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Analysis Of Mathematics Tests In Public Teacher Training Colleges In Malawi With Respect To Higher Order Thinking Skills

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Abstract: Bloom's taxonomy has been around since 1956 and was later revised by Anderson (2001). Since Bloom's is widely used in Malawian teaching curricula especially in testing and evaluating students' performance, it is important to critically analyze lecturers' set test using Blooms taxonomy.The objectives of the study were to evaluate mathematics question papers set by lecturers in public teacher training colleges with respect to higher order thinking skill as proposed by Bloom's taxonomy and to explore mathematics lecturers' awareness of Bloom's taxonomy.A study was conducted in three public teacher training colleges in Malawi. Two colleges are in the central region of the country and one is found in the southern region. Colleges were selected using simple random sampling method. Nineteen (19) lecturers who teach mathematics from the department of science and mathematics were asked to complete a self-administered questionnaire. Excel was used to draw graphs and pie charts during analysis of responses from the questionnaire .The second part of data was collected by analyzing term 2 mathematics question papers from three TTCs. Each question was analyzed and categorized according to Bloom's taxonomy. A total of 231 questions were examined, sourced from 5 papers. These questions were independently reviewed. Data analysis was performed using IBM SPSS version 21.0. The chi square was used to compare the proportion of HOTS against LOTS.The findings revealed that all lectures (n=19) have knowledge on Bloom's taxonomy of cognitive. They all agreed that they also follow it when setting tests. The findings on the analysis of question papers showed that all levels of Bloom's taxonomy were used in the three colleges. There were significant differences ($p < 0.05$) in the proportional of exam questions at lower, medium and higher level of Bloom's taxonomy. Thirty eight percent (38%) of the questions aimed at lower level; medium level questions dominated at 49% and few questions were at higher level (13%), which shows that most of the questions were at medium level of Bloom's taxonomy. Questions were fairly distributed across the six levels of Bloom's taxonomy, although the distribution was not equal. All levels were covered. Majority of questions were set at medium and higher level which constituted 62%.Lectures should be encouraged to also ask more questions on higher level especially synthesis and evaluation.Principals should intensify CPD on the table of specification (also known as a test blueprint). This can help to come up with proportional questions across the six levels. A test blueprint defines and precisely outlines the number (or proportion) of test questions to be allocated to each major and minor content area and how many (what proportion) of these questions will be designed to assess specific cognitive knowledge level [9].A similar study should be done in all public Teacher Training Colleges. This study concentrated on mathematics question papers only. It can be extended to other subjects at these public TTCs.

Key words: Higher Order Thinking Skills, Public Teacher Training College, Tests.

1. Introduction

Teacher educators are expected to produce teachers with higher order thinking skills and with sound judgment. Higher order thinking skills can be stimulated from both classroom lessons and assessments using Bloom's taxonomy (BT). Bloom's taxonomy was originally designed in order to categorize examination questions at college level [16]. Tests are most effective when more items are written at higher level of cognition [8]. Malawi, being part of the global community, is expected to produce teachers who have higher order thinking skills. Many studies have used BT as the standard for judging whether tested items are lower–order thinking or higher–order thinking. The thinking skills in BT considered lower order thinking (LOT) include knowledge and comprehension while the thinking skills of synthesis and evaluation are considered higher order thinking (HOT). Application often falls in both categories [13]. In this study, application was categorized under HOTS. Student teachers need to apply concept learnt during studying into practice.One of the goals of higher order thinking skill is to create autonomous thinkers who have clarity of thought [12]. One way of promoting this is through written tests. The use of Bloom's taxonomy is supposed to be a must at the Teacher Training College because they train teachers who are to teach the future generation. Bloom's taxonomy is useful to assist lecturers to prepare questions and it provides the structure in which to categorize the assessment tasks. Some research studies have shown that faculty members have difficulties in assessing higher order thinking skills, such as the study done by Thompson (2008) where mathematics teachers were asked the interpretation of Bloom's taxonomy, and it was analyzed that many mathematics teachers do not fully understand the meaning of higher- order thinking and thus have difficulties in creating items for students. This concurs with several numbers of researchers [19] where the results show that teachers made tests measure the lower levels in Bloom's taxonomy. Stiggins (1989) studied the assessment practices (test questions and use of oral) of 36 teachers who taught mathematics, science, social and language arts at grade levels (1-12), minus mathematics items. Over one half of the test questions at all grade levels were recall (55%) followed by inference (19%), analysis (16%), comparison (5%) and evaluation (8%). In mathematics, 72% measured inference, 19% recall and 9% comparison. The role of higher institution of learning is to constantly improve the quality of students.

