

**(iii) Teachers self efficacy:** means teacher beliefs about their capabilities to produce designated levels of performance in the teaching of science process skills to students or the extent to which teachers believe they have the capacity to positively affect students' science process skills achievement (Riggs and Enochs, 1990).

**(iv) Teachers' Capacity for Teaching Integrated Science Process Skills:** means teachers' knowledge and skills in formulating hypotheses, identifying and controlling variables, defining operationally, designing investigations and in graphing and data interpretation (Chiappetta & Koballa, 2002).

#### **1.10: Organization of the Study**

The study is organized into five chapters. Chapter One is concerned with the problem which informs the study and its context. It defines the rationale and the conceptual framework underpinning the study. Chapter Two focuses on the review of literature relevant to the study. The aim was to explore what is already known around the topic and provide a point of departure upon which the new research would be built. Chapter Three on the otherhand presents the methodology of investigation and procedures that were used to address or undertake the research problem. Chapter Four discusses research findings while Chapter Five presents a summary of the study findings, conclusions of the study and recommendations arising from the findings. The last part of the report contains data collection tools, references and appendices used in the study.

## **CHAPTER TWO**

### **LITERATURE REVIEW**

#### **2.1: Introduction**

This chapter is about the review of literature on some studies related to science process skills. The chapter comprises of summaries of how different scholars approached the topic of science process skills and their major findings. The review is organized under the following sub-headings; the history of science process skills in Tanzania, the state of teaching science process skills in Tanzania, measurement of process skills, the relationship between process skills and academic development and teachers' self efficacy in teaching science process skills.

#### **2.2: The History of Science Process Skills in the Tanzanian Education Curriculum**

The incorporation of science process skills in Tanzanian education curricula dates back to 1967 when the government introduced Education for Self Reliance (ESR) policy which re-defined the purpose of education in the country. According to Osaki (2007), the redefinition of education meant to develop learners' inquiry mind, critical thinking, confidence, and mental liberation. The philosophy of education for self reliance placed much emphasis on practical activities whereby classroom works was to be linked with real life. As a result, science classroom teaching methods were transformed to emphasize experimentation and actual experience (Ishumi & Nyirenda, 2004; Sefu & Siwale, 1977). This orientation, in some ways, provided students with opportunities to practice what they have learnt in the classroom, test their ideas and analyze data or information observed thereby developing science process skills.

A typical curriculum based on science process skills according to Osaki (2007), was firstly introduced in Tanzania in 1968. The curriculum was an effort by the School Science Project (SSP) of 1968 which sought to change the way science was taught from a theoretical mode to an inquiry manner where pupils would learn to think and solve authentic problems. It was an activity and inquiry based curriculum and it was adopted from Nuffield science materials. The curriculum covered all science subjects and focused on an experimental approach that also touched the historical development of ideas in each topic and a great deal of outdoor and laboratory activities (Osaki, 2007). As a result, Biology learning started to involve a lot of ecological sampling, collecting and identification of specimen and doing experimental write-ups. Chemistry lessons had a lot of practical works such as analysis of substances and titrations. Physics on the other hand had lots of field visits, measurement taking, calculations, and games all of which contributed to students' acquisition of science process skills (Osaki, 2007).

However, the SSP inquiry curriculum was abandoned in the mid 1970s following a mass failure of the experimental group in their final national examinations as compared to the control group which was conventionally taught (Osaki, 2007). Students' failure was translated as inquiry curriculum weakness. However, according to (Osaki, 2007), students' failure was a result of insufficient teacher orientation on the requirements of the new curriculum. The Institute of Education therefore abandoned the emphasis on inquiry science and continued to write textbooks that focused more on remembering facts and formulae instead of scientific experimental works (Osaki, 2007)

### **2.3: Teaching of Science Process Skills in Tanzania**

Teaching of science and hence, science process skills in Tanzania secondary schools has been poorly and traditionally conducted. It has been driven by the pressure of performance on high-stakes testing thus over emphasizing content knowledge than skills (Osaki, 2000). Laboratory activities which basically equip learners with science process skills are often not emphasized (Osaki, 2007). For example, a study by Mushi (1992) on the teaching of Physics in some secondary schools in Tanzania found that in Form III, out of a total of 78 periods, only 18 were assigned for laboratory activities necessary for science process skills, and in Form IV only 2 out of the 63 periods were designated for this purpose. There was no opportunity for students to use meta-cognition and constructivist thoughts rather they were expected to absorb the teacher's constructed meanings of the lessons (Mushi, 1992). With this kind of teaching, a lot of questions emerge as to whether students would really acquire scientific skills.

A survey conducted by Chonjo, Osaki, Possi, and Mrutu (1995) on the teaching of science in selected schools in Tanzania found that, very few teachers were committed in using inquiry approaches or did experiments. Teaching sessions were boring and teachers did not use a variety of teaching strategies. Chonjo *et al.*, (1995), further found that science teaching in Tanzania had been reduced to copying and memorization of facts for examinations. Similar results were also witnessed by Osaki (2007), who noted that only few laboratory works for scientific skills were assigned after instruction and they were designed to confirm the lesson rather than investigate a phenomenon.

Osaki and Njabili (2004) conducted another survey on the teaching of science in secondary schools and observed that, learners were being put into groups in the name of participatory teaching with many of them looking bored and confused as to what were points taught by the teachers, and some obviously wharfing. Teachers lectured in a didactic fashion, droning and carrying on until the end of the class. Osaki (2007) supports these findings by maintaining that practical science process skills in Tanzania had virtually been stopped due to heavy financial costs involved and little government budget support. A weak government support forced the National Examination Council of Tanzania (NECTA) in the mid 1980's to abandon real practical examinations of science subjects. Instead, costless and theoretical alternative to practical examinations were introduced. This shift was enthusiastically interpreted by science teachers to mean that there is no need for practicals and hence science process skills (Osaki, 2007).

A recent survey in Tanga region by Shemwelekwa (2008), who sought to find out how secondary school Mathematic teachers were fairing with the revised curriculum (the Competence Based Curriculum of 2005), revealed that most teachers were still using traditional teaching methods (teacher centered approaches) to deliver the contents. The researcher also found that, the mode of implementation of the new curriculum from planning the lesson to instruction of students and assessment of learning objectives to students has not changed at all. The new 2005 education curriculum requires teachers to prepare lesson objectives from predetermined class level competence listed in the respective syllabuses. This was never done by Tanga Mathematics teachers.

## **2.4: Description of Individual Integrated Science Process Skills**

Several writers have attempted to describe individual integrated science process skills and the context in which they may be developed and imparted to learners (Wetzel, 2008; Rambuda, & Fraser, 2004; Chiappetta & Koballa, 2002; Harlen, 2000; and Padilla Okey and Dillashaw, 1983). These descriptions are discussed in the following sub headings;

### **2.4.1: Hypothesis Formulation**

Hypothesis formulation is a process of making prediction (intelligent guess) based on evidence of prior investigations or the expected outcome of an experiment (Wetzel, 2008). They are predictions about the relationships between variables and guide the researcher with regard to the kinds of data to gather. According to Harlen (2000) when hypothesizing, the suggested explanation need not be correct, but it should be reasonable in terms of evidence and be possible in terms of scientific concepts or principles. The author added that at early stages of developing hypothesis formulation skill, a learner is expected to make an attempt to explain something based on his/her earlier experience. According to Rezba, Sparague, Fiel, Funk, Okey and Jaus (1995), prediction should be based on facts, opinion, hunch, or whatever resources one may possess. It is imperative to formulate a testable hypothesis which directs the way investigation should be designed and eventually carried out (Gay and Airasian, 2000). For example, in an experiment to investigate the effect of sunlight energy on the rate of photosynthesis in a Form II class, a teacher might hypothesize that '*the greater the intensity of the sunlight illuminating the leaf, the greater the amount the carbohydrate is synthesized*'.

#### **2.4.2: Identifying and Controlling Variables**

Controlling variables is the ability to identify variables that can affect an experimental outcome, keeping variables constant while manipulating only the independent variables (Padilla, Okey and Dillashaw, 1983). The skill involves manipulating and controlling properties that relate to situations or events for the purpose of determining causation (Chiappetta & Koballa, 2002). In practical investigations, the practical group is usually exposed to some treatment (the independent variable) while the control group is not exposed to such treatments (Borg & Gall, 1989). For example, in the experiment referred above '*the investigation of the effect of sunlight intensity on the rate of photosynthesis*', a teacher must have skills to control the effect of variables such as *carbon dioxide, chlorophyll* and *water* which would influence the rate of photosynthesis and manipulate sunlight intensity only. By varying light intensity, students would be able to clearly note the relationship between the *light intensity* and *starch synthesis*.

#### **2.4.3: Defining Operationally**

Defining operationally means developing statements that present concrete descriptions of an event by telling someone what to do or what to observe (Chiappetta & Koballa, 2002). According to Wetzel (2008), defining operationally involves the development of specific terms to describe what is happening in the investigation based on observable characteristics. Variables can be defined operationally by applying some kind of measurements (measured operational definition) or by listing steps taken in an experiment to produce research conditions (experimental operational definition) (Ary,

Jacobs & Razavieh, 1990). In an experiment to investigate the effect of sunlight intensity on the rate of photosynthesis, a teacher has to operationally define the rate of photosynthesis. For example, the rate of photosynthesis in this experiment might be operationally defined in terms of carbohydrate synthesis as *'the change in the weight of a leaf as measured before and after exposing to the sunlight'*.

#### **2.4.4: Formulation of Models and Graphs**

Formulation of models means creating a mental or physical representation of a process or an event (Padilla, 1990). Graphs and modes represent quantitative data and are important means of communicating scientific data (Padilla, Mckenzie and Shaw, 1986). According to Harlen (2000), learners need to become familiar with all forms of communication that are commonly used in sciences. The author adds that, the development of this skill requires a learner to be able to think consciously about the nature of what is to be communicated and to whom, in order to select the best medium of the message. Using the previous example on photosynthesis, a teacher might present his/her findings *by drawing a graph or producing sketches that illustrate how starch production of a given leaf changed with changes in light intensity illuminating it.*

#### **2.4.5: Interpreting Data**

Harlen (2000) defines data interpretation skill as the ability of putting results together so that patterns or relationships between them can be seen. It involves organizing data and drawing conclusions from it. The skill also involves creating or using tables, graphs, or diagrams to organize and explain information (Rambuda & Fraser, 2004). According to

Harlen (2000), the central part of teacher's role in developing interpreting skills is to ensure that results are used and students don't rush from one activity to another without talking about and thinking through what the results mean. For example, in determining the effect of light intensity on the rate of photosynthesis, a teacher or students must be able to record *varied light intensities and their corresponding carbohydrate produced*. The data obtained have to be analyzed and the relationship between light intensity and carbohydrate synthesis determined. This interpretation would either prove or reject earlier hypothesis formulated on the relationship between sunlight and starch synthesis.

#### **2.4.6: Experimenting**

An opportunity to practice all individual science process skills discussed above is provided by experiments. Experiments according to Ary *et al.*, (1990) are scientific investigations in which the researcher controls some independent variables and observes the effects of these manipulations on the dependent variable. Before experimenting, the investigator starts with a question which need to be solved and then identifying the variables that needs to be held constant (Ary *et al.*, 1990; McMillan & Schumacher, 1997; Rezba *et al.*, 1995). According to these authors, the two steps above are followed by formulation of hypotheses to be tested, defining variables operationally, designing an investigation, rerunning trials and finally collecting data for interpretation. In an experiment to determine the relationship between sunlight conditions and carbohydrate synthesis in plants for example, a teacher and his/her students may demonstrate competence in designing investigation if they are able to set an experiment using appropriate apparatuses and reagents and control dependent variables identified.

### **2.5: Measurements of Integrated Science Process Skills**

The science educational reforms of the 1960's and 1970's prompted the need to develop various test instruments for assessing both teachers and students' level of science process skills (Mungandi, 2005). These tests are considered as powerful tools for measuring one's knowledge of science process skills. For example, Sanchez and Betkouski (1986) used multiple regression analysis to examine 16 predictors of students' success in Chemistry classes and found that, scores on the Test of Science Process Skills ranked third in predicting students' final grades in Chemistry, below GPA and sex.

Numerous researchers have developed instruments to measure science process skills that are associated with inquiry and investigative abilities. Dietz and George (1970) used multiple-choice questions to test the problem solving skills of elementary students. This test established the use of written tests as a means to measure problem-solving skills. Dillashaw and Okey (1980) reported that, Relay (1972) developed a test of science inquiry skills for Grade Five students which measured science process skills of identifying and controlling variables, predicting and inferring, and interpreting data. In an attempt to separate science process skills from a specific curriculum, Molitor and George (1976) developed a test of scientific skills (TSPS), which focused on the inquiry skills of inference and verification for grades four to six learners. The test was presented in the form of demonstration. It was considered to be valid, but had a low reliability, especially for the inference subset, with a reliability of 0.66 and therefore, the test was discarded.

However, Dillashaw and Okey (1980) developed a more comprehensive Test of Integrated Science Process Skills (TIPSI), which included most of the integrated skills such as (i) stating and revising hypotheses, (ii) identifying and controlling variables, (iii) operationally defining of critical terms, (iv) graphing and data interpretation, and (v) designing of experiments. The test had 36 multiple-choice items validated for students at secondary school level (Dillashaw & Okey, 1980). The test was designed to be taken in a single, untimed session. Each of the five integrated science process skills is assessed by six items on the test. All items had four response choices, and they have been stated in a practical problem context. Items were drawn from all science content areas to avoid favoring any particular science background (Dillashaw and Okey, 1980).

The Cronbach alpha reliability of TIPSI test was established by Dillashaw and Okey (1980) to be 0.89 by using over 700 secondary school students of grades 7-12. Content validity was established using specific objectives judged by a panel of science educators. The panel found a mean score of 18.99 (s.d. 7.60) for students from general curricula. Readability index was assessed and found to be 9.2 (Dyer, Myers & Washburn, 2004 and Hamilton & Swortzel, 2007). The test is still very much in use to date and it has been employed in several studies.

As a follow up of TIPSI test discussed above, Burns, Okey and Wise (1985), developed a similar test which was referred to as the Test of Integrated Science Process Skills II (TIPS II). The test was based on the objectives and format of the original TIPSI and the same number of items (36). Its reliability was found to be 0.84. The test is also still very

useful to date and employed in several studies such as that by Rowe & Foulds (1996) and the one by Ates in (2004). A recent study by Keil, Haney & Zoffel (2009) on improvements in student achievement and science process skills also employed this test to measure the knowledge level of students in science process skills.

Onwu and Mozube (1992) were the early scholars in Africa to develop a science process skills test. They used Nigerian secondary education curriculum to develop and validate a science process skills test for secondary school science students. The test was a 36 multiple choice questions intended to measure students' skills in identifying and controlling variables, defining variables operationally, formulating hypotheses, interpreting data and in designing experiments (Onwu & Mozube, 1992). The test was considered valid in the Nigerian education context and had a reliability of 0.84.

However, a recent test of integrated process skills was developed by Mungandi of the joint centre for Science Mathematics and Technology Education at the University of Pretoria, South Africa in 2005. The test is a thirty multiple-choice and its reliability was estimated using split half method with 1043 learners of grade 9, 10, and 11 to be 0.81. The test has been proven to be gender and race neutral. Its reliability coefficient is well above the lower limit of the acceptable range of values for reliability, and it is within the range of reliability coefficients obtained from similar process skills tests, such as that by Dillashaw and Okey (1980) who obtained a reliability of 0.89 and that by Burns, Okey and Wise (1985) who also obtained a reliability of 0.84. The readability level of this instrument was found to be 70.29 (Mungandi, 2005). This high readability value of the

instrument implies an easy to read and understand test (Zeitler, 1981). The test has an internal validity of 0.97 and a concurrent validity of 0.56.

The researcher of this current study adopted this test by Mungandi (2005), for assessing the knowledge level of integrated process skills of Biology teachers in Morogoro Municipality. This is because apart from being a recently constructed one, but it has also been developed in an African context making it easy for Tanzanian teachers to score.

## **2.6: The Importance of Science Process Skills**

### **2.6.1: General Importance of Science Process Skills**

Several researchers have written on the importance of science process skills acquisition. According to Rezba, Sparague, Fiel, Funk, Okey and Jaus (1995), students who have learnt the integrated skills have the tools to interpret what they observe, make inferences and predictions about their observations. To support the idea, Mungandi (2005) argued that, if learners have to be true future scientists, they need to learn the values and methods of science process skills. According to the author, successful integration of science process skills with classroom lessons will make learning experiences richer and more meaningful.

Chiappetta & Koballa (2002) on the other hand argues that, the acquisition and frequent use of these skills can better equip students to solve problems, learn on their own, and appreciate science. In the same vein, Mungandi (2005) comments that, science process skills are the instruments that scientists use to learn about the world and empower

learners with the ability and confidence to solve problems. It is through process skills that scientific ideas are developed, tested and linked. Process skills are not only important as part of the core skills in sciences, but also in enabling learners to develop the ability of using evidence in solving problems and making decisions (Harlen, 2000).

#### **2.6.2: Science Process Skills and the Development of other Academic Skills**

Competence in science process skills enables learners to learn other skills in other disciplines. According to Mungandi (2005), science process skills are part of and central to other disciplines and its integration will produce positive effects on learning science. A study by Shann (1977) for example revealed that, teaching process skills can enhance problem-solving skills in Mathematics. Ostlund (1998) on the other hand, argues that the development of scientific process skills simultaneously develops reading skills of learners. Other researchers (eg Zeitler, 1981; Scharmann, 1989; & Arena, 1996) had found that science process skills not only enhance the operational abilities of kindergarten and first grade learners, but also facilitate the transition from one level of cognitive development to the next. Simon and Zimmerman (1990) also found that teaching of science process skills enhances oral and communication skills of students. The findings of these researchers were in line with Bredderman's (1983) findings in his study on the effect of activity based elementary science on student outcomes, that science process skills are more effective in raising students' performance and attitudes than the traditional programmes. Hence, the role of science skills in the development of learners' ability of learning with understanding is of crucial importance (Arena, 1996).

