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Assessing Knowledge Levels of Selected Integrated Science Process Skills of Morogoro Biology Secondary Students - Tanzania

Jamal Jumanne Athuman

Lecturer, Department of Education, Sokoine University of Agriculture (SUA)-Tanzania

Abstract: ***This study was partly conducted in order to establish a base level of information on the knowledge levels of Tanzania students in the area ofintegrated science process skills. Specifically the study assessed students' competence in formulating and identifying testable hypotheses, in controlling variables, in designing experiments, in analyzing data and in defining operationally. Integrated science process skills, as in the Tanzania´s Competence Based Curriculum of 2005, have been identified in the science education literature as an effective inquiry method of teaching science. Advanced level biology students in Morogoro municipality schools were taken as a case study. This study aimed at assessing the knowledge level of advanced level Biology students in the Municipality of Morogoro of science process skills. Based on the Biology process skills test (BPST) scores, it was found that Biology students in Morogoro Municipality had barely average knowledge level of integrated science process skills. The mean of test scores was 17.2 items out of 35 items in the test corresponding to 49.1%. However, Morogoro students performed relative better on items measuring their ability in identifying and controlling variables with score mean of 4.05 out of 07 items and they performed extremely poor on items which measured their skills in analyzing and interpreting data with the mean of 2.34 out of 07 items.***

Keywords: science process skills, analysing data, hypothesis formulation, controlling variables, defining operationally

1. Introduction

Science process skills are a set of broadly transferable abilities appropriate to many science disciplines and reflective of the behavior of scientists. Bilgin (2006) defined science process skills as an understanding of methods and procedures of scientific investigation. 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). 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).

The revised national education curriculum in Tanzania has identified science process skills as being essential in creating the competence based curriculum (URT, 2010). The curriculum has incorporated these skills both in scientific investigations and in construction science knowledge of science curriculum. As a result of this move, many of the science syllabuses, guides, reference books and instructional materials for the revised curriculum acknowledge the need for science process skills acquisition. 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;

1) Students should have the ability to plan, record, analyze and interpret data from scientific investigations using appropriate methods and technology to generate relevant information in biological science.
2) Students should be able to develop necessary biological practical skills.
3) Students should have the ability to apply scientific skills and procedures in interpreting various biological data (p.ii-v).

All these objectives are putting emphasis on the 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).

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2. Problem Statement

It is twelve years now since the inception of the competence-based curriculum in Tanzania. The newly revised competence based curriculum of 2005 has placed a heavy emphasis on the need for secondary school science learners to acquire integrated science process skills such as formulating hypotheses, defining operationally, controlling variables, design experiments and interpreting data. According to Berliner (1986), successful implementation of a curriculum reform should be measured by the extent to which learners have acquired the targeted objectives. The learner is the primary reason for developing or reforming any curriculum. Plowden (1967) also is convinced that…

> ……….. *"At the heart of the educational process lies the child hence the evaluation of a curriculum reform must begin with learners" (Plowden 1967:7).*

Despite such a dramatic shift in curriculum policy, little is known about whether or not the reform efforts are truly transforming the educational experiences of students. There is no clear evidence of whether or not learners are appropriately acquiring competence in these scientific skills as prescribed in the curriculum. Therefore it is necessary for this study to assess the knowledge levels of some selected integrated science process skills of Tanzania Biology secondary studentsThe selected scientific skills focused include i. formulating hypotheses, ii. defining variable operationally, iii. Identifying and controlling variables, iv. planningexperiments v. analyzing and interpreting data.

3. Research Methods

Research design

In assessing the knowledge levels of the selected integrated science process skills of students, descriptive research design was adopted. According to Krathwohl (1993), descriptive research design provides current information about conditions, situations, and events. Borg and Gall (1989) maintains that descriptive studies are used to find out "what is". A descriptive design was suitable at this stage because the study intends to provide descriptions of the level of science process skills of higher biology students in Tanzania. Advanced Biology learners in the municipality of Morogoro were a representative case study. Descriptive statistics were also used to analyze overall test performance, and students performance by specific science process skills in an attempt to determine whether performance differs with the type of skill.

