Is Logic Aspects Incorporated In The Teaching And Students' Assessment? Case Study In Secondary Schools Located In Dodoma Municipality, Tanzania

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Abstract: The study assesses teacher's use of logic in teaching and students' assignments, exercises, group work, test and examination. Every University in Tanzania has its own teachers' training curriculum; the way teachers are educated to meet challenges and still upholding teaching qualities is questionable. The study involved qualitative (focus group discussion and observation of students assessments) and quantitative (structured interview) design. The study noted that; majority of teachers lack sufficient logical knowledge of subject matter and do code switch between English and Swahili in teaching although Swahili is not language of instructing science subjects. The study revealed that teacher's use of logic in teaching and student's assessment is not good and requires understanding of subject matter. Respondents recommend the use logic in the students' assessment from simple to complex problems as logical skill acquisition. Something lacking in learners is problems solving skills, they rely on reading and memorizing solved questions instead of making logic from what they were taught. The study contributes significantly to understanding of students' learning and understanding as well as the teachers' teaching and students' assessing skills.

Keywords: assessing; logic; logical assessment; principal components; SPSS; teaching

1. Introduction

Many studies in the teacher's education (Ball & McDiarmid, 1989; Kennedy, 1990) continuously address key important aspects in the teaching career. These aspects are teachers' knowledge of subject matter (Ball & McDiarmid, 1989; Hotaman, 2010; Jadama, 2014) and teacher's pedagogical skills (Hotaman, 2010;

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Millar, 2009; Mykrä, 2015; Paulo & es Salaam, 2014), teachers psychology (Nezhad & Vahedi, 2011), ethics, value and moral (Bullough, 2011; Veugelers, 2008), code of ethics and the teaching professionalism (Barretta & Anangisye, 2005; Hotaman, 2010; Mkumbo, 2012; Opdenakker & Van Damme, 2006; Whitty, 2000) as well as overwelming subject-specific studies (Abrahams & Reiss, 2012; Chiaverina & Vollmer, 2005; Lin, 2013; Mabula, 2012; Mhaiki, 1986; Olufsen M, 2015; Rao, 2011) as among the requirement for the successful teaching and learning in the teaching career. These studies and other related to the teaching aspects (Mkumbo, 2012; Paulo & es Salaam, 2014) have yet not or insufficiently addressed how teachers reason correctly in delivering of lessons, setting examination questions or evaluating learners based on available education principles and knowledge of subject matter in critical, non-obvious and enhanced way. In this regard possession of logic.

Unfortunately, people use the word logic and logical synonymously and more frequently without actually understanding what they mean. However, the term logic or logos (Greek) is used to mean thought, idea, argument, account, reason or conception and integration of multiple ideas. It is therefore a science of formal principles of reasoning or correct inference (Simpson, 2000). In fact logic is the study of how to evaluate arguments and reasoning. In this regard, logic can also be regarded as science of how arguments must be formed and arranged in order to have correct meaning, and arrive at conclusion. Understanding of idea or subject in this case is critical, and requires reasoning through critical thinking and reflection because without correct reasoning, it's too easy to fall into error.

The term logic has been used mostly in philosophy and mathematics as well. In mathematics, logic is commonly used in mathematical operators and calculus. Historically, philosophy is itself the original of logic mainly from ancient Greek philosopher Aristotle. This was further developed and systematized by the Stoics and the medieval scholastic philosophers (Simpson, 2000). In mathematics, logic has been argued to enhance teaching that support the development of students' competence in argumentation (Durand-Guerrier, Boero, Douek, Epp, & Tanguay, 2011). Regarding the potential of logic in teaching mathematics, Hanna Gila (2000) points out that one of our key tasks as mathematics educators, however, is to understand the role of proof in teaching so that we can enhance its use in the classroom" and that in the classroom, the key role of proof is to promote mathematical understanding (Hanna, 2000). Proof in this case is used to mean the ability to provide evidence, substantiation, testimony or confirmation of an idea.

Despite the requirement and need of logic in teaching, learning activities and learners' assessment, application of logic is also necessary in life. This is because people are daily confronted with tremendous amounts of information and ill-defined problems with real uncertainty as to how they can be best thought and solved (Angeli, 2009). Whether it is due to lack of critical thinking as aspect of logic or unknown reason, studies show that educational system in Tanzania as yet been unable to impose a meaningful and enduring impact on the lives of learners (Mehta, 2012).

