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DESCRIBING THE SELF-EFFICACY OF TANZANIA SECONDARY SCHOOL BIOLOGY TEACHERS IN TEACHING INTEGRATED SCIENCE PROCESS SKILLS

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ABSTRACT

This study intended to examine the self-efficacy levels of the current secondary school science teachers in Tanzania towards teaching of science process skills. Science process skills have been heavily emphasized in the newly introduced Competence Based Curriculum of 2005. Specifically, the study intended to; (i) determine the self-efficacy level of Morogoro Municipality Biology teachers with regard to the teaching of integrated science process skills, and (ii) determine the influence of teachers' knowledge level of science process skills on their self-efficacy towards teaching these scientific skills to learners. Science process skills approach by Chiappetta & Koballa (2002), and Bandura's (1997) self-efficacy theory formed the conceptual and theoretical frameworks of the study respectively. Science Teaching Self-Efficacy Belief Instrument (STEBI-A) and a test of Integrated Process Skills developed by Mungandi (2005) were used to collect data among 63 sampled biology teachers. The results indicated that Morogoro Biology teachers have unsatisfactory knowledge of integrated science process skills and average self-efficacy level. The study recommends an urgent need to refocus on science teachers' training and professional development programmes.

KEYWORDS: Self-efficacy, Science process skills, Competence Based Curriculum, Biology teachers and Science Teaching Efficacy Belief Statement Instrument

INTRODUCTION

Since the late 1970s, researchers have considered teachers' self-efficacy to be a crucial factor for improving teacher education and promoting educational reforms (Ashton, 1984; Goddard, Hoy & Woolfolk Hoy, 2000; Ross, 1998 and Wheatley, 2002). Bandura (1977) defines self-efficacy as people's beliefs about their capabilities to produce designated levels of performance. Self-efficacy beliefs determine how people feel, perceive, aspire, think, motivate themselves, and behave. High self-efficacy reflects confidence in the ability to exert control over one's own motivation, behavior, and environment, and allows students to become advocates for their own needs and supports. Research suggests that self-efficacy can boost student achievement, foster emotional health and well-being, and serve as a valid predictor of motivation and learning. Some scholars (DeMesquita & Drake, 1994; Sridhar & Badiei, 2008 and Wheatley, 2002) have even concluded that reforms that do not address teachers' self-efficacy as the main innovation agents may be doomed to failure. Self-efficacy is a strong

factor which might contribute to teachers' ability or failure to perceive themselves as effective agents of education innovations and student learning (Woolfolk & Hoy, 1990). According to Riggs & Enochs (1990) teachers with a high sense of self-efficacy are willing to experiment new approaches, adaptive to new reforms and they believe they can make a difference in student learning.

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), 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 revised secondary school science syllabuses (curriculum) explicitly state and emphasize the need for science learners to acquire competence in science process skills. Science process skills are activities that scientists execute when they study or investigate a problem, an issue or a question. Padilla (1990) defines science process skills as a set of broadly transferable abilities appropriate to many science disciplines and reflective of the behaviour of scientists. The intention is to expose students not only in the factual knowledge generated by science but also to teach them the process of generating scientific information (Nugent, Kunz, Levy, Harwood, & Carlson, 2008). 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 engages with the world and gains intellectual control of it through the formation of concepts and development of scientific thinking (Mungandi, 2005 & 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.

The Competence Based Curriculum of 2005 in Tanzania was streamlined to address the needs of developing analytical and market-oriented skills (URT, 2008). The curriculum has also been reviewed in the spirit of constructivism to enhance participatory and inquiry approaches of teaching (Tilya & Mafumiko, 2008). 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)... be able to develop necessary biological practical skills, (iii) be able to develop mastery of carrying out experiments on various biological processes, (iv)... be able to apply scientific skills and procedures in interpreting various biological data, and (v) be able to develop and apply knowledge and skills on scientific processes of studying Biology.

The objectives above clearly put emphasis on learner centered method of learning where students should directly be involved in inquiry activities such as doing, observing, hypothesizing, experimenting, analyzing, and interpreting data. As a result, students will develop biological practical

skills which culminate to science process skills. In addition, 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 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). All these learning abilities and competences are collectively known as science process skills (Chiappetta and Koballa, 2002).