Sample size and sampling of participating schools

The population for this study was the advanced level biology students (Form V and VI) who have Biology as one of their major subjects in secondary schools in the municipality of Morogoro. A list of advanced level secondary schools in the Municipality of Morogoro and subjects they offer was provided by the district education officer for secondary education. According to the list, there are four secondary schools in different locations of Morogoro municipality which offers biology for advanced level students. These schools are Kilakala, Alfa Germs, Bigwa Sisters and Lutheran junior seminary. These schools differ in terms of a number of students taking biology. The subjects involved were all Form V and VI students who had undergone the revised science syllabus. Because of a need to assess a large sample of students, all students in these four schools were involved. It means that sample size, in this case, was equal to the population of advanced biology learners in the municipality of Morogoro. Furthermore, this implies that no any sampling technique was employed to obtain the appropriate sample size. The number of subjects in each grade level based on their gender has been shown in table 1 below.

Table 1: Schools and number of students that participated in the study

Sex	School	Type of Student		Total
		Form VI	Form V	
Female	Kilakala	48	91	138
	Alfagerms	22	25	47
	Bigwa sisters	9	14	23
	Lutheran Junior Seminary	18	19	37
Total		**97**	**149**	**246**
Male	Alfagerms	25	37	62
	Lutheran Junior Seminary	20	25	45
Total		**45**	**62**	**107**
Grand	**Total**	**142**	**211**	**353**

Research survey data (2014)

Data collection instrument

In assessing the knowledge level of integrated process skills of advanced biology students in Morogoro, a biology process skills test (BPST) developed and validated in the first stage of this study was used. The test measures five (05) individual integrated scientific skills (identifying variables, stating hypotheses, operationally defining, designing investigations and analyzing and interpreting data) to advanced secondary school learners. The reliability of the instrument was established by the researcher in the year 2014 using 610 learners to be 0.80 (Cronbach's alpha). Concurrent validity of BPST was established by comparing students score in the process skills test (TIPS II) by and Burns, et al. (1985). 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, et al. (1985) who also obtained a reliability of 0.84. Biology process skills test (BPST) has a readability index of 72.0. This high readability value implies an easy to read text to students who English is not their first language like Tanzania students. The test fits with the context of Tanzania and the competence-based curriculum being implemented.

Procedures and administration

Prior each administration of the test the purpose and importance of the test was explained to students. In each school, the administration of the test was done simultaneously in the classes under the supervision of Biology teachers and a researcher within school time. The test duration was one hour and was again voluntary. The identity of all students participating remained confidential. The only demographics collected were gender and grade levels. Student scores were not reported back to teachers and were used only for the research purpose only. However, students were informed about their right to know their score. All test papers were collected at the end of each test and the

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teachers were not allowed to keep or make copies. Test scripts were scored by allocating a single mark for a correct response and no mark for a wrong, omitted or a choice of more than one alternative per question. The total correct scores were determined and percentage of score out of the total number of possible scores (the total number of items) calculated.

Grading system of students performance in BPST

The grading system for the advanced level students of Tanzania was adopted in grading Morogoro biology student scores in the process skills test. This scale has been upgraded by the National Examination Council of Tanzania (NECTA) in 2014 and classifies student scores into seven (07) classes. Grade A which ranges from 75% to 100% implies a very satisfactory or excellent performance, while B+ ranges from 60% t0 74% and implies satisfactory or good. The scale award to a student grade B who will score between 50% to 59% implying ´´Good or above average´´, and grade C (average), for a student who will score between 40% to 49%. Grade D stands for ´´Below average´´ or unsatisfactory performance and is awarded for a score between 30 – 39%. Grades E and F stands for poor and very poor respectively and are awarded to those students who would score between 20% - 29% and between 0%- 19% respectively. After marking, student scores were converted into percentages and classified into seven categories using the above criteria and presented in the format as shown in Table 2 below.