### **2.7: Teacher Beliefs (Self efficacy) in Teaching Science**

Investigation of teacher beliefs is vital to a more complete understanding of teacher behavior and the capacity to teach effectively. Several researches have been conducted to measure with accuracy teacher beliefs or self efficacy (Riggs & Enoch, 1990; Ashton, Doda & Webb, 1983; Gibson & Demba 1984 and Hamilton & Swortzel, 2007). Koballa and Crawley (1985) define belief as information that a person accepts to be true. Person beliefs according to Riggs and Enochs (1990), are termed as person's efficacy and it refers to the extent teachers (persons) believe they have the capacity to positively affect students achievement. Bandura (1977) suggests that people develop a generalized expectancy about action-outcome contingencies based upon life experiences. Additionally, people also develop specific beliefs concerning their own coping abilities.

Beliefs have been closely linked to behavior in Bandura's social learning theory with phobics and self efficacy (1977). According to Gibson & Demba (1984), Bandura's self efficacy theory is very useful in the study of teacher effectiveness in the classroom. The theory enables one to predict that "teachers who believe students learning can be influenced by effective teaching (outcome-expectancy beliefs) and who have confidence in their own teaching abilities (self efficacy beliefs) would persist longer, provide a greater academic focus in the classroom and would exhibit different types of feedback than teachers who have lower expectancies (Gibson & Demba, 1984).

Several studies suggest that teacher efficacy beliefs may account for individual teacher differences in their teaching effectiveness (Bandura, 1977; Brophy & Evertson, 1981).

Student achievement has also been shown to be significantly related to teacher efficacy beliefs (Ashton & Webb, 1984; Hackett, & Betz, 1989). Ross (1998) for example, reviewed 88 teacher efficacy studies and suggested that, teachers with higher levels of efficacy are more likely to (i) learn and use new teaching approaches, (ii) provide special assistance to low achieving students, (iii) build students' self-perceptions of their academic skills, and (iv) persist in the face of student failure.

### **2.8: Literature Gap**

Despite numerous studies in the area of science process skills (Dillashaw and Okey, 1980; Padilla *et al.*, 1983; Scharmann, 1989; Roth & Roychoudhury, 1993; Yager & Lutz, 1994; Arena, 1996; Harlen, 2000; Dyer, Myers & Washburn, 2004; Rambuda & Fraiser, 2004; Ates 2004; Mungandi 2005; and Hamilton & Swortzel, 2007), none of them had been conducted in Tanzania. Studies by Mushi, 1992; Chonjo, Osaki, Possi and Mrutu, 1995; Osaki, 2000; Osaki and Njabili, 2004; Osaki, 2007 and Shemwelekwa, 2008 focused much on how science was taught in Tanzania schools and the availability of science teaching and learning resources. A review of literature failed to identify researches that have investigated the capacity of science teachers in the area of science process skills in Tanzania. The current researcher remains convinced that there is an educational gap in this area, both in bringing these skills into the classroom and in training teachers to teach these scientific skills.

## **CHAPTER THREE**

### **RESEARCH METHODOLOGY**

#### **3.1: Introduction**

This chapter describes the research methodology that was used in assessing Morogoro Biology teachers' capacity for teaching integrated science process skills. Quantitative method was a dominant research paradigm adopted. The chapter spells out the methodological aspects such as research design, area of the study, sample size, sampling procedures, data collection methods and data analysis plan used in the study. Finally, the chapter provides ethical issues that were considered while undertaking the research.

#### **3.2: Research Design**

Both correlational and descriptive research designs were employed. Correlational research involves the search for relationships between variables through the use of various measures of statistical associations such as Chi square, Student's t and F tests (Borg & Gall, 1989). Correlational design was chosen because this study aimed at exploring the relationship between teachers' self-efficacy, qualification, working experience and gender and their capacity to teach science process skills in Morogoro.

Descriptive research design on the other hand provides current information about conditions, situations, and events. Borg and Gall (1989) maintains that descriptive studies are used to find out "what is". Descriptive design was also suitable in this study because the study intended to provide a description of teachers' knowledge, their self efficacy for teaching science process skills, the effectiveness of school laboratories as a

vital resource in the teaching of science process skills, and how Biology teachers in Morogoro teach these scientific process skills in the classroom.

### **3.3: Area of the Study**

The study was conducted in Morogoro Municipality. The area was conveniently selected to represent other districts in the country. The basis for convenience selection of Morogoro Municipality stem from the fact that, Biology teachers throughout the country have undergone a uniform centralized teacher training curriculum in teacher training colleges and universities. The assumption is that, they are somewhat similar in terms of their science process knowledge and skills. In the case like this, where the researcher has a wider possibility of obtaining the needed data, he/she is allowed to search a sample by his/her convenience (Borg and Gall, 1989). Morogoro Municipality was a convenient area for the researcher because it is the researcher's working station making easier for him to obtain reliable needed data.

According to the Morogoro Municipal Council data (2009), the Municipality is located at a distance of 200km from the Indian Ocean on the eastern arc of the Uluguru Mountains on the high way to the southern highlands of Tanzania. It covers a total area of 260sq.km with 19 administrative wards. Currently, the region has 07 government secondary schools, 151 community secondary schools, 8 Christian and 2 Muslim secondary schools making a total of 190 schools (URT, 2008). The Municipality of Morogoro in particular has a total of 36 secondary schools, of which 22 are government schools and 14 are privately owned (Municipal Council Data, 2009)

### 3.4: Study Population

The population for this study was all teachers who have Biology as one of their major teaching subjects in 36 secondary schools present in Morogoro Municipality. The researcher decided to involve biology teachers because he is conversant with most of the concepts and scientific processes in Biology as he is a Biology teacher himself. One hundred and seventy six (176) potential participants (Biology teachers) were identified from the current list of Municipal secondary school teachers provided by the office of the District Education Officer for secondary education.

### 3.5: Sampling Procedure and Sample Size

#### 3.5.1: Sampling of Biology Teachers

Ross (2005) maintains that financial, physical, economical, and social constraints may force the researcher to rely only on the part of the population to obtain information. In determining the sample size of Biology teachers, the researcher employed a simplified formula provided by Yamane (1967:886) to calculate the sample size at confidence level of 5% and when the population is known and the precision level of the study chosen. The formula is as follows;

$$n = \frac{N}{1 + N (e)^2}$$

Where as  $n$  = sample size

$N$  = population

$e$  = Precision level chosen

In this study, the researcher decided to choose a precision level of 10% or 0.1 and since the population of Morogoro Municipality Biology teachers is known (176), then the sample size was calculated as follows;

$$n = \frac{N}{1 + N (e)^2} \quad ; \text{ hence} \quad = \frac{176}{1 + 176 (0.1)^2} = 63$$

Hence, the sample size of Biology teachers needed for a good study was 63 as computed from the calculation using the formula above.

### 3.5.2: Sampling of Participating Schools

It was also observed that 10 schools were enough to provide the required 63 Biology teachers. To obtain the 10 schools required, all 36 schools were classified basing on the nature of their ownership. There were 19 community secondary schools, one in each ward, eight (08) privately owned schools, (02) normal government schools, one (01) special secondary school, four (04) Christian seminary schools and two (02) Islamic seminary schools. A random sampling technique was done in each group of schools to obtain the required 10 secondary schools. A guiding principle was that at least one school from each of the six categories of schools should provide a member in the sample. This mixed sample assured the researcher of collecting information from a wide variety of schools and teachers. Categories with many schools (community and private schools) were given additional 03 and 01 chances respectively to obtain the required 10 schools. As a result, Kilakala, Uluguru, Morogoro, Kihonda, Kigurunyembe, Forest Hill, Mazimbu, Sumaye, Jabal Hira Seminary, and St. Peters seminary constituted the sample

schools. Kilakala represented government special schools, St Peters and Jabal Hira represented seminary schools, Kigurunyembe and Forest Hill represented private schools, Morogoro represented normal government schools while Kihonda, Sumaye, Mazimbu and Uluguru represented community secondary schools. The ten (10) sampled schools had a total of 69 Biology majored teachers. However, there was no need to employ any sampling technique to remain with 63 teachers required in this study. This is because 06 teachers were not able to participate in the study for several reasons including sickness and being out of the work station. Sampled teachers varied in terms of sex, level of qualifications, and work experience as indicated in Table 3.1 below.

**Table 3.1: Schools at which the Research was Conducted**

S/No	School name	Total No. of teachers	No. of teachers by sex		No. of teachers by qualification	
			Male	Female	Diploma	Degree
1.	Kilakala Sec	08	04	04	04	04
2.	Uluguru Sec	06	04	02	04	02
3.	Moro Sec	11	05	06	07	04
4.	Kihonda Sec	08	04	04	05	03
5.	Jabal Hira Seminary	04	03	01	03	01
6.	St. Peters Seminary	07	04	03	03	04
7.	Kigurunyembe Sec	05	02	03	04	01
8.	Forest Hill Sec	06	03	03	03	03
9.	Mazimbu Sec	04	03	01	04	00
10.	Sumaye Sec	04	03	01	03	01
<b>Total</b>		<b>63</b>	<b>35</b>	<b>28</b>	<b>40</b>	<b>23</b>

Source: Field data, (2009).

From Table 3.1 above, the sample comprised of 35 male teachers (55.6%) and 28 female teachers (44.4%) making a total of 63 teachers. Of the 63 teachers, 40(63.5%) had diplomas in education while 23(36.5%) had Bachelors degree (Science). The essence of having such categories was to enable the researcher find out whether there is a statistical

significant difference between Morogoro Biology teachers' qualification level, gender and work experience and their capacity to teach science process skills.

### **3.6: Data Collection Methods**

In order to collect as much information as possible, several data collection methods were used depending on the specific objectives of the study. These included a form II Test of Integrated Science Process Skills developed by Mungandi (2005), Science Teaching Efficacy Belief Instrument (STEBI) developed by Riggs and Enochs (1990), and several observation checklists. Additional data relevant to the study were collected from teacher responses on a researcher's developed instrument designed to collect demographic data, including years of teaching experience, gender, education qualification levels, and nature of the school (see Appendix A).

#### **3.6.1: Test of Integrated Science Process Skills by Mungandi**

In assessing Biology teachers' knowledge level of integrated process skills, a Form II science process skills test developed by Mungandi of the University of Pretoria in 2005 was administered to a sample of 63 teachers (see Appendix B). The test measures five (05) individual integrated scientific skills (identifying variables, stating hypotheses, operationally defining, designing investigations and interpreting data) to students of Grade 10 equivalent to Form II students in Tanzania.

The reliability of the instrument was established by Mungandi (2005) using 1,043 Grade 10 learners to be 0.81 (Cronbach's alpha) and an internal validity of 0.98. The

instrument was also proven to be a gender and race free test. The test has reliability coefficient well above the lower limit of the acceptable range of values for reliability, and it is within the range of reliability coefficients obtained from similar studies, such as those by Dillashaw and Okey (1980) who obtained a reliability of 0.89 and Burns, Okey and Wise (1985) who also obtained a reliability of 0.84. Mungandi's test has a readability index of 70.29. This high readability value implies an easy to read text (Mungandi, 2005). The researcher adopted this test in measuring teachers' knowledge of science process skills because apart from being a more recent test but also it has been developed in an African context making it easy for Tanzanian teachers to score. Table 3.2 below shows the distribution of questions in the test and the specific process skill they measure (see Appendix B).

**Table 3.2: Questions in the Test and Individual Science Process Skill they Measure**

	<b>Integrated science process skills</b>	<b>Questions in the test measuring it</b>
1.0	Identifying and controlling variables	Question No; 2, 6, 19, 28, 29 and 30
2.0	Stating hypotheses	Question No; 8, 12, 16, 20, 23 and 26
3.0	Operational definitions	Question No; 1, 7, 10, 21, 22 and 24
4.0	Graphing and interpreting data	Question No; 4, 5, 9, 11, 14 and 17
5.0	Experimental design	Question No; 3, 13, 15, 16, 18 and 27

**Source:** Mungandi, (2005:63).

Since the test by Mungandi (2005) was made for ordinary secondary level students (Form II), an ordinary level grading system of Tanzania was adopted to categorize each teacher's score in the test. O-level grading system of Tanzania grades students marks into five classes, grade A (very satisfactory or excellent), B (satisfactory or good), C (average), D (poor or unsatisfactory) and grade F (very poor or very unsatisfactory). After marking, teacher scores were converted into percentages and classified into six

categories using the above criteria and presented in the Format as shown in Table 3.3 below.

**Table 3.3: Test Scores Grading System**

Range of scores	Corresponding %	Grade	Description of the level of process skill
0-6	20 and below	F	Very unsatisfactory
7-12	21-40	D	Unsatisfactory
13-18	41- 60	C	Average
19-24	61-80	B	Satisfactory
25-30	81-100	A	Very satisfactory

Source: URT (1995)

Since it was not possible to bring all 63 teachers from 10 different schools in one centre for taking the test, the researcher visited the Biology teachers in each sampled school after an appointment. The test was administered to teachers in their own departmental offices. The test papers were collected by the researcher after 50 minutes of the test time. The return rate was 100% as all the test papers were returned dully filled.

### **3.6.2: Science Teaching Efficacy Belief Statement Instrument (STEBI)**

Science Teaching Efficacy Belief Statement instrument developed by Riggs and Enochs (1990) was used to determine Morogoro teachers' self efficacy level (Appendix C). The instrument contains 25 items that are rated on a 5-point Likert scale, ranging from strongly disagree (1) to strongly agree (5). Reliability of the instrument was determined on two separate factors, one called Personal Science Teaching Efficacy (PSTE) where an instrument was found to have Cronbach's alpha of 0.92 and the second factor labeled as Science Teaching Outcome Expectancy (STOE) with a Cronbach's alpha of 0.77 (Riggs & Enochs, 1990). The following items; 1, 4, 5, 7, 9, 11, 12, 14, 15, 16, 18 and 23 in the

instrument were revised scored in order to produce values between positively and negatively worded items (see Appendix C). According to Riggs and Enochs (1990) revising scores on these items produces high scores for those teachers with high self efficacy and low scores for those with low level of self efficacy.

With STEBI, the lowest score is 25 points if a teacher were to score only one point in each of the 25 statements that would represent the lowest possible teacher's self efficacy level. The highest possible teacher score with STEBI is 125 points if a teacher were to score maximum of five (05) points in each of the 25 statements that would represent the highest possible teacher's self efficacy level. After marking STEBI papers, each teacher's self efficacy level was determined and categorized into five classes from very low to very high self efficacy depending on the score he/she obtains as summarized in Table 3.4 below.

**Table 3.4: Classification System of Teachers' Self Efficacy Levels**

<b>Self efficacy level categories</b>	<b>Range of Scores/ points in the STEBI</b>
Very low self efficacy level	25-40
Low self efficacy level	41-60
Average self efficacy level	61-80
High self efficacy level	81-100
Very high self efficacy level	101-125

**Source:** Riggs & Enochs, (1990).

STEBI was administered to each participant teacher (63 teachers) after he/she had finished attempting the science skills test. Due to the nature of the statements in the instrument, all STEBI items were easily accomplished by teachers in less than 15 minutes. All the papers were then collected at a 100% return rate.

### **3.6.3: Physical Observation Checklists**

The use of direct classroom observation over the last decade according to Good & Brophy (2000) has resulted in the accumulation of an impressive body of information about the nature of effective teaching. Three kinds of observation checklists were constructed and employed in this study. They include (a) classroom teaching observation checklist for checking teacher's effectiveness during classroom sessions, (b) a checklist for observing teachers' competence in science process skills during laboratory practical classes, and (c) laboratory observation checklist for assessing the availability of resources for enhancing science process skills teaching and acquisition in each Biology laboratory in the 10 sampled schools.

The first checklist, a classroom teaching observation checklist was constructed by the researcher to assess how well did Morogoro Biology teachers adhere with the principles of effective teaching of science process skills as stipulated by Harlen (2000:181-190) (see Appendix D). However, due to incompatibility of timetable of some teachers and that of the researcher, it was not possible to physically assess the teaching of all 63 sampled teachers. As a result, only 42 (67%) Biology teachers were visited and assessed in the classroom to check and assess their teaching. It means that these 42 teachers were conveniently selected after looking at their timetable for Biology classes. Teacher's effectiveness in teaching was rated by the researcher as very good, good, average, poor

and very poor depending on the degree to which his/her practice in the classroom had abided with Harlen's principles.

The second checklist was also formulated by the researcher to guide the researcher to systematically assess competence of teachers in teaching science skills during laboratory practical sessions (see Appendix E). The checklist contained 5 individual integrated science process skills under this study; identifying and controlling variables, stating hypotheses, operational definitions, interpretation of data, and designing of experiments. Classroom teaching observation checklist and a checklist for checking teacher's competence during laboratory practical classes intended to supplement the findings of the Mungandi's science process skill test. The intention was to make a personal observation on the capacity of the existing Morogoro teachers in teaching science process skills and compare the findings with the results obtained from Mungandi's test.

Laboratory resources observation checklist on the other hand was constructed by the researcher to enable him physically assess the availability of laboratory resources for teaching science process skills as compared to the actual demand as per student populations (see Appendix F). As noted by several writers (Woolnough and Allsop, 1985; Roth and Roychoudhury, 1993; Osaki, 2007), the teaching and development of science process skills is a valid aim for science laboratory work as they provide opportunities for practical investigations. The resources that were observed included laboratory equipments, apparatus, specimens, chemicals and reagents.

### **3.7: Validation of Instruments**

A valid instrument is one which measures what is supposed to measure (Ross, 2005). In this study, observation checklist instruments were subjected to content analysis. Several drafts of the instruments were discussed with the supervisor. This helped to rectify ambiguities in the items. Mungandi's process skill's test and the STEBI instrument were also discussed with the supervisor to see whether they fit with the local context. However, there was no need to re-validate these two tools because they are acceptable and published instruments with known reliability and validity. Moreover, they have been used in many studies worldwide as it has been shown in the literature review, Chapter II.