Problem Statement

The 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), teachers are the main implementers of the designed curriculum and are the final arbiter of what, how, and when the content gets taught. DeMesquita & Drake (1994 and Wheatley (2002), education reforms that do not address teacher efficacy may be doomed. Hence, for a successful implementation of Competence Based Curriculum (2005) which emphasizes the acquisition of science process skills, teachers' self-efficacy towards teaching of these scientific skills is so central. On the basis of this fact, it becomes vital to assess the self-efficacy of the existing science teachers in Tanzania towards teaching science process skills. A review of literature failed to identify research that has investigated the self-efficacy level of science teachers towards science process skills in Tanzania. This follows up study, intended to fill this research gap.

Purpose and objectives

The general purpose of this study was to assess the self-efficacy level of the existing biology teachers in Morogoro Municipality with regard to the teaching integrated science process skills. Science process skills have been heavily emphasized in the Competence Based Curriculum of 2005 in Tanzania. Specifically, this study intended to;

- (i) Determine the self-efficacy levels towards the teaching of integrated science process skills of secondary school Biology teachers in Morogoro municipality.
- (ii) Assess the influence of self-efficacy of Morogoro Biology teachers towards teaching of integrated science process skills.

Research Hypotheses

The study was guided by the question *'do the knowledge level of integrated science process skills of Morogoro Biology teachers influence their self-efficacy level?* The following null hypothesis (Ho) was formulated and tested.

Ho: There is no significant relationship between teachers' knowledge and their self-efficacy level towards teaching integrated science process skills.

Conceptual & Theoretical Framework of the study

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. Integrated science process skills include skills in identifying and controlling variables, defining variables operationally, formulating hypotheses, interpreting data and in designing experiments (Chiappetta and Koballa, 2002). In Table 1 below, Chiappetta & Koballa (2002) provides the meaning of each specific (individual) integrated science process skills.

Table 1: Definitions of Individual Integrated Science Process Skills

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

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 teachers, the higher their capacity to teach and implement reforms such as Competence Based Curriculum (2005) which emphasizes science process skills, and the reverse is also true.

METHODOLOGY

The study was conducted in Morogoro Municipality. The area was conveniently selected to represent other districts in the country. 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 determining the relationship between teachers' self-efficacy and their knowledge of science process skills in Morogoro. Descriptive research design on the other hand provides current information about conditions, situations, and events. Borg and Gall (1989) maintain that descriptive studies are used to find out "what is". Descriptive design was also suitable in this study because this study also intended to provide a description of teachers' knowledge and their self-efficacy in the area of integrated science process skills.

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 list of Municipal secondary school teachers provided by the office of the District Education Officer for secondary education.

Sampling of Teachers and Schools

In determining the sample size of Biology teachers, a simplified formula provided by Yamane (1967) to calculate the sample size at confidence level of 5% and when the population is known and the precision level of the study chosen was adopted.

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

Whereas n = sample size
 N = population
 e = Precision level chosen

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

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

Hence, the sample size of Biology teachers needed for a good study was 63 as computed above. The 63 Biology teachers were randomly selected from Kilakala, Uluguru, Morogoro, Kihonda, Kigurunyembe, Forest Hill, Mazimbu, Sumaye, Jabal Hira Seminary, and St. Peters seminary. These schools were selected based on the nature of their ownership (special, government, private, religious and community-based schools). The sample comprised of 35 male teachers (55.6%) and 28 female teachers (44.4%). Of the 63 teachers, 40(63.5%) had diplomas in education while 23(36.5%) had Bachelor's degree (Science). The essence of having such categories was to enable the researcher find out whether there is a statistically significant difference between Morogoro Biology teachers' self-efficacy level and their knowledge of integrated science process skills.

Data Collection Methods

Science Teaching Efficacy Belief Statement Instrument (STEBI-A)

Science Teaching Efficacy Belief Statement Instrument-A developed by Riggs and Enochs (1990) was used to determine Morogoro teachers' self-efficacy level. 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. 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-A, the lowest score is 25 points if a teacher will score only one point in each of the 25 statements. This score would represent the lowest possible teacher's self-efficacy level. The highest possible score with STEBI-A is 125 points if a teacher were to score maximum of five (05) points in each of the 25 statements. The score of 125 represents the highest possible teacher's self-efficacy level. After marking STEBI-A 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 into either very low, low, average, high and very high self-efficacy.

Test of Integrated Science Process Skills by Mungandi 2005

In assessing Biology teachers' knowledge level of integrated process skills, a test of integrated science process skills developed by Mungandi (2005) was administered to sampled teachers. The test measures five (05) specific integrated scientific skills (identifying variables, stating hypotheses, operationally defining, designing investigations and interpreting data) to students of Grade 9, 10 and 11 equivalents to Form I-III students in Tanzania. The reliability of the instrument was established by Mungandi (2005) using 1,043 Grade 9,10 and 11 learners to be 0.81 (Cronbach's alpha) and an internal validity of 0.98. The instrument has 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 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 test has a readability index of 70.29. This high readability value implies an easy to read text (Mungandi, 2005).