One of the method is to produce quality student is to educate them how to think rather than what to look for [20]. Teacher Training colleges, not only being one of the higher institution of learning but also train student teachers who will teach the future generation, have the task to produce teachers who are able to generate ideas. Abdul [1] and Beyer [3] stated that generation of ideas is categorized as a higher order thinking skills (HOTS) activity that requires high level creativity, thinking and action. Many people have defined HOT differently. For instance, [14] defined it as the creative formation of new knowledge based on old knowledge and the ability to apply owned knowledge to new situation. While [17] defined HOTS as the ability to apply, analyze, generate, integrate and evaluate.[10].They further stated that people need HOTS, both in school and in the world, so that they will not be just told what to think and what to do.

2. Literature review

A literature review is an account of what has been published on a topic by accredited scholars or researchers [15].A review of the literature on the topic was conducted. It was found that the Bloom's taxonomy has been around since 1956 and later revised by Anderson (2001). But, none had looked beyond evaluating students' thinking process. Case [5] highlights the Blooms taxonomy limits to students' capability to think beyond a sequence given. [18] also stated that it is insufficient in nurturing balanced attributes among students. [23]also viewed the Bloom's pyramid as somewhat giving wrong message about the importance of knowledge in learning. They further stated that application to history courses, treats knowledge as a dank concrete basement, necessary for a house's foundation but hardly worth of hosting honored guests. Despite all of those criticisms, many educational institutions globally use Bloom's taxonomy when assessing students' standards in higher-order thinking skill and Malawi is inclusive. Bloom's taxonomy is more influential than any other taxonomy. According to [16], it was designed in order to categorize examination questions at college level. They further stated that Bloom's taxonomy shows few signs of its age and is very concise and very well written. Bloom's Taxonomy of Educational objectives is a classification system by Educational psychologist, Benjamin Bloom, who created it. His aim was to make student aware of what they were learning hence strive to attain more sophisticated level of learning. It focuses on developing thinking ability which involves simple acquisition to more complex process [4]. It has been regarded for a long time as an important tool for cognitive development. The original framework comprised the following six categories: knowledge, comprehension, application, analysis, synthesis and evaluation. With the exception of knowledge, all categories were labeled as abilities and skills; for each of these, knowledge was deemed a prerequisite. The categories were presumed to constitute a cumulative hierarchy, that is, each category was conceived as building on and comprising a more advanced achievement than its predecessor.

1. Knowledge-which entails foundation cognitive skills that require students to retain specific, discrete pieces of information.
2. Comprehension-which requires students to paraphrase the content of knowledge in their own words, classify items in groups, compare and contrast items with similar entities or explain a principle to others.
3. Application-entailing students to use knowledge, skills, or techniques in new situation.
4. Analysis-which requires students to distinguish between fact and opinion and identify the claim upon which an argument is built.
5. Synthesis –This entails the need to create a new/novel product in a specific situation.
6. Evaluation-which requires students to critically appraise the validity of a study and judge the relevance of its results for application.