In regard to possession of logical concepts together with knowledge of subject matter, studies show that teachers who understood multiple concepts are able to further students' understanding than those with less knowledge (Mehta, 2012). In this case, if teaching is about helping others learn, then understanding what is to be taught is a most requirement of teaching (Ball & McDiarmid, 1989). Understanding teacher's teaching by students depends on how best a lesson is constructed and presented logically. Prominent scholars in science education and philosophers in logic have shown that logic logical reasoning to a great extent serves two purposes; facilitating verbal interaction by providing a set of inference that are made automatically in process discourse, and integrate information received from different source or at different time (Overton, 2013).

Teachers with subject-specific critical thinking (Ennis, 1989), pedagogy teaching skills as well as knowledge of subject matter are likely to pose questions, construct meaning explanation, suggest alternative explanations, and propose additional inquiries than those with weaker knowledge (Overton, 2013). In the teaching career, valid assessment of learners' knowledge incorporates application of logic skills. For example in science, laboratory practicals examination requires one to be logical in order to have correct judgment of the experimental results, in this regard practicals in science is essential for knowledge construction (Kang & Wallace, 2005). This is because doing practicals is generally characterized by involvement of theory in practice, integrity, creativity, curiosity, initiative/discovery, and the ability to analyze (Tanzania institute of education, 2007) which is essentially logic-specific learning manner. However, it should be understood that not all logical inference constitutes a scientifically valid demonstration because correct reasoning is not scientifically valid if it not based on a true and primary starting point (Simpson, 2000).

Education practice such as classroom instruction, alternative teacher's responses to students' questions and constructing students' assessment require the use of logics

in that subject. Thus, possession of logics in the subject and student assessment is essentially an indicator of subject matter understanding as well as one of the teacher's domains in the teacher's professionalism. In this case, incorporation of logic in a teaching and learning context is expected to lead into the following; development of critical thinking skills, integration of knowledge within and across disciplines as well as develop ability to work in a team to solve problem. Therefore, since critical thinking is subject specific (Ennis, 1989), it is possible to teach logical or critical thinking but a level of exposure may be necessary before a student's skills begin to develop. In view this, it should be understood that the use of logic in teaching and learning context distinguishes between doing science and studying science. Studies show that teaching students to think like a scientist, researcher or diagnostician is different from simply being a student of science which focus primarily on passing examination (Mehta, 2012).

Furthermore, logic has been argued as fundamental to rationality. In this context, teaching students in a logic manner improves their logical reasoning skills. Studies point out that critical thinking skills can readily be learned when learners are embedded in a specific subject referred as infusion method (Angeli, 2009). Based on this, it is difficult to see and appreciate how one characterizes critical thinking without implementation of logic. This is because teachers lacking correct reasoning may consequently not teach precisely what is to be included in their presentation texts.

The ideas of teachers' correct reasoning originates from the fact that the main task of teachers in teaching and learning process is to figure out ways of presenting the subject to the students in ways that they can understand (Kennedy, 1990). This is because students do not learn by merely receiving information from the teachers but by actively constructing mental images of the correctly presented material by teacher. In view of this, teachers need an analytic understanding of the subject (Facione, 2011), pedagogical skills and posses logic aspects in order to improve and enhance teaching and students' assessment. The present study assesses the use of logic in teaching, learning and students assessment by science teachers where logic is considered as practical, experiential or observable skills of the teaching profession. This is an attempt to figure out problems associated with secondary education studies including National Examination Council of Tanzania (NECTA) students' results in Tanzania.

2. Methodology

The study was conducted in Dodoma municipal, Tanzania with the area of 2,769 Km sq. According to United Republic of Tanzania Census of 2012, the district had a population of 410,956 people, and annual growth rate of 2.7%. The population of this study was all available senior (A-level) secondary schools with science subjects and ordinary (junior) secondary schools (O-level). The latest statistics reveals that Dodoma has a total of fifty seven secondary schools in the year 2016. The study has involved both secondary and primary data; primary data were collected through various tools which enabled obtainance of reliable data for analysis. Such tools involved were; individual questionnaires, key informant questionnaires, focus group discussion. In addition, observation of students exercises, assigned group work, individual assignments as well as mid-term and terminal examination as secondary data were made. The aim was to assess questions in these documents to check if students' assessment is made according to Bloom's taxonomy learning domain skills. Therefore, these secondary data references were gathered to supplement the results obtained through questioners and focus group discussion and aided in conclusion and discussion made in this study.