Since the test by Mungandi (2005) was made for ordinary secondary level students, 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).

Data Analysis

The test of integrated process skills provided quantitative data. These data were analyzed using SPSS version 21.0. Descriptive analysis of frequencies, percentages, means, and standard deviations were used to categorize, organize and analyse teacher scores. Analysis of variance (ANOVA) and independent samples t-test were used to determine the relationship between teachers' knowledge of science process skills and their level of self-efficacy.

Ethical Issues

Ethical dimensions for participant schools and teachers were fully considered. All the participants were duly informed of the objectives of the study before the test was administered. Moreover, 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. Sampled 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. Test scripts were handled by researchers only. Test scripts have been stored in a safe place and they will be destroyed after one year. 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.

FINDINGS AND DISCUSSION

General Scores of Teachers in the STEBI-A Instrument

For a successful implementation of any education reform such as Competence Based Curriculum and science process skills in Tanzania, the sense of self-efficacy of teachers as the main change agents is extremely important. The first objective of this study was to determine the self-efficacy of Morogoro Biology teachers towards teaching science process skills. Science Teaching Self-Efficacy Belief Instrument (STEBI-A) constructed and published by Riggs & Enoch (1990) was administered to all 63 teachers who participated in this study. The results showed that all 63 participant teachers scored above the minimum score of 25 indicating that none belonged to a very low self-efficacy class with respect to teaching of science process skills. 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.

Further descriptive analysis of results indicated that Morogoro teacher scores ranged from 47 to 89 points with an overall mean being 69 and a standard deviation (s.d) of 5.73. The mean (69), falls into an average self-efficacy level. 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).

Moreover, with the average mean of 69, Morogoro Biology teachers exhibited low self-efficacy level as compared to other science teachers in other studies. For example, Hamilton & Swortzel (2007) employed the same instrument, (STEBI-A 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 to the effective implementation of the 2005 education curriculum. 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.

Morogoro Teacher Scores in the Specific STEBI Statements/Items

An analysis of scores for each statement in the STEBI-A scale was done in order to have a wider picture of the overall Morogoro teachers' own beliefs with respect to science process skills. Science teaching belief instrument (STEBI-A) is composed of 25 specific statements measuring both Personal Science Teaching Efficacy (PSTE) and Science Teaching Outcome Expectancy (STOE). The overall results also suggested the same that Morogoro Biology teachers do not have a strong self-efficacy level to be effective in teaching science process skills. For example, out of 63 teachers 28(44%) 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. 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. 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 09 (14%) teachers believed that good teaching could overcome the inadequacy of a student's science process skills background. In addition 24(38%) teachers strongly disagree that students' achievement in science process skills is directly related to the teachers' effectiveness in teaching. Either a good number of teachers 13(20%) believes that, effectiveness in science teaching has little influence on the achievement of students. Surprisingly however, 42(67%) teachers agreed that they continue finding better ways to teach science process skills effectively while (51%) were skeptical to agree that they are not very effective in monitoring science experiments. In one school the researcher of the current study recorded one teacher strongly disagree the statement that`If students are under achieving in science process skills it is most likely due to ineffective science teaching" by arguing that,

... "we are getting very weak form one students, ...I fail to imagine how comes s/he passed the std 7 exam.....even a teacher from the heaven cannot make these students learn especially sciences.....they have low motivation and concentrates

much on memorizing bongo flavor songs, so it is unfair to generalize and blame teachers for the poor achievement of some students.

The above statements provided by respondent 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.

Moreover, from the above kind of teachers' own beliefs, it is clear that 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, reforms and education innovations.

Performance of Teachers in the Science Process Skills Test by Mungandi 2005

General Performance of Teachers in the Science Process Skills Test

The second 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 all 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. For example, there was no a single teacher who managed to score 24 and above questions correctly to be graded or regarded as having a very satisfactory knowledge level of integrated science process skills.

Calculation done on the scores of all 63 teachers provided an overall mean of 56% which means that on average, Morogoro teachers scored 17 (56%) items correctly out of 30 total questions. Teacher scores ranged from 06 (20%) as the lowest mark to 23 (77%) as the highest score. The average score of 56% to teachers who are supposed to teach students represents 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.

Table 2: 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
0-20	03	05	Very unsatisfactory
21-40	24	38	Unsatisfactory
41-60	17	22	Average
61-80	19	27	Satisfactory
81-100	00	00%	Very satisfactory

Source: Field data (2019).