A pilot study was done at Mugulasi secondary school involving five (05) Biology teachers to see whether the instruments above have the capacity to generate the data required for this study. All the instruments were proven to be effective. All the test questions were found to be correct and free from any ambiguity. Minor changes were done by contextualizing names of people and other objects used in the original Mungandi's test. According to Dillashow and Okey (1980) changing original names in the test/instrument does not affect reliability and validity of the instrument.

### **3.8: Data Analysis Plan**

Both, the test of integrated process skills and the STEBI's likert scale provided quantitative data. These data were analyzed using SPSS version 13.0. Descriptive analysis of frequencies, percentages, means, and standard deviations were used to categorize, organize and analyse data from these instruments. Bivariate analysis and

Pearson correlation were used to determine the influence of self efficacy on teachers' capacity to teach science process skills. Analysis of variance (ANOVA) and independent samples t-test on the other hand were used to determine the relationship between teachers' knowledge of science process skills and their level of qualification, teaching experience, and gender. Data from observation checklists were qualitatively analyzed through interpretive method and content analysis.

### **3.9: Ethical Issues**

Before data collection process started, permission to carry out the study in Morogoro Municipality was sought from the University of Dar es salaam, where a research clearance permit was granted. Then, the Regional Administrative Officer of Morogoro and the District Executive Director (DED) of the Municipality also granted permission to visit the sampled schools (see Appendices G, H and I). Ethical dimensions for individual participants were also considered. All the participants were duly informed of the objectives of the study before the test was administered. All the procedures that involved the participants were explained to them, and they were informed of their right to decline from participating in the study if they wish. Participant teachers were given number codes from T1 to T63, and their schools were given letter codes (Q to Z), to ensure that they remain anonymous to external populations. The test scripts were handled by the researcher and the supervisor only. After marking, the scripts were stored in a safe place and they would be destroyed one year after completion of this study. The performance of each participant on the test was treated with high confidentiality. All participant teachers were promised to access their test results if they wish upon request.

## **CHAPTER FOUR**

### **DATA PRESENTATION AND DISCUSSION**

#### **4.1: Introduction**

This chapter presents and discusses the key findings of the study on Morogoro teachers' capacity to teach integrated science process skills. It is subdivided into four sections according to the specific objectives of the study. The first section presents findings on Morogoro Biology teachers' knowledge level of integrated science process skills. Teachers' self-efficacy level for teaching science process skills is discussed in the second section of the Chapter. Section three discusses the influence of self-efficacy, level of qualification, teaching experience and gender on Morogoro teachers' capacity to teach integrated science process skills. The final section of the Chapter discusses the effectiveness of school laboratories as a vital resource in teaching science process skills.

#### **4.2: Morogoro Teachers' Knowledge Level of Integrated Science Process Skills**

##### **4.2.1: General Performance of Teachers in the Science Process Skills Test**

Integrated science process skills are higher order activities that scientists execute when they study or investigate a problem, an issue, or a question (Chiappetta & Koballa, 2002). These skills include identifying and controlling variables, stating hypotheses, defining variables operationally, interpretation of data, and designing of experiments. The first objective of this study was to assess the knowledge level of integrated science process skills of Morogoro Biology teachers by using a science process skills test

developed by Mungandi (2005). The test was administered to a group of 63 science teachers who participated in this study.

Descriptive analysis for frequencies, means and percentages of teacher scores was carried out. The results from the test showed that, majority of Morogoro Biology teachers have unsatisfactory knowledge level of science process skills and they scored from satisfactory to very unsatisfactory. There was no a single teacher who scored very high to be graded or regarded as having a very satisfactory knowledge level of integrated science process skills shown in Table 4.1 below.

**Table 4.1: Teacher Scores in the Test of Integrated Science Process Skills (n=63)**

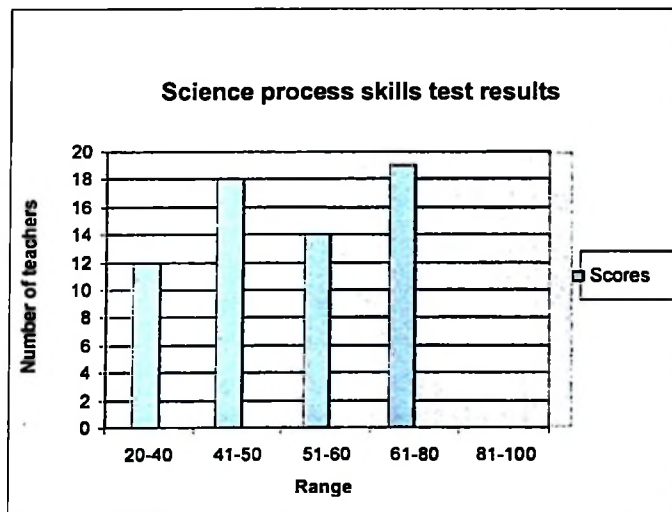
Range of scores by %	No. of teachers in the range	% of teachers in the range	Description of the level of integrated process skill
Below 40%	12	19	Very unsatisfactory
41-50	18	28.7	Unsatisfactory
51-60	14	22.3	Average
61-80	19	30	Satisfactory
81-100	00	00%	Very satisfactory

**Source:** Field data (2009).

Calculation done on the scores of all 63 teachers provided an overall mean of 40% which means that on average, Morogoro teachers scored 12 (40%) items correctly out of 30 total questions. Teacher scores ranged from 06 (20%) as the lowest mark to 23 (77%) as the highest score. According to ordinary secondary level grading system of Tanzania adopted in this study, 40% represents a “D” class which means poor or unsatisfactory knowledge level. This means that, on overall, Morogoro Biology teachers had unsatisfactory knowledge level of integrated science process skills. Poor teachers’

scientific skills in Tanzania according to Osaki (2007) might be attributed to their ineffective preparation at colleges where teacher education curriculum over emphasize more on teaching methodology than content part which would give prospective teachers an opportunity to build their investigation science skills.

To make a better view of teachers' test scores, Figure 4.1 below further summarizes teachers' performance. The figure indicates that 61-80 (satisfactory scored group) was a mode class having the highest frequency (19 teachers) followed by the 41-50 group which had 18 biology teachers (the unsatisfactory scored teachers).



**Figure 4.1:** Integrated Science Process Skills Test results

Test scores were further analyzed and it was found that, test items that most teachers scored well, were *data interpretation questions* followed by questions measuring their hypothesis formulation skills. On the other hand, questions measuring skills in *designing experiments* were poorly performed by Morogoro Biology teachers (a detailed discussion on this is done in the next sub-section 4.2.2).

Apart from performing poorly in the science process skills test, it was also witnessed that, the majority of Biology teachers in Morogoro were not aware of what science process skills are, even if they exist in their syllabus. During data collection, the question below was so common to most teachers;

*“Mr researcher, what do you mean by science process skills, it is the first time I am hearing of this, can you elaborate more”?*

Respondent T16 for example reached a position of arguing that;

*“.....we don't have such a topic (science process skills) in our syllabus; we only teach what is prescribed in the official curriculum”.*

This respondent thought science process skills was a topic in the syllabus. So, Morogoro teachers not only showed a weak capacity to answer questions about science process skills, but also they were unaware that science process skills are specific competences emphasized in their new education curriculum. They could have known this either from their teacher education training or from in-service curriculum orientation workshops.

Comparatively, the general performance of Morogoro Biology teachers in the process skills test was lower than the results reported by Dyer, Myers and Washburn (2004) in their study on Florida Agriscience teachers' ability to teach integrated science process skills. In that study, Florida teachers scored an average of 29 items or 89% correct out of 36 possible items with a range from 24 to 33 correct responses. Morogoro teacher scores were also lower than those obtained by Hamilton & Swartzel (2007) in their study to determine Mississippi teachers' capacity to teach science process skills. Mississippi teachers had the mean overall score of 26.65 out of 36 questions or 74% correct with

standard deviation (s.d) of 6.01 and a range from 17 to 34 correct responses. It is so serious to note and quite surprising to find that teachers who are supposed to guide students on the learning of science skills have failed a Form II science process skills test.

The implication of this kind of results is that, Morogoro Biology teachers do not have enough knowledge that is needed to instruct their students in the area of science process skills. It can be inferred that, teacher training institutions need to enrich teacher education curriculum with science process skills contents. This will increase the capacity of prospective teachers' capacity in teaching specific science process skills in different topics. Furthermore, demand driven professional development workshops and seminars for in-service teachers on science process skills should be mounted.

#### **4.2.2: Performance of Teachers in Specific Integrated Science Process Skills**

In an attempt to find out the kinds of questions in the process skills test that Morogoro teachers performed best and the ones they performed poorly, descriptive statistics for teacher scores were further analyzed. Mungandi's science process skills test is composed of 30 items where each of the individual integrated science process skill (identifying and controlling variables, stating hypotheses, operational definitions, graphing and interpreting data and experimental design) is measured by six (06) questions.

The results by specific integrated skill revealed that, Morogoro Biology teachers performed better questions measuring their skills in "*graphing and data interpretation*". Test scores showed that teachers had a mean of 4.65 out of six (06) in graphing and data

interpretation questions. Of the six questions (questions number 4, 5, 9, 11, 14 and 17) which measured teachers' data interpretation skill, question number 17 on *interpreting the graph of human population with number of years* was answered correctly by the majority of the respondents. The results showed that 49 (78%) out of 63 teachers in the sample got the correct answer. Comparatively, question number 5 on the *size range that one will find the longest tiger fish in the dam* was poorly performed. The results indicated that 42 (67%) out of 63 teachers failed to get the correct answer. It was a technical question which required teachers to clearly understand the meaning of data in both X and Y axis with respect to the range and size of fish. However, researcher's observation in the classroom teaching failed to justify the competence of Morogoro teachers in data interpretation because most of the contents they taught did not involve data and graphic interpretations. Their teaching was dominated by science contents than scientific skills such as graphic and data interpretations.

Morogoro teachers on the other hand performed very poor on questions that measured their skills in *designing experiments*. The results of descriptive analysis on questions number 3, 13, 15, 16, 18 and 27 which measured their skills in designing experiments showed that teachers had a mean of only 0.95 or 15.8% out of six (06) questions. Question number 3 on *what plan to choose in testing the influence of daylight on plant flowering* and question number 16 on *how to test why anthills lean towards the west on nature reserve* seem more difficult than other questions. The results showed that each of these questions was scored correctly by 06 (09%) teachers only out of 63. These were

technical questions that needed teachers to be able to identify all variables (dependent and independent) first, before proposing a plan or a model for an experimental design. Table 4.2 below summarizes the performance of Morogoro Biology teachers by specific integrated science process skills in the Mungandi's test.

**Table 4.2: Mean Test Scores by Individual Scientific Process Skills (n = 63)**

Individual integrated science process skills	Total items	Minimum Score	Maximum Score	Mean Score	SD	Percent Correct
Identifying variables	6	2	5	3.75	1.06	62
Identifying and stating hypotheses	6	0	6	3.42	1.43	57
Operationally defining	6	0	5	2.82	1.47	47
Graphing and interpreting data	6	1	6	4.65	1.42	77.5
Designing experiments	6	0	3	0.95	0.81	15.8

Source: Field data, (2009).

The above results on Morogoro teacher skills in designing experiments clearly correspond with the researcher's observation during Biology classes. Probably the most difficult job during data collection of this study was to get participating teachers prepare practical sessions so that their science process skills could be assessed. Even in the presence of time and resources, many teachers seem afraid of preparing practical experiments. This is a sign of low competence on the part of teachers toward setting experiments. As a result, the researcher managed to assess the experimental design skills of only seven (07) or 17% teachers out of 42 who were visited during teaching sessions.

The respondent T9 for example, a Form II Biology teacher at X secondary school was teaching Nutrition in plants (photosynthesis). In this topic according to the Biology

syllabus (p.46), a teacher is required to guide students not only to design and conduct experiments to verify the role of carbon dioxide, water, chlorophyll and sunlight energy in the process of photosynthesis but also to verify the production of oxygen and carbohydrates as end products of the process. However, the researcher observed that no single practical work was carried out by this teacher apart from lecture notes and some assignment questions. When asked why practical work missing, the teacher responded;

*“....we always conduct all practicals cumulatively by the end of Form IV near national examinations, we do this because students tend to forget and laboratory resources are not that much enough for practicing at the end of each lesson”.*

During the survey, it was also observed that several teachers were unable to prepare chemical reagents such as standard solutions or set up practical experiments (for example teachers T3, T23, and T34). Several reasons might be attributed to the problem of teacher incompetence in teaching practical science process skills. Osaki (2007) attributed this to poor science teacher preparation in teacher training institutions. According to the author, teacher education curriculum has failed to promote reflective practices and constructivist approaches to prospective science teachers. As a result, these institutions are increasingly producing teachers who are weak in practical skills especially laboratory experiences (Osaki, 2007).

Morogoro teacher results also correspond with those by Hackling and Garnett (1991) who conducted a research on teachers ability in carrying out experiments and found that teachers at all levels showed a poorly developed skills of problem analysis, planning, and carrying out controlled experiments. Another similar finding is that by Foulds and

Rowe (1996) who found that teachers were capable of identifying all variables influencing an experiment, scoring about 50% on the test items and they could also produce testable hypotheses, with scores of about 40%. However, they were unable to design a controlled experiment, gaining an average mark of only 18%.

However, the performance of Morogoro teachers by specific integrated science process skills differs from those reported by both Hamilton & Swortzel (2007) and Dyer, Myers, and Washburn (2004), where teachers scored higher on questions measuring their skills in *identifying variables and stating hypotheses* and failed questions on *graphing and data interpretation*. On the other hand, as indicated in Table 4.2 above, Morogoro teachers performed extremely poorly on questions dealing with *designing investigations* where 22.2% of all teachers in the sample failed to score even a single question. This means that 14 teachers out of 63 scored zero in the questions measuring their skills in designing experiments. The maximum score out of six questions was only 3 and the standard deviation was only 0.95 or 15.8% correct responses.

From the above findings on science process skills, it can be inferred that Morogoro Biology teachers needs more time in professional development workshops especially on designing experiments, identifying variables and in formulating testable hypotheses so that they can be better equipped to teach students in these areas. Professional development will provide science teachers with opportunities to explore new roles, develop new instructional techniques and refine their science teaching practices.

### **4.3: Teachers' Self-Efficacy Level for Teaching Science Process Skills**

#### **4.3.1: General Scores of Teachers in the STEBI Instrument**

Teacher's self efficacy has been found to be one of the important variables consistently related to positive teaching behavior (Gibson & Dembo, 1984; Woolfolk & Hoy, 1990). For a successful implementation of any education reform such as Competence Based Curriculum and science process skills in Tanzania, teachers' sense of self efficacy as the main change agents is extremely important. The second objective of this study was to determine the self-efficacy of Morogoro Biology teachers towards teaching of science process skills. Science Teaching Self-Efficacy Belief Instrument (STEBI) constructed and published by Riggs & Enoch (1990) was administered to all 63 teachers who participated in this study after they have finished attempting Mungandi's scientific skills test.

STEBI results showed that all 63 participant teachers scored above the minimum score of 25 out of 125 possible points indicating that none of the teacher in Morogoro belonged to a very low self efficacy class with respect to the teaching of science process skills. Six (10%) teachers on the other hand, scored between 41-60 points out of 125 possible points and from the self efficacy classification system by Riggs & Enochs (1990), they were graded as having low self efficacy level. As summarized in Table 4.3 below, majority of teachers 48(76%) scored between 61-80 points in the instrument and exhibited an average self efficacy level towards the teaching of science process skills. However, none of the teachers in Morogoro scored between 101-125 points out of 125

possible points to be graded as having a very high self efficacy. More results from the STEBI instrument are summarized in Table 4.3 below.

**Table 4.3: Science Efficacy Scores of Morogoro Municipally Biology Teachers (n = 63)**

Self efficacy level categories	Range of Scores/ points in the STEBI	Frequency	Percent
Very low self efficacy level	25-40	00	00%
Low self efficacy level	41-60	06	10%
Average self efficacy level	61-80	48	76%
High self efficacy level	81-100	09	14%
Very high self efficacy level	101-125	00	00%

**Source:** Field data, (2009).

A further descriptive analysis indicates that Morogoro teacher scores ranged from 47 to 89 points with an overall mean of 69 and a standard deviation (s.d) of 5.73. The mean (69), falls into an average self efficacy level category (see the self efficacy classification system Table 3.4 p.39). Hence Biology teachers in Morogoro Municipality had an average self efficacy level for teaching integrated science process skills. An average self efficacy of Morogoro Biology teachers means that they have neither high nor low expectation that their science process teaching could positively influence students learning of science process skills (Riggs & Enochs, 1990).

With the average mean of 69, Morogoro Biology teachers exhibited a low self efficacy level than most science teachers in other studies. For example, Hamilton & Swortzel (2007) employed the same instrument, (STEBI by Riggs & Enochs, 1990) to determine the self efficacy of Mississippi teachers in teaching science process skills and found their efficacy scores to range from 79 to 107 with the overall mean being 90.3 and standard deviation (s.d) of 6.73.

The findings on teachers' self efficacy in the teaching of science process skills have a great implication on the implementation of the newly introduced education curriculum in Tanzania which emphasizes these skills. The average/low self efficacy means that, Morogoro teachers have low capacity to teach integrated science process skills. Low self-efficacy of teachers towards teaching science according to Riggs & Enochs (1990), results in avoidance of teaching science and a reduced quality of science instruction. According to Riggs & Enochs (1990), teachers with high levels of efficacy produce a generative capability that enable them adopt innovations, construct new teaching strategies, and increase their levels of effort in the face of difficult circumstances. The findings of this study statistically proved that, teachers who had higher self efficacy scores from STEBI were those who also scored satisfactorily in the Mungandi's test (see a discussion of this in sub section 4.3.3 where results of two instruments are tallied).