Chemistry teachers and students were used as representative science teachers and students respectively. Chemistry was chosen because the subject is studied by majority of students in secondary education. Dodoma municipality was purposely sampled as a study site because the area has many secondary schools, at low cost reachable by researchers, and the area bears both urban and rural characteristics. The schools enroll students from various parts of the country with a range of characteristics varying from cultural to geographical aspects.

2.1. Sampling Technique Involved

Simple random sample was used to select secondary schools which were involved in study so as to reduce biasness which could have resulted otherwise as the results of distance and cost impression. A secondary school was chosen to comprise a sample of study if it has science subjects either for advanced secondary education (senior secondary school), ordinary secondary school (junior secondary school) or both, and if it is only in Dodoma municipal. A list of secondary schools in Dodoma municipal was obtained from the office of District education officer (DEO) used as a sampling frame for the study. For observation of students exercise, assigned group work and assignments and mid-term and terminal

examination, sampling involved only form three and four for junior (O-level) secondary schools, and form five and six for senior (A-level) secondary schools students assessment documents mentioned above. Collection of students' assessment documents considered the most recent five years back from the year 2016 in those visited schools.

Sample Size

From the population of these secondary schools, a sample size of schools was chosen using Yamane (1967) formula. The formula used to compute the sample size (Yamane (1967)) is;

Equation 1 $n = \frac{N}{1+N(\varepsilon^2)}$ and $\boldsymbol{\varepsilon^2} = \frac{Z_{\propto/2}}{2\sqrt{N}}$

$$n = \frac{57}{1+57(0.245)} \approx 4 \text{ schools}$$

This is the minimum number of schools required for study results to be used for inferences.

Where: **N** is the population size; **n** is sample size drawn from the population: $\boldsymbol{\varepsilon^2}$ is Margin of error.

Margin of error is a statistic expressing the amount of random error in a survey result. The margin of error expresses the maximum expected difference between the true population parameter and a sample estimate of that parameter.

$\boldsymbol{\varepsilon^2} = \frac{1.96}{2\sqrt{16}}$ = 0.245, Given α = 0.05 and $Z_{\alpha/2}$=1.96

Due to the nature of study population the team of researchers decided to exceed the minimum suggested sample size and took a sample size of 13 secondary schools for consideration of this study.

2.1.1 Sample Taken

This study had divided respondents into about three major categories according to their role they play in the field of science subjects. The first category comprised of students of O-level (specifically form 3 & 4) and A-level secondary schools in Dodoma municipality. About 116 students were involved in a one to one interview through structured questionnaire. In addition, a total of 13 focus groups discussion, each consisting 5-8 students were held to supplement quantitative data collected. Second category comprised of 31 Chemistry teachers who were available in those

visited secondary schools. They were involved in a one to one interview through structured questionnaire interview as well as focus group discussion to extract as much supplementary information as possible. The third category was that of Tanzania central zone school quality assurance officers involving seven available officers, two (2) were science subject specific. These officers were consulted to get insight of what was already checked through Chemistry teachers and students as well as knowing what are their inspection domains and role in schools. During the study, collection of students' assessment documents (tools) considered the most recent five years back from the year 2016 in those visited schools. Here student's exercises, assignments and mid-term and terminal examination for at least two years were collected and assessed based on bloom taxonomy examination setting skills.

2.2. Pilot Study

Before the actual data collection exercise started pilot study was conducted to ensure reliability and validity of the data collection instruments, this study was conducted in Sechelela secondary school in Makulu Dodoma located in Dodoma municipal. The problems realized during a pilot study led into excluding classroom observation during teaching, therefore making adjustment and re-arrangement of questions to suit available time frame and research context. A one to one interview through structured questionnaire interview was administered to sample of students, and focus groups discussion conducted with minority of students from the classroom to get insight of what was asked through structured questionnaire to secondary students.