Comparatively, the general performance of Morogoro Biology teachers in the science process skills test are 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 are also lower than those obtained by Hamilton & Swortzel (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 quite surprise to find that, teachers who are supposed to guide students on the learning of science skills failed a science process skills test meant for ordinary level secondary school students.

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 prospective teachers' capacity to teach specific science process skills in different topics. Furthermore, demand driven professional development workshops and seminars for in-service teachers on scientific skills should be mounted.

The results by specific integrated science process 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 answer correctly. 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 only by 06 (09%) teachers 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 3 below summarizes the performance of Morogoro Biology teachers by specific integrated science process skills in the Mungandi's test.

Table 3: 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, (2019).

The findings on Morogoro teacher skills in designing experiments clearly correspond with the results 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. Similar finding were also obtained by 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 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.

The Influence of Integrated Science Process Skills Knowledge on the Self-Efficacy of Morogoro Biology

This study also sought to find out the influence of teachers' knowledge of integrated Science Process Skills on the sense of self-efficacy of Morogoro Biology teachers. As it has been described on the theoretical framework, teachers' knowledge is one of the strong determinants of their self-efficacy level. Hence, it was necessary for the researcher to determine the relationship between the self-efficacy level teachers and their knowledge of integrated science process skills. Teachers' knowledge 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-A). Tallying was done to enable the researcher test null hypothesis (H_0) that, *'there is no statistically significant relationship between teachers' knowledge and their self-efficacy towards teaching integrated science process skills'*. Bivariate analysis was conducted using SPSS and correlation coefficient of self-efficacy and knowledge level of science process skills computed using a two tailed test at alpha level (α) of 0.05.

As shown in Table 4 below, data analysis found a correlation coefficient (r) of 0.151 and significance (ρ) of 0.037. Hence, ρ was < 0.05 , rejecting the null hypothesis (H_0) and suggest a positive association between teacher's self-efficacy and their knowledge of science process skills. The rejection of the null hypothesis (H_0) means that, Morogoro teachers with higher self-efficacy scores from STEBI-A

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: Correlation Coefficient (r) Between Teachers’ Self-efficacy and their knowledge level of Integrated Science Process Skills

		Knowledge Level of Integrated Process Skills	Self-Efficacy Level
Knowledge of Science Process Skills’	Pearson Correlation	1	0.151**
	Sig. (2-tailed)	.	0.037
	N	63	63
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 (2019).

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 knowledge and capacity to teach these scientific skills effectively, but also it would increase their confidence and motivation (self-efficacy). Similar results were 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 knowledge level of inquiry focused model of science instruction was also found by Nugent et al, (2008).

Based on the study findings, the following recommendations are made;

The issue of teachers' efficacy is very critical. However, the main question that faces science teacher educators is how to specifically develop high levels of context-based teaching efficacy at both the pre-service and in-service levels of teaching. There are some recommendations arising from this study;

i. 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 towards science process skills.

ii. Pre-service science teacher preparation programs are in a unique position to enhance the knowledge and 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.

iii. Educational level predicts teachers' personal teaching efficacy, confidence and motivation. Hence Morogoro science teachers should also be given opportunities for further academic training. This will not only improve their teaching practices but also their sense of self-efficacy towards teaching science process skills.

iv. According to the literature and findings of this study it is necessary to take into consideration the efficacy beliefs in the teacher training environment or professional development courses to promote and fostering sense of teaching efficacy beliefs among teachers. 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 that increases their knowledge and self-efficacy with respect to science process skills. This requires major and fundamental changes in pre-service science teacher education contents, including providing a range of effective laboratory experiences.

v. Teacher's 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.

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. Self-efficacy and science process skills seem a new research topic in Tanzania education system. This current study focused on assessing Biology teachers' knowledge and self-efficacy in the area of integrated science process skills. However, several studies should also be conducted to assess students' knowledge and self-efficacy towards science process skills at different education levels. These studies will provide a wider picture as to whether students at all education levels are acquiring science process skills as campaigned by the 2005 Competence Based Curriculum.
- iii. This study employed a Science Teaching Belief Instrument (STEBI-A) published by Riggs and Enochs (1990) for assessing teachers' self-efficacy and a test of integrated science process skills developed by Mungandi (2005) 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 and a self-efficacy instrument in Tanzania. Hence, studies to develop and publish (a) self-efficacy instrument, (b) science process skills tests for Tanzania students and teachers using Tanzania syllabuses and in the context of Tanzania should be conducted.

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