#### **4.3.2: Morogoro Teacher Scores in the Specific STEBI Statements/Items**

Self efficacy is a strong factor which might contribute to the teachers' ability or failure to perceive themselves as effective agents of reforms, innovations, and student learning (Woolfolk & Hoy, 1990). The analysis of scores for each statement in the STEBI scale was done in order to have a wider picture of the overall Morogoro teachers' own beliefs with respect to the teaching of science process skills. Science teaching belief instrument (STEBI) is composed of 25 specific statements measuring both personal science teaching efficacy (PSTE) and science teaching outcome expectancy (STOE). The overall

results also suggested that Morogoro Biology teachers do not have a strong self efficacy level to be effective in teaching science process skills as summarized in Table 4.4 below.

From Table 4.4 below, 28(44%) teachers out of 63 indicated to believe that even when they try very hard, they do not teach science process skills as well as they do when teaching other science contents. These responses are in line with the researcher's observation that most teachers are afraid of preparing or conducting practical works to students. Only 12 (19%) teachers strongly agree that when a student does better than usual in science process skills, it is often because the teacher exerted a little extra effort. On the other hand, only 12 (19%) teachers believed that good teaching could overcome the inadequacy of a student's science process skills background. Their responses correspond with the results obtained during interview where participant teachers attributed poor students' performance in sciences not to their poor teaching methods but to students' background and behavior. A good number of teachers 24(38%) strongly disagree that students achievement in science process skills is directly related to the teachers' effectiveness in teaching. Either, 13(20%) teachers believes that, effectiveness in science teaching has little influence on the achievement of students. Thirty one (49%) teachers on the other hand believed that, increased effort in science process skills teaching produces little change in science process skills achievements of some students.

From the above kind of teachers' own beliefs, it can be inferred that Morogoro Biology teachers, (i) do not have strong confidence that their science teaching could result into positive learning of science process skills as expected, (ii) they do not believe that they

have the ability to teach science process skills as required by the new curriculum, and (iii) perceive themselves (self belief) as incapable of teaching science process skills effectively. But for a successful implementation of any education innovation or reform, self beliefs (self efficacy) of teachers as the main implementers, is very important. According to Riggs & Enochs (1990) teachers with a high sense of efficacy are willing to experiment new approaches, and they believe that they can make a difference in student learning and also demonstrates this belief with certain behavioural skills such as having remedial classes to weak students.

During data collection in school Y, the researcher was curious and wanted to know whether teacher responses provided on the paper were reliable and true representation of their perceptions and beliefs towards teaching of sciences to students. So the researcher decided to trigger an informal debate by posing an argument with a panel of six Biology teachers while gathered in their departmental office that;

*“mie siamini kama kuna mwanafunzi mjinga ambaye daima hawezi kufaulu, mara nyingine ni sisi walimu hatuwafuatilii”*

Meaning that;

*“I myself don't believe that there is an irreparable underachieving student that will never ever achieve and prosper academically, sometimes is due to lack of our commitment (teachers) and follow-up that other students fail”.*

The response and reactions from respondents T36, T38, T39 and T41 were as follows;

*...“ Mr researcher your argument is so hypothetical, ... we wish you could be one of us in this school, we are getting extremely weak from one students, that one fail to imagine how comes s/he passed std 7 exam.....even a teacher from the heaven cannot make these students learn especially sciences and mathematics.....they have low motivation and concentrates more on*

*memorizing bongo flavor songs, so you can not generalize and blame teachers for the poor achievement of some students.*

The above statements provided by respondents from school Y, represents a typical sign of teachers with a low sense of self-efficacy, who believe that things are tougher than they really are, a belief that fosters stress, depression, and a narrow vision of how best to solve the problem. Teachers with a strong sense of self efficacy always approach difficult tasks as challenges to be mastered rather than as threats to be avoided.

Table 4.4 below further summarizes teacher responses on specific STEBI statements. From the table, 21(33%) teachers indicated that they are usually at a loss on how to help the student who has difficulty in understanding science process skills concepts. Twenty eight (44%) teachers on the other hand, claimed to understand science process skills well enough to be effective in teaching sciences at secondary schools. Surprisingly however, 42(67%) teachers agreed that they continue finding better ways to teach science process skills effectively. Thirty two (51%) teachers on the other hand were skeptical to agree that they are not very effective in monitoring science experiments.

Given a choice, 37 (59%) teachers in the sample would not invite education inspectors to evaluate their science process teaching because they wonder whether they really had the necessary knowledge to teach these skills effectively. The researcher interviewed Mr Hamisi Lissu, an inspectorate officer for science subjects in eastern zone on the state of science teaching in secondary schools and the observed attitude of teachers towards

inspection. The aim was to check whether responses given and attitude shown by teachers in this study were consistent with inspectors' documented reports. During the interview, the inspector used several vivid examples of teachers' classroom practices they observed during inspection and came up with a general conclusion that;

*".....so the majority of science teachers are incompetent both in the content of the subjects they teach and in the methodology of teaching. As a result they have low confidence and hate very much to be inspected".*

On the same aspect, the general report produced in 2009 by the inspectorate of eastern zone after surveying 101 secondary schools in Morogoro and Pwani regions has also documented poor teaching by science teachers' especially in practical works (science process skills). The document recommended an urgent need for in-service training workshops of science teachers especially in the area of laboratory works.

As an aspect of self efficacy, during observation, the researcher witnessed a general behavior for teachers to delay attending teaching sessions. For example, respondents T3, T11, T20, T30, T48 and T56 were late for more than 30 minutes while they were just in the office doing non teaching business. Moreover, through classroom attendance books, the researcher also noticed a number of unattended periods almost in all classes. For example respondent T48, a Biology teacher of Form III (A, B, C) at school X who had a total of 48 periods per month, had 16 periods unattended between November and December, 2009. The tendency for teachers to miss teaching sessions according to Gibson and Dembo (1984) is among the major signs of low sense of self efficacy.

Teachers with high sense of self efficacy tend to devote more time in the classroom and focus less on discipline as a prerequisite to student learning (Gibson & Dembo, 1984).

On the overall, this study was conceptualized from Bandura's self efficacy theory that teachers' self efficacy towards teaching of science process skills is one of the strong variables defining teachers' capacity to teach these skills. According to the conceptual framework (see Fig 1.1 p. 12), when all other variables are held constant, teachers with higher self efficacy with respect to the teaching of science process skills would also have a higher capacity to teach these skills and vice versa. From the STEBI results, it was clear that Morogoro teachers have a weak sense of self efficacy, hence their capacity to teach science process skills is also low. Teachers with low self efficacy tend to have low aspirations, low motivation, a weak commitment to teaching, and therefore they easily develop stress and depression. This in turn hampers their capacity for teaching science process skills effectively. Specific findings with STEBI statements are summarized in Table 4.4 below.

**Table 4.4: Teacher Scores in the Individual STEBI Items (n=63)**

S/N	LIKERT SCALE STATEMENTS	SA		A		UN		D		SD	
		N	%	N	%	n	%	n	%	n	%
01	When a student does better than usual in science process skills, it is often because the teacher exerted a little extra effort.	12	19	18	29	04	06	20	33	09	14
02	I am continually finding better ways to teach science process skills	34	54	08	13	03	05	10	16	08	12
03	Even when I try very hard, I do not teach science process skills as well as I do most science contents.	11	17	17	27	07	11	13	21	05	08
04	When students improve in science process skills, it is often due to their teacher having found a more effective teaching approach	22	35	16	25	04	06	11	17	10	16
05	I know the steps necessary to teach science process skills effectively	09	14	19	30	10	16	08	13	17	27
06	I am not very effective in monitoring science experiments	16	25	15	24	13	21	09	14	10	16
07	If students are under achieving in science process skills it is most likely due to ineffective science teaching	16	25	13	21	12	19	13	21	09	14
08	I generally teach science process skills ineffectively	05	08	06	10	17	27	28	44	07	11
09	The inadequacy of a student's science process skills background can be overcome by good teaching	26	41	22	35	06	10	07	11	02	03
10	The low process skills achievement of some students can not generally be blamed on their teachers	22	35	16	25	04	06	11	17	10	16
11	When a low achieving child progresses in science it is usually due to extra attention given by the teacher	17	27	13	21	04	06	20	32	09	14
12	I understand science process skills well enough to be effective in teaching sciences at secondary schools	09	14	12	19	11	17	20	32	11	17
13	Increased effort in science process skills teaching produces little change in some students science achievements	13	21	18	26	09	14	11	17	12	19
14	The teacher is generally responsible for the achievement of students in sciences process skills	22	35	16	25	04	06	11	17	10	16
15	Students achievement in science process skills is directly related to their teachers' effectiveness in science teaching	08	13	14	22	06	10	11	17	24	38
16	If parents comment that their child is showing interest in science process skills at school, it is probably due to performance of the child's teacher	19	30	20	32	16	25	11	17	09	14
17	I find it difficult to explain to students why science experiments work	16	25	15	24	13	21	09	14	10	16
18	I am typically able to answer students' science process skills questions	14	22	16	25	10	16	12	19	10	16
19	I wonder if I have the necessary skills to teach science process skills	18	29	17	27	11	17	11	17	10	16
20	Effectiveness in science teaching has little influence on the achievement of students with low motivation	13	20	22	35	09	14	10	16	09	14
21	Given a choice, I would not invite the principal to evaluate my science process skills teaching	12	19	25	40	06	10	11	17	09	14
22	When a student has difficulty understanding a science process skill, I usually at a loss as to how to help the student understand it better	09	14	12	19	11	17	20	32	11	17
23	When teaching science process skills, I usually welcome students questions	18	29	19	30	08	13	10	16	08	13
24	I do not know what to do to turn students on to science process skills	07	11	13	21	14	22	18	29	11	17
25	Even teachers with good science process teaching abilities can not help some kids to learn science	14	22	14	22	06	10	10	16	19	30

Source: Field data, (2009).

### **4.3.3: The Relationship/Influence of Self-Efficacy on Morogoro Biology Teachers' Capacity to Teach Integrated Science Process Skills**

As it has been described in earlier sections, teachers' self efficacy was conceptualized as one of the strong determinants of their capacity to teach integrated science process skills. Hence, it was necessary for the researcher to determine the relationship between the self efficacy level teachers and their capacity/knowledge to teach integrated science process skills. Teachers' capacity was defined by their scores from Mungandi's science process skills test. The relationship was determined by tallying the results of two instruments; the Mungandi's science process skills test and the self efficacy belief instrument (STEBI). Tallying was done to enable the researcher test null hypothesis ( $H_0$ ) that, *'there is no statistical significant relationship between Morogoro teachers' self efficacy level and their capacity to teach integrated science process skills'*. Bivariate analysis was conducted using SPSS and correlation coefficient of self efficacy and science process skills computed using a two tailed test at alpha level ( $\alpha$ ) of 0.05.

As shown in Table 4.5 below, data analysis of these variables found a correlation coefficient ( $r$ ) of 0.151 and significance ( $\rho$ ) of 0.037. Hence,  $\rho$  was  $< 0.05$ , rejecting the null hypothesis ( $H_0$ ) and suggest a positive association between teacher's self efficacy level and his/her knowledge and capacity of science process skills. The rejection of the null hypothesis ( $H_0$ ) means that, Morogoro teachers with higher self-efficacy scores from STEBI instrument were those who also reported to have higher knowledge level of science process skills from the Mungandi's process skills test, and the reverse is also true. Table 4.5 below summarizes Bivariate analysis results.

**Table 4.5: Correlation Coefficient (r) Between Morogoro Teachers' Self Efficacy Level and their Capacity to Teach Integrated Science Process Skills.**

		Teachers Level of Integrated Process Skills	Teachers Self Efficacy Level
Teachers Level of Integrated Process Skills	Pearson Correlation	1	0.151*
	Sig. (2-tailed)	.	0.037
	N	63	63
Teachers Self Efficacy Level	Pearson Correlation	0.151*	1
	Sig. (2-tailed)	0.037	.
	N	63	63

*\*Correlation is significant at 0.05 level (2 tailed).*

**Source:** Field data (2009).

As shown in Table 4.5, Morogoro teachers' self efficacy level towards the teaching of science process skills correlated positively with their knowledge/capacity to teach these skills. Hence it can be inferred that, Morogoro teachers should be given more opportunities to improve their knowledge and competency level in science process skills. This would not only increase their capacity to teach these scientific skills effectively, but also it would increase their confidence and motivation (self efficacy).

Similar results were also obtained by Downing and Chamberlain (1997) in their study to examine the relationship between pre-service elementary teachers' competency in science process skills and their self efficacy towards science teaching using a sample of 46 science teachers. Their data analysis found a significant positive relationship between how well teachers performed science process skills and their attitudes (self efficacy) toward science teaching. Different findings however, were reported from a study by Hamilton & Swortzel (2007) who employed a correlation analysis to calculate the

association between teachers' knowledge of scientific skills and their self efficacy and obtained a negative correlation coefficient ( $r = -0.13, \rho < 0.05$ ). A low negative relationship between teachers' self efficacy level and their capacity for inquiry focused model of science instruction was also found by Nugent *et al*, (2008).

#### **4.4: The Influence of Selected Teacher Variables on the Morogoro Teachers' Capacity to Teach Integrated Science Process Skills**

Other determinant of teachers' capacity to teach science process skills conceptualized in this study included teacher variables; education level, years of experience, and gender (Fig 1.1 p.12). Hence, the third objective of this study was to determine the influence of above variables on the capacity of Morogoro teachers to teach science process skills. Depending on the nature of variables' association, independent samples t- test on mean of groups and one way analysis of variance (ANOVA) were separately performed in order to test the null hypotheses stated in sub-section 1.4.2. Again, teachers' capacity to teach science process skills was defined by their scores from Mungandi's process skills test. The SPSS analyses results are discussed in the following sub sections.

##### **4.4.1: The Influence of Education Qualification on the Capacity of Morogoro Biology Teachers to Teach Integrated Science Process Skills**

The study sought to find out the association between Morogoro teachers' knowledge level of integrated process skills and their education qualifications. Forty (40) study participants were reported to hold diploma in education (science), and the remaining 23 teachers were bachelor degree holders in science related programmes. One's common knowledge would suggest graduate teachers to have higher capacity to teach integrated

science process skills than diploma holder teachers. Descriptive cross tabulation for teacher scores in the Mungandi's test based on their qualifications also indicated degree holder teachers in Morogoro were better than diploma teachers in terms of science process skills. For example, of the twenty three (23) degree holder teachers, 8 (35%) had satisfactory, 7(30%) had average, 5(22%) had unsatisfactory, and 03(13%) had very unsatisfactory knowledge level of science process skills respectively. On the other hand, out of 40 diploma teachers who took the test, 11(27.5%) had satisfactory, 7(17.5%) had average, 13(32.5%) had unsatisfactory and 09(22.5%) had very unsatisfactory level of science process skills.

In an attempt to find out whether a difference in scores identified by cross tabulation between graduate and diploma teachers in Morogoro was statistically significant or not, the null hypothesis (Ho2) was tested with SPSS independent t-test. The hypothesis stated that *'there is no significant relationship between level of qualification and the capacity of Morogoro teachers to teach integrated science process skills'*. Independent -t test was a suitable test for this kind of analysis because it involved testing the means of test scores of two independent groups (diploma & degree teachers). Contrary to the cross tabulation results, no significant differences were found between teachers' qualification and the capacity to teach integrated process skills when the null hypothesis (Ho2) was tested. This means, t-test accepted Ho2 at  $(\alpha) = 0.05$ . Tables 4.6 below summarize independent samples t-test results for teacher scores based on qualification.

**Table 4.6(a): Group Statistics t-Test Scores Based on Level of Qualification**

	Teachers' qualification level	N	Mean (M)	Std. Deviation(s)	Std. Error Mean
Teachers level of science process skills	Diploma level	40	3.5	1.13228	0.17903
	Degree level	23	3.13	1.05763	0.22053

Source: Field data, (2009).

**Table 4.6(b): Independent Samples t-Test Scores Based on Level of Qualification**

		Levene's Test for Equality of Variances		t-test for Equality of Means			Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
		F	Sig.	T	Df	Sig. (2-tailed)			Lower	Upper
Respondent level of integrated process skills	Equal variances assumed	0.924	0.340	1.277	61	0.206	.36957	.28941	0-20914	0.9482
	Equal variances not assumed			1.301	48.636	0.199	.36957	.28405	0-20136	0.9405

Source: Field data, (2009).

From Table 4.6(a) and 4.6(b) above, a *t* test failed to reveal a statistically reliable difference between the mean scores of diploma teachers ( $M = 3.5$ ,  $s = 1.13228$ ) and that of degree teachers ( $M = 3.13$ ,  $s = 1.05763$ ),  $t(61) = 1.277$ ,  $\rho = .0206$ ,  $\alpha = 0.05$ . With  $\rho > 0.05$ , the null hypothesis ( $H_0$ ) was accepted that, there is no significant difference between teachers' qualification level and the capacity to teach science process skills.

The Morogoro findings however, differ from those by Kasoko-Odyeko (2008), who conducted a study to examine the correlation of teachers' profile (self efficacy, education qualification, and attitude) and students' achievement. The author found a significant relationship between teachers' profile and their capacity to enhance students' academic achievement. It can be inferred that in-service training for Morogoro teachers in the area of science process skills is needed regardless of their level of qualification.

#### **4.4.2: The influence of Years of Working Experience on the Morogoro Teachers' Capacity to Teach Integrated Science Process Skills**

Teacher's working experience influences the formation of attitude which in turn influences their capacity for classroom practice (Kasoko-odeyeko, 2008). This study was also intended to find the association between years of teaching experience and the capacity of Morogoro teachers to teach integrated process skills. Years of teaching experience were self-reported by participant teachers. Based on years of experience, each teacher was assigned to one of five groups as follows; (i) zero to five years (ii) six to ten years (iii) eleven to fifteen years (iv) sixteen to twenty years and (v) twenty one and above years of teaching. Difference in test scores and years of experience were determined using one-way analysis of variance (ANOVA) at 0.05 alpha level. ANOVA was a suitable test for this analysis because it involved testing the means of test scores of more than two groups (the researcher had five groups).