3. Analysis

For analysis, the team used SPSS and Excel packages to process and analysis collected data. The study involved eight junior secondary schools and five senior secondary schools out of whom about 50 were females and 66 were males from both school levels. Further analyses were done to explore factors that are statistically significant in explaining the use of logic by teachers in teaching and students' assessment. Factor analysis, one of data reduction method was used to obtain fewer significant variables to comprise principal components through the use of principal components analysis. Variable to consist of principal component were selected through examination of the value of communalities. All variables with communalities were greater than 0.5 were considered significant in explaining

the use of logic by teachers. The first category of respondents were chemistry-specific teachers, and results were as follows; The first principal component formed was termed as teacher's teaching and classroom assessment which comprised of two variables named; giving difficult questions in exams and assignments (communality score 0.809); Combining idea and use of difficult questions in teaching (communality score 0.773). While the second formed principal component was termed as teacher's flexible teaching skills which comprised of one variable named the use of different teaching techniques by the teacher (communality score 0.589) and Competence of science instruction language (communality score 0.619).

For the teacher's teaching and classroom assessment (Figure 1), few teachers from government and private owned schools rate "not important" and "average" by (22% & 15%) and (63% & 50%) respectively on matter related to teacher's teaching and classroom assessment.

According to the opinion from both school teachers, it show that private owned school teachers consider teacher's teaching and classroom assessment important aspects compared with government school owned teachers indicated as 63% against 50% respectively. This means the conduct of asking difficult questions during teaching in the classroom, constructing difficult assignment and examination is likely a common practice in private schools than in the government schools.

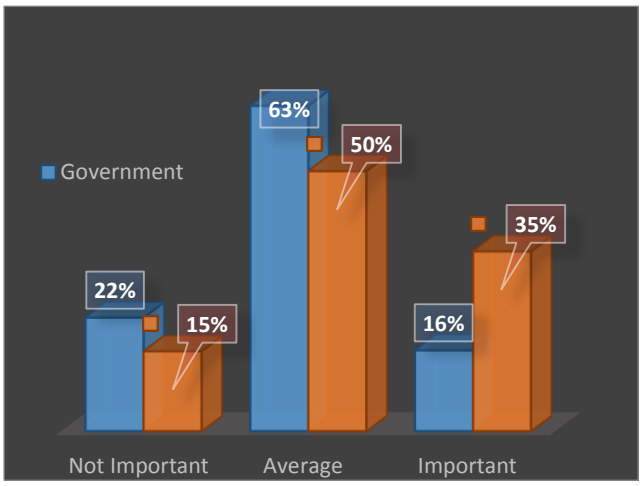

Figure 1. Teacher's opinion on teacher's classroom teaching and assessment (First principal component)

The opinion of teachers is about 79% and 73% of government and private secondary schools respectively on the teacher's flexible teaching skills *(*second principal component*)*. This implies that teacher's flexible teaching skills are one of important aspects in the teaching career. On other hand, despite type of school ownership, the aspect of teacher's flexibility seems to be a paramount factor for science subjects' performance improvements.

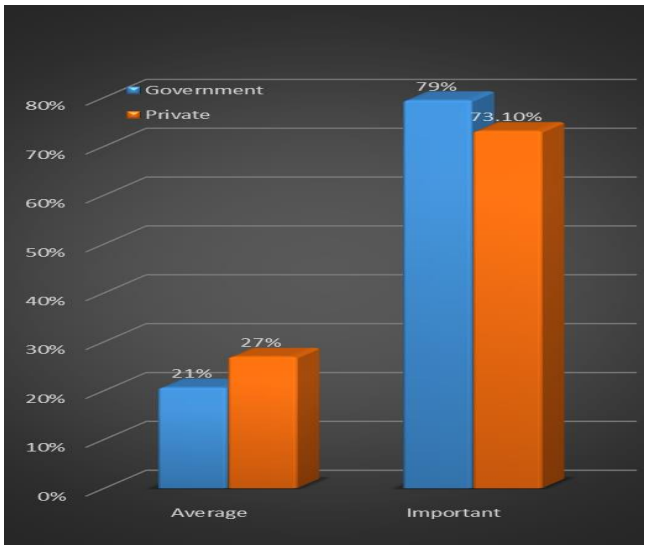

Figure 2. Teachers' opinion on teacher's Flexibility Teaching Skills (First principal component)

For the second category of respondents was secondary education students, and the analysis of their responses were as follows: Six variables whose communalities score were greater than 0.5 were chosen and used in exploring the use of logic by science teachers. The six variables were used in further analysis and resulted into three principal components.