Table 2: Test scores grading system

Range of scores	Corresponding %	Grade	Description of the level of process skill
0- 6	0-19	F	Very unsatisfactory
7 - 10	20-29	E	Unsatisfactory
11- 13	30-39	D	Below average
14- 17	40 - 49	C	Average
18 - 20	50- 59	B	Satisfactory
21- 26	60-74	B+	Very Satisfactory (Very Good)
27 - 35	75-100	A	Excellent

Source: URT (2014)

Data analysis plan

Descriptive statistics were used to analyze overall test performance and students' performance by specific science process skills in an attempt to determine whether performance differs with the type of skill. Students' score were analyzed using SPSS version 21.0. Descriptive analysis of frequencies, percentages, means and standard deviations was used to categorize, organize and analyze student score from BPST. General students' performance, as well as their performance in individual science process skills, was analyzed through descriptive statistics. Analysis of variance (ANOVA) and independent samples t-test, on the other hand, were used to statistically determine whether there was the difference in the performance of students in the specific process skills.

4. Results and Discussion

General performance of Morogoro students in the Biology process skills test (BPST)

The first objective of this stage was to assess the general knowledge level of integrated science process skills of Morogoro biology students by using a science process skills test developed in the first phase. The test was administered to a group of 353 advanced level biology students from all four biology based schools present in the municipality of Morogoro. The study involved 246 (69.7%) female students and 107(30.3%) male students of which 142(40.2%) were form six students and 211 (59.8%) were form five students. Descriptive statistics was performed to examine means, standard deviations, percentages, and frequency distributions of scores. Descriptive statistics indicates that the mean score of students was 17.2 (49.1%) with s.d of 7.3. The highest score was 28 (80%) and the lowest 09 (25.7%) out of 35 possible. 66 (18.6%) students out of 353 scored 18 (51.4%) out of 35 and this was the mode score, followed by 15 (42.8) which was scored by 54 (15.2%) of all students who participated in the study. More statistics descriptive to the general performance of science process skills is given in Table 5.4. According to the table, (Table 3) majority of Morogoro biology students 116 (32.8%) out of 353 scored average on the scale grade ie between 14-17 out of 35 maximum possible and were classified as having an average performance . Some 99 (28%) students out of 353 in the sample had satisfactory knowledge level of process skills (18 – 20) as shown in Table 4 below.

Table 3: Descriptive statistics of student scores in the BPST instrument (n=353)

Range of scores	Corresponding %	Grade	No. of students	% of students	Description of the level of the skill
0- 6	0-19	F	0	0.0%	Very unsatisfactory
7 - 10	20-29	E	6	1.7%	Unsatisfactory
11- 13	30-39	D	43	12.2%	Below average
14- 17	40 - 49	C	116	32.8	Average
18 - 20	50- 59	B	99	28.0%	Satisfactory
21- 26	60-74	B+	86	24.3	Very Satisfactory
27 - 35	75-100	A	2	0.6%	Excellent

Source: Field data (2014).

Although the table shows that none (00%) of the students had F grade, implying that all biology students scored more than 06 items out of 35. However only 02 (0.6%) students out of 353 scored A grade. These excellent graded students both scored 27 out of 35 possible which is equivalent to 77%. Some 06 (1.7%) students scored between 7– 10 items and they were graded as unsatisfactory while 43 (12.2%) scored below average 30-39%. On the other hand, 86 (24.3%) students scored between 60-74% (21-26) and from the secondary education grading system of Tanzania, they were graded as having a very satisfactory level of science process skills. Skewness of scores which is the extent to which a distribution of values deviates from symmetry around the mean was also calculated and a value of 0.046 was obtained. A value of a positive 0.046 skewness means that there were a relatively greater number of smaller values than mean (Dover, 1979). It also indicates that most of the students taking the test obtained low scores. On the other hand, the overall mean score was 17.2 (49.1%) which means that on average, the advanced level biology students in Morogoro scored between 17 to 18 items correctly out of 35

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total questions. According to the grading system of Tanzania adopted in this study, 49.1% represents a "C" class which means average knowledge level. This means that on overall, Morogoro biology students have barely average knowledge level of integrated science process skills.