ANOVA tested the null hypothesis (Ho3) which stated that *'there is no statistical significant relationship between years of experience and the capacity to teach integrated science process skills of Morogoro Biology teachers'*. As indicated in Table 4.7 below, no significant differences were found between test scores and years of teaching experience of teachers when the null hypothesis Ho3 was statistically tested. This means that all  $p$  values (significances) in each of the five teacher groups based on years of experience were greater than the alpha value (0.05).

**Table 4.7: Analysis of Variance for Test Score by Years of Teaching Experience**

Years of Experience	Df	F	Sig (p).
0- 3 yrs	6	0.81	0.43
04-09 yrs	6	0.76	0.49
10-15 yrs	6	0.44	0.19
16- 20 yrs	6	0.51	0.67
21 and yrs	6	0.27	0.56

**Source:** Field data (2009).

**Key:** Df = Degree of freedom; F= Value (ratio);  $p$  = Significance

Similar results were reported by Dyer, Myers and Washburn (2004) who also employed ANOVA to determine the influence of years of teaching experience on science teachers' capacity teach scientific process skills. Their study also failed to find a statistical reliable difference between teachers' years of teaching experience and their capacity to teach science process skills. Again, it can be suggested that professional development efforts for science teachers in Morogoro must be strengthen in order to improve their capacity to teach science process skills regardless of their years of teaching experience.

#### **4.4.3: The Influence of Gender on the Capacity of Morogoro Biology Teachers to Teach Science Process Skills**

Hackett and Betz (1989) argues that, gender differences in teaching sciences arises as a function of home, cultural, educational, and mass media influences. Another task of this study was to find out whether there is a significant difference between male and female biology teachers in Morogoro in terms of their knowledge and hence the capacity to teach science process skills. As described earlier, Mungandi's test score defined teachers knowledge of integrated science process skills. Teachers' test scores based on sex were subjected to independent t test. Independent t test was suitable for this kind of analysis

because the test involved testing the mean scores of only two independent groups (males & females). The study involved 35 male and 28 female teachers.

A descriptive cross tabulation of teacher scores based on gender indicated as if Morogoro male teachers were better than female teachers in terms of science process skills. For example, out of 35 male teachers, 11(31%) had satisfactory, 8 (23%) had average, 10 (29%) had unsatisfactory, and 6(17%) had very unsatisfactory knowledge level of scientific skills. On the other hand, out of 28 female teachers in the sample, only 8 (29%) had satisfactory, 6(21%) had average, 8(29%) had unsatisfactory and, 6(21%) had very unsatisfactory knowledge level of science process skills.

However, no statistical significant differences were found between teachers' knowledge and their capacity to teach integrated science process skills based on their sex when the null hypothesis (Ho4) was subjected to independent samples *t* test. The null hypothesis (Ho4) stated that, *'there is no statistical significant relationship between the sex of the teacher and his/her capacity to teach integrated science process skills in Morogoro'*. An analysis of independent samples *t* test based on gender at alpha ( $\alpha$ ) =0.05 produced a  $\rho$  of 0.689 and a *t* value of 0.403, hence, failed to reject the null hypothesis (Ho4). As indicated in Tables 4.8 (a and b) below, a *t* test failed to reveal a statistically significant difference between the mean score of male teachers ( $M = 3.3143$ ,  $s = 1.10537$ ) and that of female teachers ( $M = 3.4286$ ,  $s = 1.13622$ ),  $t(61) = 0.403$ ,  $\rho = 0.689$ ,  $\alpha = 0.05$ . Hence, the null hypothesis, (Ho4) *that there is no statistical significant relationship between the sex of the teacher in Morogoro and his/her capacity to teach integrated science process*

*skills* was accepted at 0.05 alpha level. Tables 4.8 (a and b) below summarize the independent samples t-test of scores based on teachers' sex.

**Table 4.8(a): Group Statistics t Test for Test Scores Based on Gender**

	Sex of the respondent	N	Mean	Std. Deviation	Std. Error Mean
Respondent level of integrated process skills	Male	35	3.3143	1.10537	.18684
	Female	28	3.4286	1.13622	.21473

Source: Field data (2009).

**Table 4.8(b): Independent Samples t-Test for Test Scores based on Gender**

		Levene's Test for Equality of Variances		t-test for Equality of Means			Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
		F	Sig.	T	df	Sig. (2-tailed)			Lower	Upper
Respondent level of integrated process skills	Equal variances assumed	0.56	0.814	-0.403	61	0.689	-0.1143	0.2837	-0.68168	.45311
	Equal variances not assumed			-0.402	57.285	0.690	-0.1143	0.2846	-0.64420	.45563

Source: Field data (2009).

The above findings on Morogoro teachers correspond with the result obtained by Dyer & Myers (2006) who investigated on how male and female teachers integrated laboratory experiences on student content knowledge and science process skills. They found that, sex of the teacher did not contribute significantly to the variance in content knowledge achievement of students they teach. On the other hand, Morogoro teachers' result differs from those by (Riggs, 1991), who conducted a study to examine how gender affects elementary-school teacher attitudes and ability to teach sciences. The author's result using 331 teachers revealed a significant higher score for males than females. In their own findings on the effect of gender on teachers' problem-solving

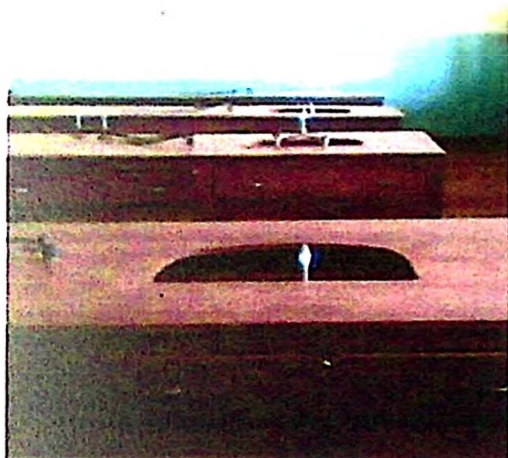
skills, Shaibu & Mari (1997) discovered that female teachers were significantly better than their male counterparts in the ability to solve quantitative problems. Trigwell (1990), Bazler and Simonis (1991), and Baker and Leary (1995) have also been reported to claim that female teachers have more difficulties than male teachers in chemical problem-solving topics.

On the overall, this study was framed conceptually from the reported findings that certain teacher variables notably the level of qualification, years of teaching experience and sometimes gender are important determinants their teaching effectiveness. Anecdotal evidence would suggest male teachers with higher qualification and many years of teaching experience have higher capacity to teach integrated science process skills than teachers who miss these qualities. However, that was not the case with Morogoro Biology teachers. Statistical tests of hypotheses found that, regardless of years of teaching experiences, level of education qualification and gender, Morogoro teachers possesses unsatisfactory ability for teaching science process skills. This means that education level, working experience and gender had no significant influence on the capacity of Morogoro teachers to teach science process skills. It can be suggested that, Morogoro teachers need in-service training and workshops on science process skills regardless of their gender, years of working experience and level of qualification.

#### **4.5: The Effectiveness of Morogoro School Laboratories as a Vital Resource in the Teaching of Integrated Science Process Skills**

For science process skills to be taught effectively, science laboratories must be an integral part of science teaching (Beihle & West, 1999). Laboratory experiences provide students with opportunities to design investigations, make observations, engage in scientific reasoning, manipulate equipment, record and analyze data, and discuss findings (Hofstein & Lunetta, 1982). These are essential activities for students to acquire scientific skills. This study also sought to assess the availability of laboratory equipment in sampled schools as a vital resource in enhancing teachers' ability to teach science process skills. From the conceptual framework (Fig 1.1 p.12), the presence of a well equipped laboratory also defines teachers' capacity to teach practical science skills.

An observation made in school science laboratories using a prepared checklist (see Appendix F) to assess the availability of apparatuses, equipment and reagent found these resources in the sampled schools to be either inadequate or an obsolete state. Almost in all schools, laboratories were ill equipped and with no apparatuses, reagents, water supply, and electricity. For example, the researcher found no special constructed laboratory facility at Kihonda, Sumaye and Uluguru secondary schools, rather one classroom in each of these schools have been modified to serve both as a Biology and Chemistry laboratory. There were very unsatisfactory amount of basic reagents such as iodine solution, Sudan (III) solution, Benedict's solution and chloroform in Sumaye, Kigurunyembe, and Mazimbu secondary schools and which are vital in basic experiments such as food test.



**Figure 4.2(a):** A Modified Laboratory Classroom at Kihonda School      **4.2(b):** A Cupboard for Storage of Chemicals at Kihonda Secondary

The researcher also found several incomplete sets of dissecting kits and microscopes at Kilakala and Forest Hill secondary schools. The ratio stood at one kit to five advanced level students (1:5) at Kilakala secondary schools. The presence of broken apparatuses such as pipettes, burettes, hand lens, thermometers, beakers, test tubes, measuring cylinders, reagent bottles and other delicate vessels was a common phenomenon in all the surveyed schools. Moreover, several reagent bottles containing expired chemicals were also witnessed. There was also insufficient amount of chloroform and commonly used basic acidic chemicals such as Hydrochloric acid (HCl), Sulphuric Acid (H<sub>2</sub>SO<sub>4</sub>) and Nitric Acid (HNO<sub>3</sub>) and basic alkali such as Sodium Hydroxide (NaOH), Sodium Chloride (NaCl), Sodium Thiosulphate (Na<sub>2</sub>S<sub>2</sub>O<sub>3</sub>), Potassium dichromate (KCr<sub>2</sub>O<sub>7</sub>) and Potassium permanganate KMnO<sub>4</sub>. Calcium, Magnesium, Lead, Copper, Zinc, Iron, Aluminum, and Barium related solutions were also insufficient in all the participant schools. However, preserved plant and animal specimens, human system models such as digestive, reproductive, respiratory, and nerve systems were seen almost in all schools.

Teachers in all 10 schools were complaining about lack of chemical reagents and equipment for carrying out practical works. However, the available equipments were kept in unsatisfactory conditions. Schools lacked maintenance programs and thus many apparatuses such as retort stand, bell jars and Bunsen burners were in unserviceable and in useless conditions. In some cases, it was possible that chemicals and equipment were locked up in the laboratory store without teachers being aware of their existence. Laboratory store for the safe keeping of equipment and chemicals was also a problem. There were no laboratory stores at Mazimbu, Kihonda, Sumaye and Uluguru schools. Chemicals and other resources were kept in teacher's offices, although this kind of storage is strictly prohibited by laboratory safety regulations.



**Figure 4.3:** Form II Students on a Food Test Practical at Kigurunyembe Sec School

Moreover, school laboratories were unreasonably equipped, for example at Kihonda secondary school, there was an excessive of expensive round bottomed flasks but few cheap test-tube, burettes and pipettes which are very useful in volumetric and quantitative analysis and many other practical works.

The size of laboratories observed was very small compared to the number of students in most community and government schools. In addition, the ratio of laboratory tables and chairs to students were also very high. For example, Kihonda secondary school has more than 400 form I, about 300 Form II about 250 Form III and about 250 Form IV students but they have only one room serving both as a Biology and Chemistry laboratory. It has to be noted that, biology is a compulsory subject for all ordinary secondary school students in Tanzania hence it is taken also by all Kihonda students. The room has the capacity of carrying only 40 students per one practical session. In short, school laboratories which are necessary resources for investigations and science process skills were found to be under equipped. They were few in numbers, with small carrying capacities compared to the number of students enrolled.

Science process skills are basically investigation skills, hence it was conceptualized that, apart from teachers' knowledge and their sense of self efficacy, the availability of a well equipped science (Biology) laboratory would greatly enhance Morogoro teachers' capacity to teach practical skills (science process skills). A full equipped laboratory is an ideal place where teachers can plan and set experiments for students to practice. It is also an ideal place where students can practice theories taught during classroom sessions. From the above findings on science laboratories in Morogoro schools, can be deduced that the capacity of Morogoro teachers to teach science skills is also hampered by the inadequacy of laboratory equipment and chemicals. For effective teaching of scientific skills, science laboratories should also be stocked with enough reagents and equipment to a level that provides an acceptable student resource ratio.

## **CHAPTER FIVE**

### **SUMMARY, CONCLUSIONS AND RECOMMENDATIONS**

#### **5.1: Introduction**

This chapter presents the summary of findings, conclusions of the study and the recommendations arising from the findings. The study was conducted in order to establish a base level of information on science teachers' knowledge and capacity to teach science process skills as one of the competences advocated in the 2005 Competence Based Curriculum. The chapter is divided into three parts (i) summary of the findings, (ii) conclusion of the study, and (iii) recommendations from the study.

#### **5.1: Summary of Findings**

Science process skills, as in the Competence Based Curriculum of 2005 in Tanzania, have been identified in the science education literature as an effective inquiry method of teaching science. This study aimed at assessing the capacity of biology teachers in Morogoro Municipality to teach integrated science process skills. Specifically the study intended to; (i) determine the knowledge level of integrated science process skills of Biology teachers in Morogoro Municipality schools, (ii) examine Biology teachers' self-efficacy for teaching science process skills, (iii) assess the influence of self-efficacy, level of qualification, work experience, and gender on the capacity of Morogoro Biology teachers to teach integrated process skills and finally, (iv) explore the effectiveness of school Biology laboratories as a vital resource in helping teachers to teach science process skills. The study was conducted in 10 randomly selected secondary schools in

Morogoro Municipality using 63 Biology teachers varying in terms of their sex, years of working experience, and level of qualification (diploma and graduates).

Based on the Mungandi's science process skills test scores, it was found that Biology teachers in Morogoro Municipality had unsatisfactory knowledge and capacity to teach integrated science process skills. The test produced shocking results that the majority of the teachers who are supposed to guide students to acquire scientific skills failed a Form II science process skills test. The average test score was only 12 items out of 30 questions in the test corresponding to 40%. However, Morogoro teachers performed better on questions measuring *data interpretation skills* and performed extremely poor on questions which measured their skills in *designing experiments*. Observation made by the researcher during teaching sessions confirmed these test results by witnessing an ineffective teaching of science process skills by Biology teachers. They mostly used teacher centered methods especially lecturing and in cases where experiments were done, demonstration dominated a large part of the lesson denying students the opportunities to practice the lesson and acquire science process skills.

Apart from teachers' knowledge, it was also conceived that, successful implementation of any education reform on students depends to a large part on teachers' personal beliefs regarding their ability to teach and produce positive outcomes (self efficacy). In this study, Science Teaching Belief Instrument (STEBI) by Riggs and Enochs (1990) was employed to measure teachers' self efficacy for teaching science process skills. The instrument found out that Biology teachers in Morogoro did not have a strong self

efficacy towards the teaching of science process skills. The findings showed that, out of 125 maximum possible scores with STEBI, Morogoro teachers had a mean of 69 points, (an average self efficacy level). This means that these teachers have neither high nor low expectations that their science process teaching would influence students learning. The findings suggest a need to refocus on science teachers' professional development so as to produce science teachers who are both content knowledgeable and with a strong sense of self efficacy towards science teaching.

Due to social experiences of women in the society, anecdotal evidence would suggest male teachers to have higher levels of achievement in science-related disciplines than females. However, the findings from Morogoro biology teachers in this study did not support that assertion. Based on the science process skills test scores of the 28 females and 35 males in the study, no statistical significant differences were found to exist in terms of their capacity to teach integrated science process skills.

A science teacher who doesn't have strong academic and professional qualifications would undoubtedly have a low capacity for teaching science process skills. In this study, 23(37%) of participant teachers had Bachelors degree and 40(63%) had Diplomas in education. Again, no significant differences were found to exist between diploma and degree holder teachers in terms of their test scores. Although job experience is a strong determinant for one's job performance, an analysis of variance (ANOVA) in this study failed to find a statistical significant difference between years of experience and the capacity of Morogoro teachers to teach science process skills. On the other hand, a

Pearson correlation analysis found a weak (low) positive association between teachers' self efficacy level and his/her knowledge level of science process skills at 0.05 alpha. The study found that, Morogoro teachers who performed better in the science skills test were those who also scored high in the self efficacy measuring instrument (STEBI).

Finally, the current competence based syllabus recommends the use of practical based laboratory methods in teaching sciences. However, the study found no meaningful organized laboratory activities that would engage students in any mental thinking activities. Even when practical sessions were organized, contents were often overwhelming the process of investigation, thus preventing students from acquiring science process skills. Science laboratories as a vital resource for enhancing the acquisition of science process skills were also found to be in an obsolete state. They were ill equipped and with no modern apparatuses, reagents, supply of water and electricity for heating purpose.

## **5.2: Conclusion of the study**

Based on the findings above, the study concludes that;

(i) Irrespective of years of teaching experience, qualification level, or gender, Morogoro Biology teachers have unsatisfactory knowledge level of science process skills. Low knowledge level makes these teachers to have low propensity, competence, and skills for teaching science process skills as advocated by the newly introduced Competence Based Curriculum. Hence, Morogoro teachers do not possess foundation knowledge of scientific skills espoused to be essential in effective science instruction.

(ii) Biology teachers in Morogoro Municipality secondary schools have a weak self efficacy level with regard to the teaching of integrated science process skills .This means that, (a) they do not have confidence that their teaching could result into students learning of science process skills, (b) they do not believe their own ability to teach science process skills as required by the new curriculum, and (c) perceive themselves as incapable of effectively teaching science process skills to produce expected outcomes.

(iii) Years of teaching experience, level of education qualification and gender as variables that might determine the teaching capacity of teachers were found to have no influence on the capacity of Morogoro teachers to teach integrated science process skills. Regardless of these variables, Morogoro teachers were generally found to have low knowledge of science process skills. This calls for an urgent need for corrective measures if the teaching of science process skills advocated in the new curriculum is to be effective.