The first principal component was formed by the variable teacher stimulates my interest in the subject with a communality score of 0.900. It was renamed as "subject motivation by teacher" for better explanation of the subject matter in this study. The second component was formed from the variables; teachers' combine various ideas in teaching (communality score 0.602) and teachers' use difficult questions in teaching, assignments and exams (communality score 0.700).This principal component was named "Teacher's Teaching and Classroom Assessment". The third component was formed by using the variable; teachers' use of discussion

and group work in classes and practical sections (communality score 0.915). This was renamed as "teacher's teaching methodology". Then all variable(s) of each principal component (s) was or were selected and quantified statistically to obtain students percentage opinion responses for each principal component.

For the first principal component (Figure 3), majority of students agree that there is an average motivation of students by teachers in teaching. This means that there is an average level of students motivation by teachers reflected from the analysis results for students' opinion (Figure 3) by 43% and 57% of government and private school students respectively. On other hand, based on the percent value (Figure 3), the government school students opinion indicate that to great extent they are motivated by teachers on average basis compared with private school students. This is shown by high percent (43%) of private school students against 35% of government school students' opinion on "*very good*" the level of teachers' motivation.

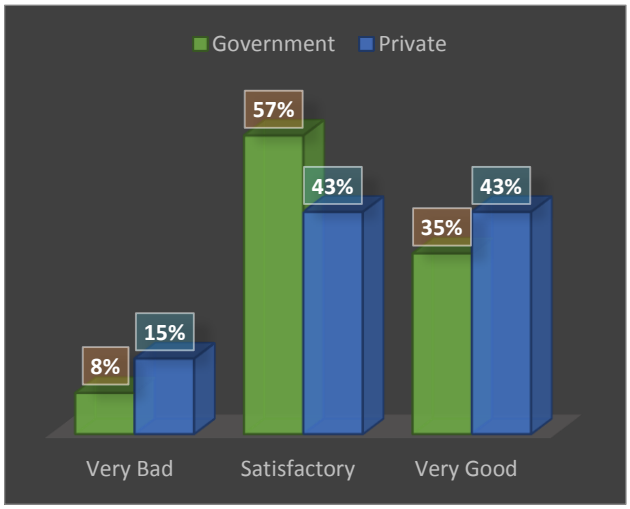

Figure 3. Students' opinion on teachers' students' motivation in a subject (first principal component)

For the second component (Figure 4) majority of government and privately schools student view the conduct of teachers' teaching by combining various ideas and teachers' use difficult questions in teaching, assignments and exams as best ways of assessing students on science subjects. This is indicated by the percentage opinion for "Satisfactory" and "very good" of about (53% & 39%) and (37% & 45%) for government and private schools respectively.

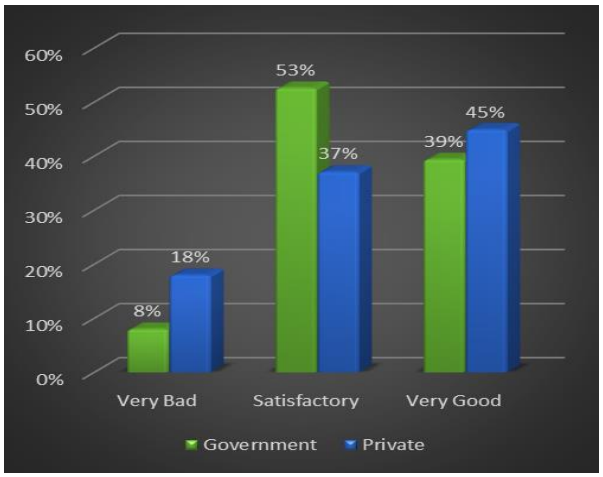

Figure 4. Students' opinion on teacher's teaching and assessment classroom (second principal component)

For teachers' use of discussion and group work in classes and practical sections (Figure 5), majority of students from private and government schools rate their teacher's teaching methodology "satisfactory". This is revealed by percent opinion score of about 53% and 44% respectively. On other hand, the least students rate teachers teaching methodology "very good" indicated as 39% and 40% for government and private schools respectively, while the most lest students view teachers teaching methodology very poor with percentage opinion of 8% and 16% for government and private schools respectively. The most lest percent opinion of students among all interviewed students reveal the fact that teachers do teach on average basis than.