Their overall level of performance in this study cannot be regarded as "good" considering the high premium placed on the subjects' acquisition of science process skills in their science curricula. Some of the possible reasons for the students' "mediocre" performance might be that many might not be familiar with the types of tasks investigated and assessment used in this study. Germann, et al. (1996) asserted that students' good performance on science process skills was dependent on their experience with and domain-specific practice activities on the skills in prior tasks, while Ruiz-Primo and Shavelson (1996) reported that student scores depended on the particular tasks investigated and on the particular method used to assess their performance. In the similar vein, Millar and Driver (1987) found that students' ability to use process skills depend on the extent of their knowledge of the contexts they are asked to work on. This is also explained by the finding (Rowe &Foulds, 1996 & Tobin and Capie, 1982) that performance of tasks requiring these process skills is strongly content-dependent. There is a problem of how to integrate content and process of science in Tanzania. Science process skills exercised in relation to some science content and have a crucial role in the development of learning with understanding (Harlen, 1999). Tanzania science teachers need to capitalize on opportunities in the activities done in the science classroom to emphasize science process skills. Students conducting these activities are expected to develop such skills as stating hypotheses, operationally defining variables, designing investigations, and interpreting data in addition to mastering the content of the courses.

This might be due to the fact that the lecture method, that predominates in Tanzania science classrooms of all levels (Osaki et al. 2004), does not facilitate the development of generalizing skills and other science process skills in the subjects. 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).

Performance of Biology students by specific science process skill

The main objective of this study was to examine the performance of advanced level biology students of Morogoro municipality based on the five integrated science process skills namely i. formulation of hypotheses ii. identifying and controlling variables, iii. design experiments iv. Analyzing and interpreting data and v. defining variable operationally. Therefore for additional analyses, the entire Biology process skills test down into its five subscales of process skill objectives. The mean scores end standard deviations on the BPST total and each subscale and overall students were calculated and summarized in Table 4 below.

For overall students, correct response percentages were highest for the process skills of identifying and controlling variables with the mean score of 4.05(57.7%) and were lowest for the process skills of analysis and data interpretation with the mean score of 2.34(33.4%). The mean of a raw score of the subtest was low, indicating that the students found the subtest more difficult. Table 4 below is a summary of descriptive statists and the difficulty levels of each process skill objective as a subscale of the BPST.

Table 4: Descriptive statistic of the test and its component skills (n=353)

Specific science process skills	Total items	Minimum Score	Maximum Score	Mean Score	SD	Percent Correct
Identifying and controlling variables	7	1	6	4.05	0.88	57.8
Identifying and stating hypotheses	7	1	6	3.49	1.43	49.8
Operationally defining	7	1	6	3.71	0.96	53
Analysis and interpreting data	7	0	5	2.34	0.75	33.4
Designing experiments	7	1	6	3.27	0.96	46.7

Source: Research survey (2014)

For overall students, correct response percentages were highest for the process skills of identifying and controlling variables with the mean score of 4.05(57.7%) and were lowest for the process skills of analysis and data interpretation with the mean score of 2.34(33.4%). The mean of a raw score of the subtest was low, indicating that the students found the subtest more difficult. As it is shown in table 4 above, Morogoro Biology students had a mean or average of correct responses of 3.71 in questions measuring their skills in defining variables operationally. Student scores in questions measuring this skill ranged from 01 as the lowest score to 06 out of 07 questions as the highest score. Students, on the other hand, had a mean of 3.49 (an average performance) in questions measuring their skills in hypothesis formulation. In these questions, student scores ranged from zero (01) out of six to 06 out of seven (07) items. Lastly, Morogoro students had a mean of 3.27 (average of performance) on questions measuring their skills in designing experiment. In these questions, teachers had scores ranging from zero (01) to five (06) out of seven questions. The table shows that subjects did perform relatively better on the skill of identifying and controlling variables probably because most of the items requiring this skill gave prescriptive directions on what the subjects should measure and how to record (first level of the developmental progression of the skill). But a close look at the subjects' test scripts revealed that only of a few of them were able to interpret tables and graphs and record data in more complex table form on their own and that they were better able to complete and construct tables than graphs. The construction of graphs demands the ability to recognize relations between relations or formal operations in Piagetian terms which many students are incapable of (Shayer & Adey, 1981). The subjects performed fairly well on interpreting data that demanded extracting information from graphs and tables, but they were less successful (barely "average")on the skill of generalizing which entailed making conclusions,

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interpolating/ extrapolating between/beyond data points and identifying supporting evidence.