(iv) Poor outdated laboratory resources such as equipment, apparatuses, and reagents; lack of references that emphasize and guide the teaching of science process skills; and overcrowding of students in the classrooms were also found to reduce the capacity of Morogoro Biology teachers for teaching science process skills effectively. In this study, it is argued that if these factors would not be taken seriously, then the implementation of Competence Based Curriculum and hence science process skills would be unfeasible.

**5.3: Based on the Findings, the Following Recommendations are made;**

**A: Recommendations for Teacher Training Institutions on Preparing Pre-service/Prospective Teachers with High Capacity to Teach Science Process Skills**

(i) Pre-service science teacher preparation programs are in a unique position to enhance the teaching capacity of prospective science teachers. Hence, effective science instruction methods in teacher training institutions of all levels should be infused into teaching methods courses as a way to reinforce the scientific rigor of prospective science teachers. Moreover, method-based and hands-on investigative activities should be a significant component of pre-service teacher education. This will help future science teachers to realize that, they have the potential capabilities, ability and capacity to teach their students effectively in the area of science process skills.

(ii) Improving science teachers' competence in laboratory experiences (activities) is of critical importance if integrated science process skills are to be well taught. Teacher training institutions which are charged with the responsibility of training science teachers at all education levels in Tanzania are increasingly producing teachers without requisite laboratory practical experiences. Thus, ongoing science teacher education and professional development programs should ensure that, prospective science teachers have practical experiences that familiarize them with inquiry-based laboratory skills needed to facilitate teaching of science process skills. This requires major and fundamental changes in pre-service science teacher education contents, including providing a range of effective laboratory experiences.

(iii) This study found a positive statistical association between teachers' self efficacy level and his/her knowledge of science process skills. Hence, teacher training institutions preparing science teachers should investigate on how to incorporate more science based courses in the instruction in order to produce science teachers who are both content knowledgeable, process competent and with a strong sense of self efficacy.

**B: Specific Recommendations for the Ministry of Education and Vocational Training Regarding the Findings of the Study;**

The following are some specific recommendations to the Ministry of Education and Vocational Training from this study related to the implementation of competence based curriculum and hence science process skills.

(i) Teachers orientation on the requirements of the Competence Based Curriculum and hence science process skills should be a matter of urgency. It was observed from this study that, many teachers have not yet received any kind of training on the competency-based approaches. Hence, the Ministry of Education and Vocational Training should organize and coordinate demand driven in-service training for teachers about the requirements of the new curriculum. During data collection in this study, participant teachers seem unaware of what exactly is Competence Based Curriculum, some even are unaware if it exists and hence they treated it in a similar manner to the phrased out one.

(ii) The Ministry of Education and Vocational Training as a standard regulatory unit should mount workshops for in-service science teachers to up-date them on the teaching of science process skills. In addition, a system of ongoing, school-based in-service

teacher training is needed to allow teachers to continually develop and upgrade their pedagogical skills and content knowledge.

(iii) The Tanzania Institute of Education (TIE) as a curriculum development unit should (a) produce new science textbooks in conjunction with new syllabuses and science process skills, and (b) develop a set of laboratory activities to guide secondary school science teachers in teaching practical science process skills.

(iv) The Ministry of Education and Vocational Training should play a critical role in supporting secondary schools to successfully integrate laboratory experiences with science instruction and enhance science process skills acquisition to students. This can be done by providing schools with adequate and improved laboratory equipment, reagents, apparatuses and supporting staff like laboratory technicians.

### **C: Specific Recommendations for Biology and Other Science Teachers in General**

(i) Teaching science process skills is a challenging experience but a rewarding one. Science teachers need to capitalize on opportunities of classroom activities. While this is not an easy solution, it remains the best alternative available at this time where there is a serious shortage of textbooks emphasizing and guiding teaching of science process skills. Teachers should give as much authentic assignments to students as possible. This will help students to develop scientific thinking and skills.

(ii) Leading laboratory activities to students is a demanding task requiring teachers to have sufficient knowledge of both science content and science processes. Hence, Biology teachers in Morogoro need to do practices on such activities as designing of investigations, recording and analyzing data in a lifelong learning spirit. This will in turn improve their skills and capacity to teach science process skills effectively.

#### **D: Recommendations on Areas for Further Research**

Generalization of these findings is limited because of the nature of the study and the sample size used. However, the findings from this study present several research opportunities. These research opportunities are in the following areas;

(i) This study was confined to only 10 secondary schools in Morogoro Municipality using 63 Biology teachers. However, other research works involving bigger samples countrywide are needed to understand the phenomena under study and to attempt generalization through replication of findings.

(ii) Science process skills seem a new research topic in Tanzania education system. This current study focused on assessing Biology teachers' knowledge and competence in the area of integrated science process skills. However, several studies should also be conducted to assess students' knowledge level of science process skills at different education levels (primary, secondary, and tertiary). These studies will provide directions as to whether pupils and students at all education levels are acquiring science process skills as campaigned by the 2005 Competence Based Curriculum.

(iii) This study employed a test of integrated science process skills developed and published by Mungandi (2005) in South Africa to measure the knowledge level of Morogoro Biology teachers in the area of science process skills. A review of literature failed to obtain a study which developed and validated a test of science process skills in Tanzania. Hence, studies to develop and publish science process skills tests for Tanzania students and teachers using Tanzania syllabuses and in the context of Tanzania should be conducted. The local instruments would be more suitable in assessing the knowledge level of science process skills of local teachers and students than the internationally imported ones. Imported tests rarely take into consideration the local reality of education environment and the curriculum of another country.

(iv) Laboratory experiences as a part of science curricula in Tanzania have been taken for granted for many decades, they have rarely been carefully examined. What do they contribute to science learning? What can they contribute to science learning? What is the status of laboratories in schools as a context for learning science? What is effective laboratory teaching? How should student learning in laboratory experiences be assessed? Do all students have access to laboratory experiences? What changes need to be made to improve laboratory experiences for school students?. Hence, further researches are needed to inform the ongoing professional development efforts that can effectively support improvements in teachers' laboratory skills and hence science process skills.

## REFERENCES

- Arena, P. (1996). The role of relevance in the acquisition of science process skills. *Australian Science Teachers Journal*, 42 (4), 24-38.
- Ary, D., Jacobs, L., & Razavieh, A. (1990). *Introduction to research in education*. Fort Worth: Harcourt Brace College.
- Ashton, P., & Webb, R. (1984). Teacher efficacy: A motivational paradigm for effective teacher education. *Journal of Teacher Education*, 35 (5), 28-32.
- Ashton, P., Webb, R., & Doda, C. (1983). *A study of teachers' sense of self-efficacy*. Gainesville: University of Florida.
- Ateş, S. (2004). The effects of inquiry-based instruction on the development of integrated science process skills in trainee primary School teachers with different piagetian developmental levels. *Journal of Research in Science Teaching* 24, (3) 275-290.
- Baker, D., & Leary, R. (1995). Letting girls speak out about science. *Journal of Research in Science Teaching*, 32(1), 3-27.
- Bandura, A. (1977). Self-efficacy: Towards a unifying theory of behavioral change. *Journal of Psychological Review*, 84 (3), 191-125.
- Bazler, J. A., & Simonis, D. A. (1991). Are high school chemistry textbooks gender fair?. *Journal of Research in Science Teaching*, 28(4), 353-362.
- Berliner, D. C. (1984). *The half-full glass: A review of research on teaching*. In P. L. Hosford(Ed.), *Using what we know about teaching* (pp. 51-77). Alexandria, VA: Association for Supervision and Curriculum Development.
- Biehle, J & West, S. (1999) *A guide to school science facilities*. Arlington, VA: NSTA Press retrieved from <http://www.nsta.org/> on 15<sup>th</sup> Dec 2009.
- Borg, W., & Gall, M. (1989). *Educational research: An introduction*. New York: Longman.
- Bredderman, T. (1983). Effects of activity based elementary science on student outcomes: A qualitative synthesis. *Journal of the Review of Educational Research*, 53 (4), 499-518.

- Brophy, J., & Evertson, C. (1981). *Student characteristics and teaching*. New York: Longman.
- Brotheton, P. N., & Preece, P.F.(1995). Science process skills: Their nature and interrelationships. *Journal of Research in Science & Technological Education*, 13 (1), 5-12.
- Burns, J. C., Okey, J. R., & Wise K. C. (1985). Development of an integrated process skills test: TIPS II. *Journal of Research in Science Teaching*, 22 (2), 169-177.
- Bybee, W. R. (1993). *Reforming science education: Social perspectives & personal reflections*: New York. Teachers College Press.
- Chiappetta, E. L., & Koballa, T. R. (2002). *Science instruction in the middle and secondary schools* (5th ed.) Upper Saddle River: Merrill Prentice Hall.
- Chonjo, P. N., O-saki, K. M., Possi, M., & Mrutu, M. (1995). *Science education in secondary schools. Situational analysis*. Dar es salaam: Ministry of Education and Culture.
- Dietz, M. A., & George, K. D. (1970). A test to measure problem solving skills in science of children in grades one, two and three. *Journal of Research in Science Education*, 7 (4), 341 – 351.
- Dillashaw, F. G., & Okey, J. R. (1980). Test of integrated process skills for secondary science students. *Journal of Science Education*, 64(5), 601-608.
- Downing, J., Filer, J., & Chamberlain, R.(1997). Science process skills and attitudes of preservice elementary teachers. Retrieved on 14<sup>th</sup> November 2009 from [http://www.eric.ed.gov/ERICDocs/data/ericdocs2sql/content\\_pdf](http://www.eric.ed.gov/ERICDocs/data/ericdocs2sql/content_pdf).
- Dyer, J. E., Myers, B. E., & Washburn, S. G. (2004). Assessing agriculture teachers' capacity for teaching science integrated process skills. *Journal of Southern Agricultural Education Research*, 54(1), 74-84.
- Dyer, J., & Myers, B. (2006). Effects of investigative laboratory instruction on content knowledge and science process skill achievement across learning styles. *Journal of Agricultural Education*, 47(4), 52-63.
- Furtak, M. (2006). The problem with answers: An exploration of guided scientific inquiry teaching. *Journal of Science Education*, 90 (3), 453-467.
- Gay, L., & Airasian, P. (2000). *Educational Research: Competencies for Analysis and Application*. Upper Saddle River: Merrill Publishing Company.

- Gibson, S., & Dembo, M. (1984). Teacher efficacy: A construct validation. *Journal of Educational Psychology*, 76 (4), 569-582.
- Good, T., & Brophy, J. (2000). *Looking in classrooms*. New York: Longman.
- Hackett, G., & Betz, N. (1989). An exploration of the mathematics self-efficacy/mathematics performance correspondence. *Journal for Research in Mathematics Education*, 20(2), 261-273.
- Hackling, M., & Garnett, P. (1991). Primary and Secondary School Students Attainment of Science Investigation Skills. *Journal of Research in Science Education*, 21 (1), 161-170.
- Hamilton, R., & Swortzel, K. (2007). Assessing Mississippi AEST teachers' capacity for teaching science integrated process skills. *Journal of Southern Agricultural Education Research* 57(1), 2007retrived from <http://pubs.aged.tamu.edu/jsaer/Vol57Whole.pdf> on 23rd July 2009.
- Harlen, W. (2000). *The teaching of science in primary schools*. (3<sup>rd</sup> Ed). London: David Fulton Publishers Ltd.
- Hasse, E. (2003). *Reform in biology education: Teachers' implementation of a new biology curriculum*. North Carolina: Unpublished dissertation submitted to the Graduate Faculty, North Carolina State University USA.
- Hofstein, A., & Lunetta, V. (1982). The role of the laboratory in science teaching: Neglected aspects of research. *Journal of Review of Educational Research*, 52 (2), 201-217.
- Ishumi, A., & Nyirenda, D. (2004). *Philosophy of education. An introduction to concepts, principles and practice*. Dar es Salaam: DUP Ltd
- Jaus, H.H. (1975). The effects of integrated science process skill instruction on changing teacher achievement and planning practices. *Journal of Research in Science Teaching*, 12 (4), 439-447.
- Kahle, J., Meece, J., & Scantlebury, K. (2000). Urban African-American middle school science students: Does standards-based teaching make a difference?. *Journal of Research in Science Teaching*, 37 (9), 1019 – 1041.
- Kasoko -Oyedeko, G. (2008). Correlate of teachers' profiles and pupils' academic achievement. *Journal of the Social Sciences*, 3(1), 6-11.

- Keil, C., Haney, J., & Zoffel, J. (2009). Improvements in student achievement and science process skills using environmental health science problem-based learning curricula. *Electronic Journal of Science Education*, 13 (1), 18-31. Retrieved on 14<sup>th</sup> Dec, 2009 from <http://ejse.southwestern.edu>.
- Kelly, G.A. (1991). *The psychology of personal constructs: A theory of personality*. London: Routledge.
- Koballa, T., & Crawley, F. (1985). The influence of attitude on science teaching and learning. *Journal of School Science and Mathematics*, 85 (3), 222-232.
- McMillan, J., & Schumacher, S. (1997). *Research in Education: A Conceptual Introduction*. New York: Harper Collins.
- Mechling, K., Bires, N., Kepler, L., Oliver, D., and Smith, B. (1985). A recommended science competency continuum . Retrieved from <http://www.maisk6scienceinquiry.org/> on 18<sup>th</sup> August 2009
- Molitor, L.L., & George, K.D. (1976). Development of a test of science process skills. *Journal of Research in Science Teaching*, 13(5), 405 – 412.
- Morogoro Municipal Council. (2009). *Morogoro municipal council: The profile 2009*. Morogoro: Unpublished document
- Mungandi, K. M. (2005). *Development and validation of a test of integrated science process skills for the further education and training learners*. Unpublished dissertation report: University of Pretoria, South Africa
- Mushi, P.D. (1992). *Technology: The perception of teachers and students and its place in the secondary school science curriculum*. Unpublished M.Ed.Science Dissertation. University of Leeds, United Kingdom.
- Nugent, G and Kunz, G. (2008). The impact of a field-based, inquiry-focused model of instruction on preservice teachers' science learning and attitudes. *The Electronic Journal of Science Education*, 12 (2), 1-18 retrieved from <http://ejse.southwestern.edu> on 15<sup>th</sup> October 2009.
- Ojo, E., & Sola, A. (2007). Effects of project, inquiry and lecture-demonstration teaching methods on senior secondary students' achievement in separation of mixtures practical test. *Journal of Educational and Review*, 2 (6), 124-132.
- Olson, S., & Loucks-Horsley, S. (Eds.) (2000). *Inquiry and the national science education standards: A guide for teaching and learning*. Washington, DC: National Research Council.

- Onwu, G.O., & Mozube, B. (1992). Development and validation of science process skills test for secondary science students. *Journal of Science Teacher Association of Nigeria*, 27(2), 37-43.
- Osaki, K. M., & Njabili, A. (2004). *Secondary education sector analysis*. Research Report submitted to Ministry of Science, Technology and Higher education & World Bank. Dar es Salaam: World Bank.
- Osaki, K.M. (2007). Science and mathematics teacher preparation in Tanzania: Lessons from teacher improvement projects in Tanzania since 1965-2006. *Nue Journal of International Educational Cooperation*, 2 (1), 51-64.
- Osaki, K.M. (2000). *The science education in secondary school. Internal project evaluation*. Dar es Salaam: Ministry of Education and Culture.
- Ostlund, K. (1998). What research says about science process skills. *Journal of Science Education*, 2 (4), ISSN 1087-3430. Retrieved from <http://unr.edu/homepage/jcannon/ejse/ejsev2n4> on 15th June 2009.
- Padilla, M. J. (1990). *The science process skills. Research matter – to the science teacher*. (ERIC Document Reproduction Service No. ED266961).
- Padilla, M. J., Okey, J.R., & Dillashaw, F. G. (1983). The relationship between science process skill and formal thinking abilities. *Journal of Research in Science Teaching*, 20 (3), 239-246.
- Padilla, J. M., McKenzie, L. D., & Shaw, L. E. (1986). An Examination of line graphing ability of students in grades seven through twelve. *Journal of Scholl Science and Mathematics*, 86 (1), 20-26.
- Rambuda, A., & Fraser, W. (2004). Perceptions of teachers of the application of science process skills in the teaching of Geography in secondary schools in the Free State province. *South African Journal of Education*, 24(1), 10 – 17.
- Rezba, R.J., Sparague, C.S., Fiel, R.L., Funk, H.J., Okey, J.R., & Jaus, H.H. (1995). *Learning and assessing science processes*. Dubuque: Kendall/Hunt Publishing Company
- Riggs, I., & Enochs, L. (1990). Towards the development of an elementary teacher's science teaching efficacy belief instrument. *Journal of Science Education*, 74(2), 625-637.

- Riggs, I. (1991). Gender Differences in Elementary Science Teacher Self-Efficacy. ERIC residue No ED340705 retrieved on 14<sup>th</sup> October 2009 from <http://www.eric.ed.gov/ERICWebPortal/recordDetail?accno=ED340705>.
- Ross, J.A. (1998). The antecedents and consequences of teacher efficacy. *Journal of Advances in Research on Teaching*, 7 (02), 49–73.
- Ross, K. (2005) (Ed). *Educational research: some basic concepts and terminology*. Paris: UNESCO International Institute for Educational Planning, retrieved from <http://www.unesco.org/iiep> on 10<sup>th</sup> June 2009.
- Roth, W. M., & Roychounhury, A. (1993). Development of science process skills in authentic contexts. *Journal of Research in Science Teaching*, 30 (2), 127-152.
- Rowe, J., & Foulds, W. (1996). The enhancement of science process skills in teacher education students. *Australian Journal of Teacher Education*, 21(1), 16-22.
- Scharmann, L. C. (1989). Development of science process skill instruction. *Journal of Research in Science Teaching*, 26 (8), 715-726.
- Sanchez, Z., & Betkouski, M. (1986). *A study of factors affecting student performance in community college general chemistry courses*. San Francisco: National Association for Research in Science.
- Sefu, M & Siwale, E. (1977). *The development of primary education in Tanzania*. Ontario: Brock University
- Shaibu, A.M., & Mari, J.S. (1997). Gender-related difference in the understanding of science process skills amongst secondary school students in some Nigerian schools. *Journal of Science Teachers Association of Nigeria*, 32(2), 21-27.
- Shann, M.H. (1977). Evaluation of interdisciplinary problem solving curriculum in elementary science and mathematics. *Journal of Science Education*, 61 (4), 491-502.
- Shemwelekwa, R. (2008). *The effectiveness of adoption of competence based education for teaching and learning mathematics in secondary schools*. Dar es Salaam. Unpublished Master Dissertation, University of Dar es Salaam, Tanzania.
- Simon, M.S., & Zimmerman, J.M. (1990). Science and writing. *Journal of Science and Children*, 18 (3), 7-18.
- Tamir, P. (1989). Training teachers to teach effectively in the laboratory. *Journal of Science Education*, 73 (1), 59-69.