On other hand, based on type of school ownership, private school students "rate very" bad teaching methodology of teachers twice (16%) compared with government school students (8%). Generally, low percent opinion of private students may be due to the fact that they have high expectation on teachers teaching service unlike government schools probably because they invest much in private schools cost for better service.

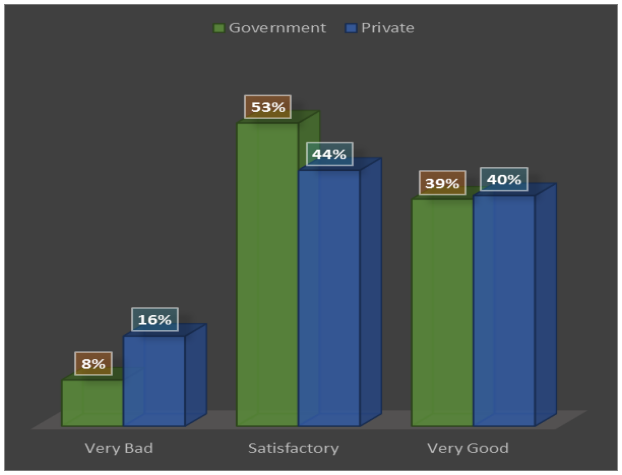

Figure 5. Students' opinion on teacher's teaching Methodology (third principal component)

4. Discussion

This study has examined teachers' use of logic teaching and learning context. Through the study, it was noted that teachers are using students centered method in their teaching approach as recommended teaching method at the nation ministry level. The target of using this method is to promote students logical thinking through their own discoveries and ultimately acquire expected learning outcome knowledge and skills. The study further noted that the manner in which the learning process is carried out for the purpose of knowledge acquisition becomes a problem and it is mostly discouraging students due to the nature of the method itself in addition to the teaching aspects of a teacher himself/herself. This was raised through discussion with students and school science subject-specific inspectors that the structured teaching and learning activities which could lead into the logical thinking and skills are not prioritized by teachers due to limited time, shortage of teaching staff compared with number of students, and lack of teachers' motivation.

It was also found that teachers' assessment are not always structured logically such as the use questions requiring high degree of reasoning, application knowledge,, discovery as well as simple recalling questions type. Both teachers and students especially from government schools point out that there no ample time in schools

given for systematic structured learning for science subjects. Insufficient time devoted for studies is more critical for junior secondary education (form 5 & 6) such that teaching and hence coverage of topics is always carry out through teacher's centered method due to available time allocated. This has made the teaching focus be based on what is possible before examination time especially the national examination. In view of this, respondents recommends for reduction of number of topics to be taught for junior secondary education (A-level) in the syllabus or extend studies for at least five months. This means teaching and assessing students' logically skills requires ample time as it involves providing questions and students practices based on expected construct to be expressed and its ultimate evaluation. Therefore, this requires multiples teaching sessions with structured learning activities such as the use of teaching which involves exercises, discussion and group assignment after teaching a given lesson. In this case, teaching a subject in a logical manner distinguishes studying from doing the subject for example doing science involves teaching students to think like a scientist, researcher or diagnostician (Mehta, 2012), here students develop logic perspectives in the subject while studying science is simply being a student of science focusing to great extent on passing the coming examination. Studies points out that logic support the development of students' competence in argumentation (Durand-Guerrier et al., 2011). This calls for increasing teachers' awareness of the role played by logical reasoning in proof.