Performance of Morogoro Biology students by specific integrated science process skills somehow resembles findings reported by both Hamilton & Swortzel (2007) and Dyer et al. (2004) where students scored higher on questions measuring their skills in identifying variables and stating hypotheses and also scored poorly on measuring their ability in graphing and data interpretation. As it is shown in Table 4 above, Morogoro Biology students performed poorly on questions dealing with analysis and interpretation of data with the performance mean of only 2.34 or 33.4% correct responses. The maximum score out of seven items was only 5 and the largest standard deviation of 2.024. Morogoro students result, however, correspond with those by Hackling & Garnett (1991) who conducted a research on students ability in carrying out experiments and found that students at all levels showed a poorly developed skill of problem analysis, planning, and carrying out controlled experiments. Another similar finding is that by Foulds & Rowe (1996) who found that students 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 and analyze experiment results, gaining an average mark of only 18%. The students 'poor performance on the skills of analyzing and interpreting data might be due to the likelihood that they had not been taught these skills and that their levels of cognitive development were inadequate to enable them to handle the skills. It is in the view of this study the teacher-centered mode of teaching science in the sampled schools, which did not allow the Biology students to practice and internalize the skills over a fairly long period, was likely to be one of the main reasons for the students' poor performance on the skills.

Detailed description on the performance students by specific science process skills under the study

The study also intended to provide full description of the performance of Biology students in each of the five integrated science process skills namely i. formulation of hypotheses ii. Identifying and controlling variables, iii. design experiments iv. Analyzing and interpreting data and v. defining variable operationally. The mean of students' scores and standard deviations on each subscale were calculated. The following section discusses the performance of Morogoro Biology students in each scientific skill focused by this study.

Performance of students in the skill of identifying and controlling variables

One aspect of the inquiry practice that directly related to student ability to carry out inquiry-oriented investigations is the ability to handle and control experimental variables. Control of variables as a fundamental science process skill has been widely regarded as an important ability in scientific investigations and as an integral component of most curricular around the world (Turaib, 2015). For overall students, correct response percentages were highest for the process skills of identifying and controlling variables with the mean score of 4.05(57.7%) out of seven items measuring this skill (see table 5.7 section 5.3.4.1 above). Although the percentage of students who showed understanding of the concept of control of variables represents less than two-third of the sample, it is still fair better than when compared to the performance in other subscales. However, during marking their tests, it was observed that students were not able to tell whether a particular variable influenced or determined the results of the experiment. This means much work is needed to improve students' ability to handle and control experimental variables into Tanzania science learners.

Across many studies, it is evident that most students and even some adults do not have a generalized understanding of controlling variables because of their ability to identify, select, or design controlled experiments depends on the task content or situational factors (Koslowski, 1996; Linn et al. 1983; Zimmerman, 2000). This skill provides students with the scope and understanding needed to carry out controlled and reliable experiments that might eventually lead to trusted outcomes and valid inferences (Chen & Klahr, 1999). The findings from this study are in congruence with the finding obtained in the study by Turaib (2015) in his study to assess students' understanding of the control of variables across three grade levels and gender in the United Arab Emirates (UAE). His findings revealed that students across grade levels exhibited alternative conceptions of key ideas related to control of variables. Similar findings have also been seen by Boudreaux et al. (2008) who found that although most of the students participating in their study were able to realize the importance of having controlled conditions for experimentation; many students had difficulties in providing a valid justification for why controlled conditions were important. Research studies in this area call for critical investigations to suggest and develop methods and approaches needed to help students develop sound and coherent understanding of this crucial and essential skill (Zimmerman, 2000). The findings with Morogoro students highlights the need for teachers to pay attention to the development of argumentation and analytical skills needed to argue for which variables need to be manipulated and which ones need to be kept constant. A suggested by Turaib (2015) students need to focus on simple steps of recognizing variables of experiments and categorize them into categories so that decisions about their manipulations can be made.