- The Biology Panel. (1967). *The Tanzania biology course experimental version- A synopsis*. Dar es Salaam: Institute of Education
- Tilya, F., & Mafumiko, F. (2008). *Compatibility of teaching methods and competence-based curriculum in Tanzania*. Dar es Salaam: Unpublished Paper
- Trigwell, K. (1990). The effects of an alternative science degree programme on the participation of women in the physical sciences. *International Journal of Science Education*, 12(1), 25-40.
- United Republic of Tanzania. (2008). *The development of education national report of the United Republic of Tanzania*. Dar es Salaam: Ministry of Education and Vocational Training.
- United Republic of Tanzania. (2008). *National 2004-2008 basic educational statistics in Tanzania*. Dar es Salaam: Ministry of Education and Vocational Training.
- United Republic of Tanzania. (2006). Education Sector Development Programme (ESDP): *Primary Education Development Programme II (2007-2011)*. Dar es Salaam: Ministry of Education and Vocational Training.
- United Republic of Tanzania. (2005). *Ordinary level biology syllabus*. Dar es Salaam: Tanzania Institute of Education.
- Wetzel, D. (2008). *Problem solving and science process skills: Science investigation skills* retrieved from <http://www.suite101.com/> on 10<sup>th</sup> July 2009.
- Woolfolk, A., & Hoy, W. (1990). Prospective teachers' sense of efficacy and beliefs about control. *Journal of Educational Psychology*, 82 (2), 81-91.
- Woolnough, B., & Allsop, T. (1985). *Practical work in science*. Cambridge: Cambridge University Press.
- Yager, R., & Lutz, M. (1994). Integrated science: The importance of "how" verses "what." *Journal of School Science and Mathematics*, 94 (1), 338-346.
- Yamane, T. (1967). *Statistics: An introductory analysis*. New York: Harper and Row.
- Zeitler, W.R. (1981). The influence of the type of practice in acquiring process skills. *Journal of Research in Science Teaching*, 18 (3), 188-197

## **APPENDICES**

### **Appendix A: Teachers Demographic Characteristics**

#### **1.0: Respondents school name .....and its nature**

- (a) Community school..... (1)
- (b) Private school.....(2)
- (c) Government school... ..(3)
- (d) Government special school.....(4)
- (e) Christian seminary.....(5)
- (d) Islamic seminary.....(6)

#### **2.0: Sex of the respondent**

- (a) Male.....(1)
- (b) Female.....(2)

#### **3.0: Level of qualification of the respondent**

- (a) Diploma of Level.....(1)
- (b) Degree Level.....(2)

#### **4.0: Teaching experience of the respondent**

- (a) 0 – 5 years.....(1)
- (b) 6 – 10 years.....(2)
- (c) 11-15 years.....(3)
- (d) 16-20 years.....(4)
- (e) More than 20 years.....(5)

## **Appendix B: Test of Integrated Science Process Skills by Mungandi (2005)**

**DURATION: 50 minutes**

**INSTRUCTIONS**

**VERY IMPORTANT**

(i) **DO NOT WRITE ANYTHING ON THE QUESTION PAPER.**

(ii) **ANSWER ALL THE QUESTIONS ON THE ANSWER GRID PROVIDED, BY PUTTING A CROSS [X] ON THE LETTER OF YOUR CHOICE.**

(iii) **PLEASE DO NOT GIVE MORE THAN ONE ANSWER PER QUESTION.**

**1.0: A learner wanted to know whether an increase in the amount of vitamins given to children results in increased growth.**

**How can the learner measure how fast the children will grow?**

- (A) **By counting the number of words the children can say at a given age.**
- (B) **By weighing the amount of vitamins given to the children.**
- (C) **By measuring the movements of the children.**
- (D) **By weighing the children every week.**

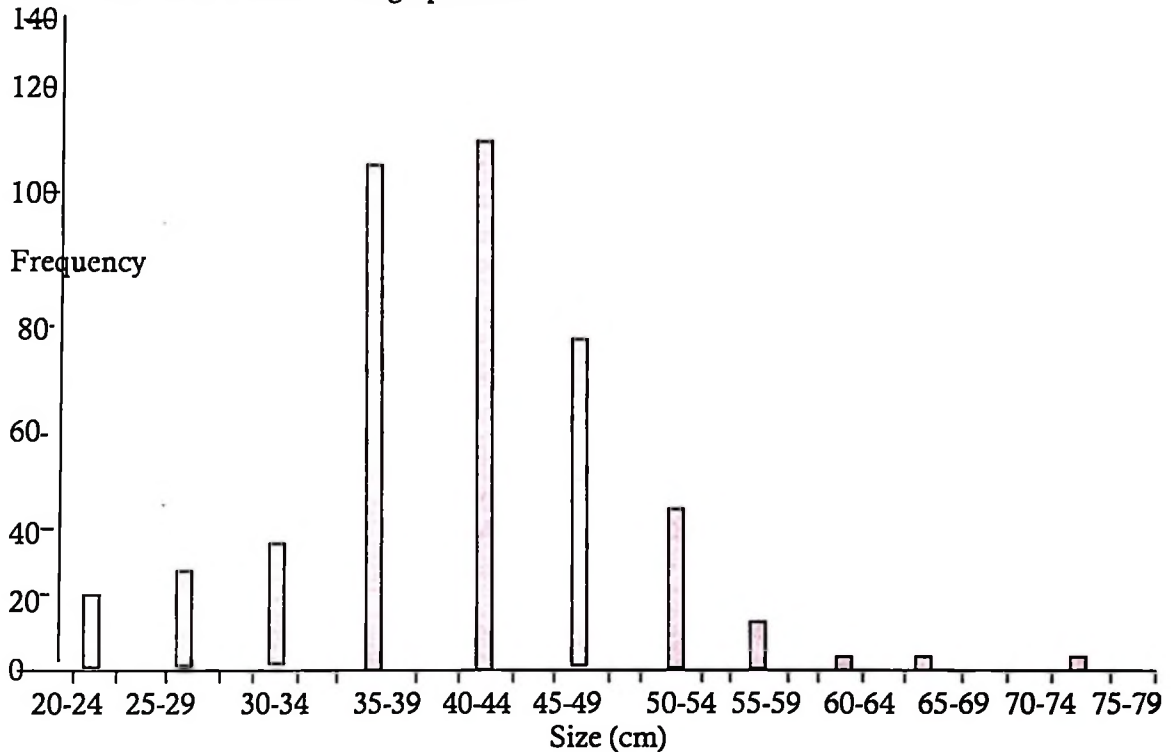
**2.0: Mariam wanted to know which of the three types of soil (clay, sandy and loamy), would be best for growing beans. She planted bean seedlings in three pots of the same size, but having different soil types. The pots were placed near a sunny window after pouring the same amount of water in them. The bean plants were examined at the end of ten days. Differences in their growth were recorded. Which factor do you think made a difference in the growth rates of the bean seedlings?**

- (A) **The amount of sunlight available.**
- (B) **The type of soil used.**
- (C) **The temperature of the surroundings.**
- (D) **The amount of chlorophyll present.**

**3.0: A lady grows roses as a hobby. She has six red rose plants and six white rose plants. A friend told her that rose plants produce more flowers when they receive morning sunlight. She reasoned that when rose plants receive morning sunlight instead of afternoon sunlight, they produce more flowers. Which plan should she choose to test her friend's idea?**

- (A) **Set all her rose plants in the morning sun. Count the number of roses produced by each plant. Do this for a period of four months. Then find the average number of roses produced by each kind of rose plant.**
- (B) **Set all her rose plants in the morning sunlight for four months. Count the number of flowers produced during this time. Then set all the rose plants in the afternoon sunlight for four months. Count the number of flowers produced during this time.**
- (C) **Set three white rose plants in the morning sunlight and the other three white rose plants in the afternoon sun. Count the number of flowers produced by each white rose plant for four months.**
- (D) **Set three red and three white rose plants in the morning sunlight, and three red and three white rose plants in the afternoon sunlight. Count the number of rose flowers produced by each rose plant for four months.**

Questions 4 and 5 refer to the graph below



The fishery department wants to know the average size of Tiger fish in Hale dam, so that they could prevent over-fishing. They carry out an investigation, and the results of the investigation are presented in the graph below.

4.0: What is the most common size range of Tiger fish found in Hale dam

- (A) 75 – 79 cm.
- (B) 40 – 44 cm.
- (C) 20 – 79 cm.
- (D) 45 – 49 cm.

5.0: In which size range would you find the longest Tiger fish?

- (A) 75 – 79 cm.
- (B) 40 – 44 cm.
- (C) 20 – 79 cm.
- (D) 35 – 49 cm.

6.0: Sikiri wants to know what determines the time it takes for water to boil. He pours the same amount of water into four containers of different sizes, made of clay, steel, aluminum and copper. He applies the same amount of heat to the containers and measures the time it takes the water in each container to boil. Which one of the following could affect the time it takes for water to boil in this investigation?

- (A) The shape of the container and the amount water used.
- (B) The amount of water in the container and the amount of heat used.
- (C) The size and type of the container used.
- (D) The type of container and the amount of heat used.

7.0: The superintendent is concerned about the accidents in schools. He makes the hypothesis that safety advertising will reduce schools accidents. He decides test the hypothesis in four middle schools. Each school will use a different number of safety posters to see if the number of accidents are reduced. Each school nurse will keep a record of students that come to the office because of an accident .How is safety advertising measured in this study?

- (A) Number of accidents reported to the nurse
- (B) Number of middle schools involved
- (C) Number of safely posters in each school
- (D) Number of accidents in the school

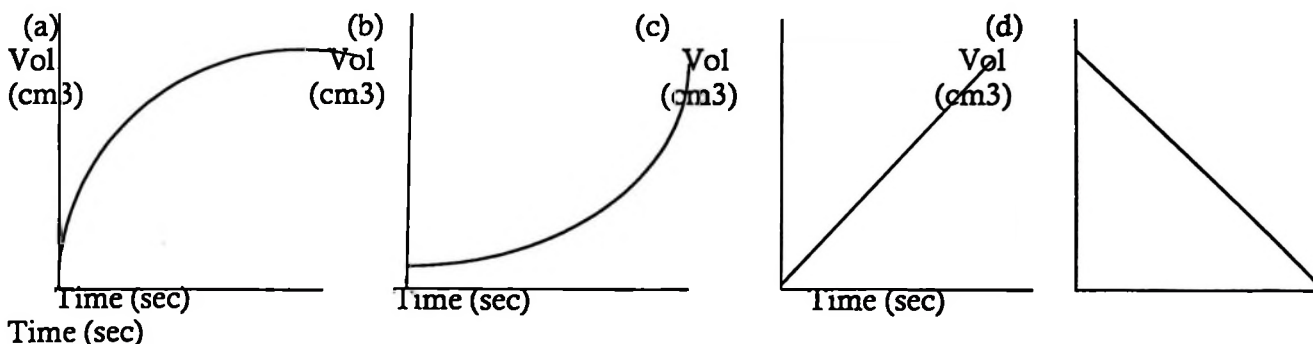
8.0: A farmer wants to increase the amount of maize he produces. He decides to study the factors that affect the amount of maize produced. Which of the following ideas could he test?

- (A) The greater the amount of maize produced, the greater the profit for the year.
- (B) The greater the amount of fertilizer used, the more the amount of maize produced.
- (C) The greater the amount of rainfall, the more effective the fertilizer used will be.
- (D)The greater the amount of maize produced, the cheaper the cost of maize.

9.0: Saidi carried out an investigation in which she reacted magnesium with dilute hydrochloric acid. She recorded the volume of the hydrogen produced from the reaction, every second. The results are shown below.

Time(seconds)	0	1	2	3	4	5	6	7
Volume (cm <sup>3</sup> )	0	14	23	31	38	40	40	40

Table 1.1. Shows the volume of hydrogen produced per second. Which of the following graphs show these results correctly?



10. A science teacher wanted to find out the effect of exercise on pulse rate. She asked each of three groups of learners to do some push-ups over a given period of time, and then measure their pulse rates: one group did the push-ups for one minute; the second group for two minutes; the third group for three minutes and then a fourth group did not do any push-ups at all.

How is pulse rate measured in this investigation?

- (A) By counting the number of push-ups in one minute.
- (B) By counting the number of pulses in one minute.

- (C) By counting the number of push-ups done by each group.  
 (D) By counting the number of pulses per group.

11: Some chickens lay an egg almost every day .Other chickens produce few eggs. A study is planned to examine factors that might affect the number of eggs produced by chickens. Which of the following is NOT a suitable hypothesis for the study?

- (A) More eggs are produced by chickens that receive more hours of light  
 (B) The more eggs produced by chickens the more weight they loss  
 (C) The larger the cage for chickens the more eggs they will produce  
 (D) The more protein there is in the feed the more eggs produced

12: Doctors noticed that if certain bacteria were injected into a mouse, it developed certain symptoms and died. When the cells of the mouse were examined under the microscope, it was seen that the bacteria did not spread through the body of the mouse, but remained at the area of infection. It was therefore thought that the death is not caused by the bacteria but by certain toxic chemicals produced by them. Which of the statements below provides a possible explanation for the cause of death of the mouse?

- (A) The mouse was killed by the cells that were removed from it to be examined under the microscope.  
 (B) Bacteria did not spread through the body of the mouse but remained at the site of infection.  
 (C) The toxic chemical produced by the bacteria killed the mouse.  
 (D) The mouse was killed by developing certain symptoms.

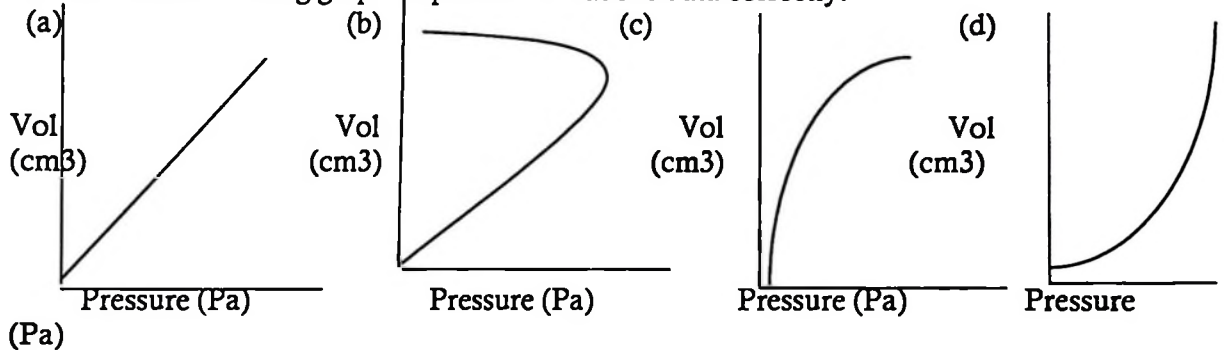
13: Juma thinks that the more the air pressure in a soccer ball, the further it moves when kicked. To investigate this idea, he uses several soccer balls and an air pump with a pressure gauge. How should Juma test his idea?

- (A) Kick the soccer balls with different amounts of force from the same point.  
 (B) Kick the soccer balls having the same air pressure Kick the soccer balls having different air pressure from the same point.  
 (C) Kick the soccer balls having the same air pressure at different angles on the ground.  
 (D) Kick the soccer balls having different air pressure from different points on the ground.

14: A science class wanted to investigate the effect of pressure on volume, using balloons. They performed an experiment in which they changed the pressure on a balloon and measured its volume. The results of the experiment are given in the table below.

Pressure on balloon (Pa)	Volume of the balloon (cm <sup>3</sup> )
0.35	980
0.70	400
1.03	320
1.40	220
1.72	180

Table 1.3. Shows the relationship between the pressure on a balloon and its volume. Which of the following graphs represents the above data correctly?



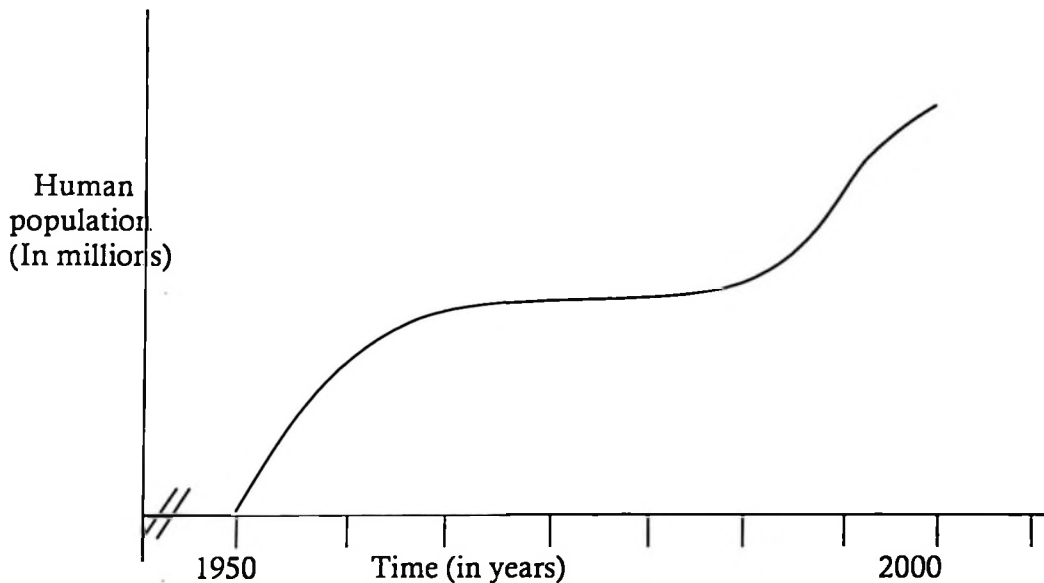
15: A motorist wants to find out if a car uses more fuel when it is driven at high speed. What is the best way of doing this investigation?