The study noted that majority of teachers lack logic aspects in their teaching. In this regard, students point out that teachers seem have good knowledge of subject matter but they are unable to deliver a lesson to level of students' satisfaction. In this case, one could believe that experienced poor performance of science in secondary education in Tanzania (Mulela, 2015) is a consequence of poor teaching including lack of logical skills either in the form of deductive and/or inductive skills. In view of this concern from students, it means that teachers are lacking pedagogical skills, reflecting teachers' inability to construct meaning explanation in vast ways. Teachers need knowledge of subject matter, pedagogical skills and through career practices develop the logical aspects in teaching. For example in teaching science subjects, studies show that construction of logical structure for practical activities requires the use of person's ideas to generate a question, prediction or assemble new situation (Millar, 2009). Teacher's logic skills is important in learning because teachers must not assume their students have highly developed reflective skills (Jr., 2011).

Assessment of collected tests, examination, assigned group work and in-class exercises through critical evaluation of tested skills noted inability of some teacher in constructing assessment marked with inappropriate use of verbs and language. This is however relatively poor for junior schools compared with senior schools, and could be associated with the nature of teachers available in schools. Some junior schools use form six leavers or bachelor holders with no education foundation. Most experienced teachers thought that the poor students assessing skills of teachers would be combated through training and strict observation of ministry education directives. Arguing on this, school quality assurance officers thought that their department within the ministry should be mandated to take full decision on the misconduct practices in schools including banning schools with unqualified teachers or with poor studying conditions like the way Tanzania Commission for Universities controlling Universities in Tanzania.

Moreover, the study noted that logical thinking capacity of a teacher in teaching have great influence on students' academic excellence. This was pointed out by respondents that teacher's use of logic, in this case possession of logics by teacher in a subject have moderately to high impact on students' examination achievement. This was specifically raised through discussion with interviewee arguing on "how a subject is taught is related to the students' examination results". They further mentioned that the way a subject is taught is related to results but depends on individual student efforts and as well as prevailing outside classroom condition such as input from parents and students living environment.

In regard to logic as main focus in this study excluding mathematicians, philosophy and theology related interviewee as well as experienced teachers approached, some of the key informants, inexperienced teachers and majority of students were noted have poor understanding of logic probably because the terms is discipline specific and need high rational reflection. In this case, they could not to realize the importance and hence role of logic in teaching and students' assessment as far as the study concern. In addition to this, few of the respondents do not realize if there is a need for teachers' knowledge in setting examination claiming that the structure of examination are always known and can be checked by teachers in case of doubt". This argument and other of the like rose by least respondents without knowing that the exam structure is indeed there but all sections individually or in totality need to assess students logically and reflect the specified learning domains skills according to bloom taxonomy. These learning domains according to bloom taxonomy are knowledge, comprehension, application, analysis, synthesis, and

evaluation (Kim, Patel, Uchizono, & Beck, 2012), and are specified in various National Examination Council of Tanzania (NECTA) and Tanzania Institute of Education (TIE) examination documents.

5. Conclusion and Recommendation

The study found that teachers' use of logic in teaching and students assessment are at low level, and is among the identified problems facing teaching and students assessment in secondary education. There is however shortage of teaching staff and teaching spaces, and limited time allocated for teaching compared with specified subject content in the syllabus. Students are not always assessed through regular assignments, exercises, group discussion, and test instead it is done through mid-term and terminal examination. There is minimal interaction of students with their subject teachers academically inside and outside the classroom for government schools especially non-boarding schools compared with private owned schools. An improved teachers' organization, concentration and composer for teaching sessions involving students' assessment requires reasonable class size and proportional teaching load for teachers, teaching facilities as well as enough space in schools. There is need for regular teachers' training to subside what is already acquired through the teachers' study programs in colleges and Universities mainly for combating the present teaching inefficiencies. In this case, professional development programs (PDP) training cannot be denied in the teaching career service. This is because PDP is among the most promising and readily available routes to growth on the job and vivid pathway to increased competence and greater professional satisfaction (Guskey, 2002). Therefore, teachers' training programs, teaching career practices and the entire science education must continuously be revised to improve teacher's possession of subject knowledge, pedagogical skills, logical and proof knowledge essential in the teaching profession for successful student achievement. There is a call for new techniques as well as principles in the teachers training program to improve logical and thinking skills of pre-service teachers which are adaptive in enabling students learn. Teachers need strategies for teaching and able to think reasonably and thinking skills, selecting and be organized for teaching multiple ideas, guiding practices in class and applying thinking skills, elaborating thinking skills, helping students academically and direct their own thinking.

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