Performance of Morogoro students in the skill of data analysis and interpretation

Data analysis entails the ability of students to assign meaning to the collected information and determining the conclusions, significance, and implications of the experimental findings (Zimmerman, 2007). Analysis of BPST scores indicated that students' scores were lowest for the items measuring their ability in data analysis with the mean score of only 2.34(33.4%) out of seven (07) items (see table 5.7. section 5.3.4.1 above). Compared other subscales, data analysis had the smallest standard deviation of 0.75. This implies that Morogoro students were so hemogeneous in terms of their ability in data analysis questions and that many students had scored the same scores as their mean score. These findings that Morogoro students had poor scores in data analysis resembles the findings reported by both Hamilton & Swortzel (2007) and Dyer et al. (2004)

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where students scored higher on questions measuring their skills of controlling variables but scored poorly on items measuring their ability in graphing and data interpretation. These finding on Morogoro students also correspond with those by Hackling & Garnett (1991) who conducted a research on students ability in carrying out experiments and found that students at all levels showed a poorly developed skill of problem analysis, planning, and carrying out controlled experiments. Another similar finding is that by Foulds & Rowe (1996) who found that students 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 and analyze experiment results, gaining an average mark of only 18%. The complexities surrounding understanding of the concept of data analysis extend to science teachers. In an early study, Shadmi (1981) studied science teachers' understanding of the control of variables and found that most teachers had difficulty interpreting the results in the context of experimental settings.

The poor students´ performance on the skills of analyzing and interpreting data might be due to the likelihood that they had not been taught well enabling them to handle this skill. It is in the view of this study that, teacher-centered model of teaching science in the sampled schools in Morogoro, did not allow the students to practice and internalize the skills over a fairly long period. This is likely to be one of the main reasons for the students' poor performance on the skills. This means that current teaching-learning processes should not only focus on conceptual understanding of science, but it must also move in directions similar to those identified in science education research as 'doing science' and 'knowing about science' (Zimmerman, 2007). In order to achieve this goal, teaching and learning processes must focus on equipping students with the intellectual and the manipulative skills that are needed to construct and reconstruct scientific knowledge rather than focusing on conceptual learning only.

Performance of Morogoro students in the skill of formulating hypotheses

A hypothesis is an educated prediction that can be tested. Formulating hypotheses is a scientific way in which the investigator forms a research hypothesis that states an expectation to be tested. Then the investigator derives a statement that is the opposite of the research hypothesis. This statement is called the null hypothesis (H0) (Ghanem, 2003). This study also intended to determine the knowledge level of students in formulating and stating testable hypotheses. The findings from BPST indicated that Morogoro students scored below average on the items measuring their ability in formulating a hypothesis. As seen in table 5.7 section 5.3.4.1 above, the mean of seven items measuring their ability in this skill was 3.49(49.8%) and the standard deviation was 1.43. Student scores ranged from one (01) to six to 06 out of seven (07) items.

These findings that Morogoro students have below average performance in items measuring their hypothesis formulation skills were not surprising. Many researchers who have studied hypotheses formulation within science education have concluded that students have weak abilities in formulating and testing hypotheses. According to Ghanem (2003) students incur three main problems when dealing with scientific hypotheses. These problems include failure to formulate valuable examined hypotheses; failure to distinguish between scientific facts, theories, and hypotheses, and difficulty in verifying hypotheses. For example, in their study on young children differentiation of hypothetical beliefs from evidence, Sodian et al. (1991) found that students tend to produce or repeat the effect rather than to discover its causes and they have trouble on identifying likely causes. Furthermore, students were unable to quickly grasp the meaning of the investigated subject, method, and the image of solving the problem (Sodian et al. 1991). The findings of the current study however, highlight the fact that better preparation of students for the future may require new teaching approaches that respond to and focus on not only learning scientific content but also on acquiring transferable abilities such as the ability to design and conduct valid and controlled experiments that yield valid and reliable findings. As the observation made by Filson (2001) that students have difficulty with hypothesis because their books and lessons mention hypothesis, but almost never really explain or model them and frequently hypotheses are confused with theories.