- (A) Ask several drivers how much fuel they use in one hour, when they drive fast, and find the average amount of fuel used per hour.
- (B) Use his own car to drive several times at different speeds, and he should record the amount of fuel used each time.
- (C) He must drive his car at high speed, for a week, and then drive it at low speed for another week, and record the amount of fuel used in each case.
- (D) Ask several drivers to drive different cars covering the same distance many times, at different speeds, and record the amount of fuel used for each trip.

16: A learner observed that anthills (termite moulds) in a certain nature reserve tend to lean towards the west, instead of being straight. In this area, the wind blows towards the direction in which the anthills lean. Which of the following statements can be tested to determine what causes the anthills to lean towards the west, in this nature reserve?

- (A) Anthills are made by termites.
- (B) Anthills lean in the direction in which the wind blows.
- (C) Anthills lean towards the west to avoid the sun and the rain.
- (D) The distribution of anthills depends on the direction of the wind.

17: The graph below shows the changes in human population from the year 1950 to 2000.



Which of the following statements best describes the graph?

- (A) The human population increases as the number of years increase.
- (B) The human population first increases, then it reduces and increases again as the number of years increase.
- (C) The human population first increases, then it remains the same and increases again as the number of years increase.
- (D) The human population first increases then it remains the same as the number of years increase.

18: Sofia wants to find out the amount of water contained in meat, cucumber, cabbage and maize grains. She finely chopped each of the foods and carefully measured 10 grams of each. She then put each food in a dish and left all the dishes in an oven set at 100°C. After every 30 minutes interval, she measured the mass of each food, until the mass of the food did not change in two consecutive measurements. She then determined the amount of water contained in each of the foods.

How is the amount of water contained in each food measured in this experiment?

- (A) By heating the samples at a temperature of 100°C and evaporating the water.
- (B) By measuring the mass of the foods every 30 minutes and determining the final mass.
- (C) By finely chopping each food and measuring 10 grams of it, at the beginning of the investigation.
- (D) By finding the difference between the original and the final mass of each food.

19: In a radio advertisement, it is claimed that Surf produces more foam than other types of powdered soap. Issa wanted to confirm this claim. He put the same amount of water in four basins, and added 1 cup of a different type of powdered soap (including surf) to each basin. He vigorously stirred the water in each basin, and observed the one that produced more foam. Which of the factors below is NOT likely to affect the production of foam by powdered soap?

- (A) The amount of time used to stir the water.
- (B) The amount of stirring done.
- (C) The type of basin used.
- (D) The type of powdered soap used.

20: Zuhura noticed that the steel wool that she uses to clean her pots rusts quickly if exposed to air after using it. She also noticed that it takes a longer time for it to rust if it is left in water. She wondered whether it is the water or the air that causes the wet exposed steel wool to rust. Which of the following statements could be tested to answer Zuhura's concern?

- (A) Steel wool cleans pots better if it is exposed to air.
- (B) Steel wool takes a longer time to rust if it is left in water.
- (C) Water is necessary for steel wool to rust.
- (D) Oxygen can react with steel wool.

21: A science teacher wants to demonstrate the lifting ability of magnets to his learners. He uses many magnets of different sizes and shapes. He weighs the amount of iron filings picked by each magnet.

How is the lifting ability of magnets defined in this investigation?

- (A) The weight of the iron filings picked up by the magnets.
- (B) The size of the magnet used.
- (C) The weight of the magnet used to pick up the iron filings.
- (D) The shape of the magnet used.

22: Masanja wanted to show his friend that the size of a container affects the rate of water loss, when water is boiled. He poured the same amount of water in containers of different sizes but made of the same material. He applied the same amount of heat to all the containers. After 30 minutes, he measured the amount of water remaining in each container. How was the rate of water loss measured in this investigation?

- (A) By measuring the amount of water in each container after heating it.
- (B) By using different sizes of the containers to boil the water for 30 minutes.
- (C) By determining the time taken for the water to boil in each of the containers.
- (D) By determining the difference between the initial and the final amounts of water in a given time.

23: A school gardener cuts grass from 7 different football fields. Each week, he cuts a different field. The grass is usually taller in some fields than in others. He makes some guesses about why the height of the grass is different. Which of the following is a suitable testable explanation for the difference in the height of grass?

- (A) The fields that receive more water have longer grass.
- (B) Fields that have shorter grass are more suitable for playing football.
- (C) The more stones there are in the field, the more difficult it is to cut the grass.
- (D) The fields that absorb more carbon dioxide have longer grass.

24: Sara wanted to find out if temperature has an effect on the growth of bread mold. She grow the mold in nine containers containing the same amount and type nutrients. Three containers were kept at 0 oC, three were kept at 10 oC and three were kept at room temperature about 27 oC. The containers were examined and the growth of the bread mold was recorded at the end of four days .The dependent variable here is;

- (i) The growth of bread mold
- (ii) Amount of nutrients in each container
- (iii) Temperature of the containers
- (iv) Number of containers
- (v) Number of containers at each temperature

25: A farmer raises chickens in cages. He noticed that some chickens lay more eggs than others. Another farmer tells him that, the amount of food and water given to chicken, and the weight of chicken, affect the number of eggs they lay. Which of the following is NOT likely to be a factor that affects the number of eggs laid by the chickens?

- (A) The size of the cage where the eggs are laid.
- (B) The weight of the chickens.
- (C) The amount of food given to the chickens.
- (D) The amount of water given to the chickens.

26: A science class wanted to test the factors that might affect plant height. They felt that the following is a list of factors that could be tested: the amount of light, amount of moisture, soil type, and change in temperature. Which of the statements below could be tested to determine the factor that might affect plant height?

- (A) An increase in temperature will cause an increase in plant height.
- (B) An increase in sunlight will cause a decrease in plant moisture.
- (C) A plant left in light will be greener than one left in the dark.
- (D) A plant in sand soil loses more water than one in clay soil.

27: A Biology teacher wanted to show her class the relationship between light intensity and the rate of plant growth. She carried out an investigation and got the following results.

Light intensity(Candela)	Plant growth rate (cm)
250	2
800	5
1000	9
1200	11
1800	12
2000	15
2400	13
2800	10
3100	5

Table 1.5. Shows the relationship between light intensity and the growth rate of a plant. Which of the following statements correctly describes what these results show?

- (A) As light intensity increases, plant growth also increases.
- (B) As plant growth increases, light intensity decreases.
- (C) As plant growth increases, light intensity increases then decreases.
- (D) As light intensity increases, plant growth increases then decreases.

Questions 28, 29 and 30 refer to the investigation below.

Peter is worried about how the cold winter will affect the growth of his tomatoes. He decided to investigate the effect of temperature on the growth rate of tomato plants. He planted tomato seedlings in four identical pots with the same type of soil and the same amount of water. The pots were put in different glass boxes with different temperatures: One at 0°C, the other at 10°C, and another at room temperature and the fourth at 50°C. The growth rates of the tomato plants were recorded at the end of 14 days.

28: What effect does the differences in temperature have in this investigation?

- (A) The difference in the seasons.
- (B) The difference in the amount of water used.
- (C) The difference in growth rates of the tomato plants.
- (D) The difference in the types of soil used in the different pots.

29: The factor(s) that were being investigated in the above experiment are:

- (A) Change in temperature and the type of soil used.
- (B) Change in temperature and the growth rate of the tomato plants.
- (C) The growth rate of tomato plants and the amount of water used.
- (D) The type of soil used and the growth rate of the tomato plants.

30: Which of the following factors were kept constant in this investigation?

- (A) The time and growth rate of tomato
- (B) The growth rate of tomato plants and the amount of water used.
- (C) The type of soil and the amount of water used.
- (D) The temperature and type of soil used plant

### Appendix C: Science Teaching Belief Instrument (STEBI); Riggs & Enochs (1990)

Please indicate the degree to which you agree or disagree with each statement below by ticking the appropriate letters to the right of each statement

SA=STRONGLY AGREE  
 A= AGREE  
 UN=UNCERTAIN  
 D=DISAGREE  
 SD= STRONGLY DISAGREE

S/n	LIKERT SCALE STATEMENTS	SA	A	UN	D	SD
1.0	When a student does better than usual in science process skills, it is often because the teacher exerted a little extra effort.					
2.0	I am continually finding better ways to teach science process skills					
3.0	Even when I try very hard, I do not teach science process skills as well as I do most topics					
4.0	When science process grades of students improve, it is often due to their teacher having found a more effective teaching approach					
5.0	I know the steps necessary teach a science process skills effectively					
6.0	I am not very effective in monitoring science experiments					
7.0	If students are underachieving in science process skills it is most likely due to ineffective science teaching					
8.0	I generally teach science process skills ineffectively					
9.0	The inadequacy of a student's science process background can be overcome by good teaching					
10	The low science process achievement of some students can not generally be blamed on their teachers					
11	When a low achieving child progresses in science process skills it is usually due to extra attention given by the teacher					
12	I understand science process skills well enough to be effective in teaching sciences at secondary schools					
13	Increased effort in science process skills teaching produces little change in some students science achievements					
14	The teacher is generally responsible for the achievement of students in sciences process skills					
15	Students achievement in science process skills is directly related to their teachers' effectiveness in science teaching					

16	If parents comment that their child is showing more interest in science processes at school, it is probably due to performance of the child's teacher					
17	I find it difficult to explain to students why science experiments work					
18	I am typically able to answer students' science process skills questions					
19	I wonder if I have the necessary skills to teach science process skills					
20	Effectiveness in science teaching has little influence on the achievement of students with low motivation					
21	Given a choice, I would not invite the principal to evaluate my science process skills teaching					
22	When a student has difficulty understanding a science process skills, I usually at a loss as to how to help the student understand it better					
23	When teaching science process skills, I usually welcome students questions					
24	I do not know what to do to turn students on to science process skills					
25	Even teachers with good science process teaching abilities can not help some kids to learn science					

**Appendix D: Teaching Practice Observation Checklist**

<b>Teaching practice</b>	<b>Very poor</b>	<b>Poor</b>	<b>Average</b>	<b>Good</b>	<b>Very good</b>
How well does the teacher acts as a facilitator rather than director of students' learning					
Does the teacher provides a variety of strategies, materials and resources to facilitate students' investigations					
How well does the teacher provides opportunities to practice a lesson					
How well does the teacher concentrate on the collection and use of evidence					
What is teacher's skills in posing thoughtful, open-ended questions to learners					
How effective does the teacher encourages dialogue among students and with him/her					
How well does the teacher welcome curiosity, reward creativity and encourage a spirit of healthy questioning					
How well the teacher does engages students in problem solving, critical thinking and other activities that make subject matter meaningful.					
How well the teacher does promotes self-directed, reflective learning for all students.					
How well the teacher does creates a physical environment that engages all students.					

**Appendix E: Practical Sessions Observation Checklist**

<b>Teacher's Competence in Teaching</b>	<b>Very insufficient</b>	<b>Insufficient</b>	<b>Sufficient</b>	<b>Very sufficient</b>
Hypotheses Formulation				
Identifying and controlling variables				
Operational definitions				
Planning investigations				
Conducting experiments				
Data collection and analysis				
Data interpretation				
Communicating findings				

**Appendix F: Laboratory Equipment Observation Checklist**

<b>Laboratory Item</b>	<b>Very insufficient</b>	<b>Insufficient</b>	<b>Sufficient</b>	<b>Very sufficient</b>
Laboratory Apparatus				
Laboratory reagents and Chemicals				
Human and other animals skeleton				
Human system models (eg digestive, reproductive, respiratory, nerve system)				
Practical guide manuals				
Preserved plant and animal specimens				

**Appendix G: A Research Clearance from the University of Dar es salaam**



**UNIVERSITY OF DAR ES SALAAM**  
**OFFICE OF THE VICE-CHANCELLOR**  
**P.O. BOX 35091 ♦ DAR ES SALAAM ♦ TANZANIA**

Ref.No: AB3/12(B)  
 Date: 5<sup>th</sup> October, 2009  
 To: The Regional Administrative Secretary,  
**Morogoro Region.**

**UNIVERSITY STAFF AND STUDENTS RESEARCH CLEARANCE**

The purpose of this letter is to introduce to you Mr. Jumanne Jamali who is a bonafide student of the University of Dar es Salaam and who is at the moment conducting research. Our staff members and students undertake research activities every year especially during the long vacation.

In accordance with a government circular letter Ref.No.MPEC/R/10/1 dated 4<sup>th</sup> July, 1980 the Vice-Chancellor was empowered to issue research clearances to the staff and students of the University of Dar es Salaam on behalf of the government and the Tanzania Commission for Science and Technology, a successor organization to UTAFITI.

I therefore request you to grant the above-mentioned member of our University community any help that may facilitate him to achieve research objectives. What is required is your permission for him to see and talk to the leaders and members of your institutions in connection with his research.

The title of the research in question is "An exploration of Science Teachers' Capacity for Teaching Integrated Science Process Skills".

The period for which this permission has been granted is from **October, 2009 to March, 2010** and will cover the following areas/offices: **Morogoro Municipality.**

Should some of these areas/offices be restricted, you are requested to kindly advise him as to which alternative areas/offices could be visited. In case you may require further information, please contact the Directorate of Research, Tel. 2410500-8 Ext. 2087 or 2410743.

  
 Prof. Rwekaza S. Mukandala  
**VICE-CHANCELLOR**

**UNIVERSITY OF DAR ES SALAAM**  
**P.O. BOX 35091**  
**DAR-ES-SALAAM**

Direct + 255 22 2410700  
 Telephax: + 255 22 2410500-8 Ext 2001  
 Telefax: + 255 22 2410375/2410514

Telegraphic Address: UNIVERSITY DAR ES SALAAM  
 E-Mail: [vicechancellor@uod.ac.tz](mailto:vicechancellor@uod.ac.tz)  
 Website address: [www.uod.ac.tz](http://www.uod.ac.tz)

Appendix H: Morogoro Region Research Permit Letter

THE UNITED REPUBLIC OF TANZANIA  
PRIME MINISTER'S OFFICE  
REGIONAL ADMINISTRATION AND LOCAL GOVERNMENT

Telegraphic Address: "REGCOM"  
Phones: 023 2 60 42 37/2 60 42 27



Regional Commissioner's Office,  
P.O. Box 650,  
MOROGORO.

Fax No: 2 60 09 73  
*In Reply please quote:*

Ref. No: AB.276/305/01/62

20/10/2009

District Administrative Secretary  
P.O. Box 681,  
MOROGORO REGION

**RE: PERMIT TO CONDUCT RESEARCH ON "AN EXPLORATION OF  
SCIENCE TEACHERS' CAPACITY FOR TEACHING INTEGRATED  
SCIENCE PROCESS SKILLS"**

Please refer to the above heading.

I have the honour to introduce to you Mr. Jumanne Jamali who is a bonafide student from the University of Dar es Salaam and currently conducting research in our Region.

The title of the Research is "An Exploration of Science Teachers Capacity for Teaching Integrated Science Process Skills".

The area of Research is Morogoro Municipality and Permit is granted from October, 2009 to March, 2010.

Please provide him with all necessary assistance to enable accomplish this important Research findings.

  
D.J. Ndomba

**For: REGIONAL ADMINISTRATIVE SECRETARY  
MOROGORO**

Copy: Prof. Rwekaza S. Mukandala  
Vice Chancellor  
University of Dar es Salaam  
P.O. Box 35091  
DAR ES SALAAM

## Appendix I: Morogoro Municipality Research Permit Letter

**HALMASHAURI YA MANISPAA MOROGORO**

Simu/Fax Na: 023 - 2614727  
Simu ya Upepo T/T

E - Mail: [morogorome@yahoo.com](mailto:morogorome@yahoo.com)



Ukurumbi wa Manispaa  
Ofisi ya Mkurugenzi wa Manispaa,  
Baraza ya Kijiji, Mfugo na Usirikia  
S.L.P. 166,  
MOROGORO - TANZANIA

Kumb: Na: E10/MMC-69/VOLII/62

Tarehe: 28 Oktoba, 2009

KATIBU TAWALA WILAYA,  
S.L.P 681,  
MOROGORO.

**YAH: KIBALI CHA KUFANYA UTAFITI JUMANNE JAMAL**

Husika na mada ya hapo juu sambamba na barua yako ya tarehe 22/10/2009 yenye Kumb Na. AB.170/206/01/164.

Kibali kimetolewa kwa mtajwa hapo juu kuja kufanya utafiti.

*H/*  
**P.S.KOBERO**  
Kny: MKURUGENZI WA MANISPAA  
MOROGORO

**MNY. MKURUGENZI WA MANISPAA  
MOROGORO**

**SPE**  
**LB1777**  
**14**  
**J85**

**Nakala:** Mr. Jumanne Jamal ✓  
**MOROGORO.**

*Wakuu wa Shule*  
*Kilakala*  
*Morogoro*  
*Nichonda*  
*Uinguru*  
*Forest Hill*  
*Jabal Hutu*  
*St Peter's*  
*Siemau*

*Mpeni viturukano katika utafiti*  
*wake*  
*Jumanne Jamal*  
*Baraza*  
Kny: AFISA ELIMU NA UTAMADUNZI  
*Afisa elimu sekondari*