Bloom's taxonomy is widely and commonly used in Malawian teaching curriculum especially in testing and evaluating students' performance. Bloom's taxonomy is the blueprint for the Malawi government through its Malawi National Examination Board (MANEB). According to Benjamin Bloom's study in 1956, the cognitive approach of learning was the best since it makes an individual to activate his cognitive process . [22]stated that, in practice, thinking is not straight forward, and individuals use different cognitive processes at the same time without limiting it to one process only. This calls for lecturers not to limit tasks and questions which demand recalling information only but also which synthesize or analyze it. Lecturers need to plan assessment items which allow student teachers to use all the skills of the taxonomy.

3. Methodology

A mixed methodology was employed in order to gather reliable data. These were survey research using quantitative method of data collection and historical research. The study is an example of historic research because past event is used to predict a certain situation. The past events were 4 years end of term two mathematics question papers (2014, 2015, 2016 and 2017) academic years. Historical research is the systematic and objective location, evaluation and synthesis of evidence in order to establish facts and draw conclusion about past events [6]. The first part of the study was based on the analysis of responses from lecturers. A questionnaire was administered to Mathematics lecturers to find out their awareness of Bloom's taxonomy at various levels. The second part of the research study was the analysis of end of term two mathematics question papers set by lecturers. Each question paper from the three TTC was analysed using Bloom's taxonomy to establish the cognitive demand and knowledge level of each of the question in the test. A total of 8 question papers were analysed and examined. Each sub-question was treated as a full question and was categorized independently. Data was collected from the questionnaires which were completed by 19 lecturers from three TTCs. Another set of data came from the past papers which were independently reviewed by the researcher and a lecturer from Lilongwe University of Agriculture and Natural Resources. The two compared the examined questions and reconciled the differences that emerged. The collected data was analysed using IBM SPSS version 20. Tables, bar graphs and pie charts were used to present the findings.

4. Results

4.1 Questionnaire return rate

A response return rate is the percentage of questionnaires that participants return to the researcher [7].

Table 1:*Questionnaire return rate per college*

College	Questionnaires distributed	Questionnaires returned	Percetage
Chiradzulu	7	7	100%
Lilongwe	8	8	100%
Kasungu	8	4	50%
Total	23	19	82.6%

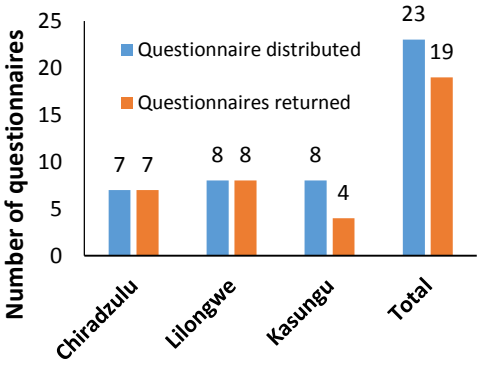

Figure 1:*Questionnaire return rate*

Table 1 and Figure 1 above show that the response return rate was good. More than 50% of respondents completed and returned the questionnaire.

4.2Demographic information of respondents
Lecturers were asked to indicate gender (Table 4).

Table 2: *Gender of lecturers*

Gender	Frequency	Percent
Male	15	78.9
Female	4	21.1
Total	19	100

Data on gender of lecturers indicated that 15-(78.9%) were males and 4-(21%) were females. There were more males than female lecturers. However, this did not affect the collection of information on bloom's taxonomy. Lecturers were asked to write their teaching experience (Table 3).

Table3: *Teaching experience of lecturers*

Teaching experience	Frequency	Percent
5 - 10 years	1	5.2
11 - 15 years	8	42.1
16 – 20 years	4	21.1
21 – 25 years	4	21.1
26 – 30 years	2	10.5
Total	19	100

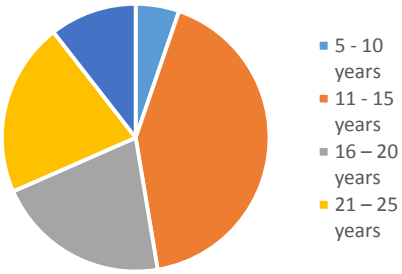

Figure2. *Teaching experience of lecturers*

Table 3 and Figure 2 above show that the majority of the respondents have 11 and above years of teaching experience. This is a clear indication that most of the respondents are aware of Bloom's taxonomy.