Performance of Morogoro students in the skill of designing scientific experiments

Developing the ability to design an experiment is critical to the understanding of the scientific process and in promoting critical thinking skills (Coil et al. 2010). Ths study also measured students´ knowledge level of designing experiments scientifically using BPST. Analysis of students score in this subscale indicated that Biology students had also a below average ability in designing experiments. The mean score of students in this subscale was 3.27(46.7%) while the standard deviation was 0.96 (see in table 5.7 section 5.3.4.1 above). These findings that Morogoro Biology students have below average performance in items measuring ability in designing experiments were also not surprising. A number of science education researchers (Coil et al. 2010; Chen & Klahr, 1999; Adey & Shayer, 1990; & Ghanem, 2003) attribute poor students' ability in correctly designing experiments to misconceptions and inaccuracies regarding randomization, sample size, and inability to identify and control variables and poor stated hypotheses. According to Adey & Shayer (1990) students weak in designing experiments because they are rarely given an opportunity to think deeply about experimental design or asked to develop experimental protocols on their own.

Scores from BPST showed that most of Morogoro students know that an experiment should contain a control, but many find it difficult to define exactly what a control is. Similar observation was made by Klymkowsky et al. (2011) in their study which intended to reveal student thinking about experimental design and the roles of control experiments. In this study Klymkowsky et al. (2011) surprisingly found that a high percentage of students had difficulty identifying control experiments even after completing three university-level laboratory courses. To address this problem Klymkowsky et al. (2011) designed and ran a revised cell biology lab course in which students participated in a weekly experimental control exercise. Not unexpectedly,

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the results indicate that the revised course led to greater improvements in students' ability to identify and explain the purpose of control experiments. So it can be concluded that using a simple experimental measure, students can become engaged in the process of scientific inquiry, and in turn, begin to think deeply about experimental design. This skill can be developed if students are allowed to work like scientists.

Performance of Morogoro students in the skill of 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). It is a specific definition of a concept in a research study. Another specific aim of this study was to measure the knowledge level of Morogoro Biology students in defining variables operationally. It has to be noted that, once researchers develop hypotheses, the next step involves forming operational definitions of the concepts to be investigated in the research (Klymkowsky et al. 2011). So it is one of the very vital integrated science process skill to be acquired by students. Analysis of students score in this subscale indicated that Biology students had above average ability in defining terms operationally. As seen in table 5.7 section 5.3.4.1 above, the mean score of students in this subscale out was 3.71(53%) out of seven items which measure this skills. The standard deviation was 0.96.

Few studies exist which explains how a teacher can help students define experimental variables operationally. Pratt & Hackett (1998) suggest that, by learning science through inquiry, a science teacher can facilitate the development of defining operationally skill and acquisition of science process skills in general. Teachers are taught inquiry teaching strategies by engaging in inquiry science activities and extending their understanding of the science concepts that they teach (Hyman & Shephard, 1980). According to Harlen (2000), teachers can facilitate the development of defining operationally skill and other science process skills in general by; (i) providing a variety of materials and resources to facilitate students' investigations, (ii) posing thoughtful and open-ended, (iii) encouraging dialogue among students and with the teacher, and (iv) keeping students' natural curiosity alive during teaching. Nevertheless it was enough for this study to indicate that Biology students had above average ability in defining terms operationally compared to other subscales.

5. Conclusion

Science process skills, as in the Tanzania´s competence based curriculum of 2005, have been identified in the science education literature as an effective inquiry method of teaching science. This study aimed at assessing the knowledge level of advanced level Biology students in the municipality of Morogoro of science process skills. Based on the Biology process skills test (BPST) scores, it was found that Biology students in Morogoro municipality had barely average knowledge level of integrated science process skills. The mean of test scores was 17.2 items out of 35 items in the test corresponding to 49.1%. However, Morogoro students performed relative better on items measuring their ability in identifying and controlling variables with score mean of 4.05 out of 07 items and they performed extremely poor on items which measured their skills in analyzing and interpreting data with the mean of 2.34 out of 07 items.

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