4.3 Analysis of responses received
Awareness of the Bloom's taxonomy by lecturers is presented in Table 4.

Table4:*Lecturer's awareness of Bloom's taxonomy*

Response	Frequency	Percent
Yes	19	100
No	0	0
Total	19	100

Are you aware of Bloom's taxonomy?

Table5: *Lecturer's awareness of the number of levels of the Bloom's taxonomy*

Response	Frequency	Percent
5	0	0
6	19	100
Total	19	100

How many levels are there in Bloom's taxonomy?

Table 6: *Proportion of lecturers who follow Bloom's taxonomy when setting exams*

Response	Frequency	Percent
Yes	19	100
No	0	0
Total	19	100

Do you follow Bloom's taxonomy when setting test?

Looking at Tables 4 to 6, the results show 100% that lecturers have perception on Bloom's taxonomy and they totally agree that they use BT when setting tests.

Table7:*Levels of Bloom's taxonomy commonly used in setting exams*

Level	Commonly used Frequency/percent	Not commonly used Frequency/Percent	Total
Knowledge	7 (36.8)	12 (63.2)	19 (100)
Comprehension	7 (36.8)	12 (63.2)	19 (100)
Application	12 (63.2)	7(36.8)	19 (100)
Analysis	6 (31.6)	13 (68.4)	19 (100)
Synthesis	4 (21.1)	15 (78.9)	19 (100)
Evaluation	5 (26.3)	14 (73.7)	19(100)

Which levels do you commonly use when setting tests?

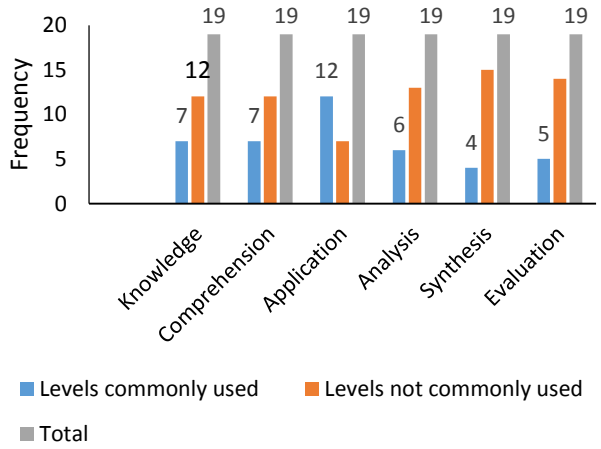

Figure3:*Levels of Bloom's taxonomy that are commonly used*

Table 7 and figure 3 depict that the highest frequencies are on knowledge (36.8%), comprehension (36.8%) and application (63.2%). These are the levels which lecturers commonly use when setting tests. The first two levels do not require students to demonstrate more abstract thinking. They demand students just to recall, memorize and repeat facts that the learnt like in case of knowledge level. Comprehension level requires students to classify and describe while application level shows a bit of abstract concepts through applying and solving problems. These first two levels encourage rote learning. Rote learning is whereby a student incorporates new information into the pre existing knowledge structure but without interaction [1].

Table 8:*Levels of Bloom's taxonomy rarely used in setting exams*

Level	Rarely used Frequency/percent	Not rarely used Frequency/percent	Total
Knowledge	6 (31.6)	13 (68.4)	19 (100)
Comprehension	0 (0)	19 (100)	19 (100)
Application	1 (5.3)	18 (94.7)	19 (100)
Analysis	3 (15.8)	16 (84.2)	19 (100)
Synthesis	6 (31.6)	13 (68.4)	19 (100)
Evaluation	12 (63.2)	7 (36.4)	19(100)

Which levels do you rarely use when setting tests?

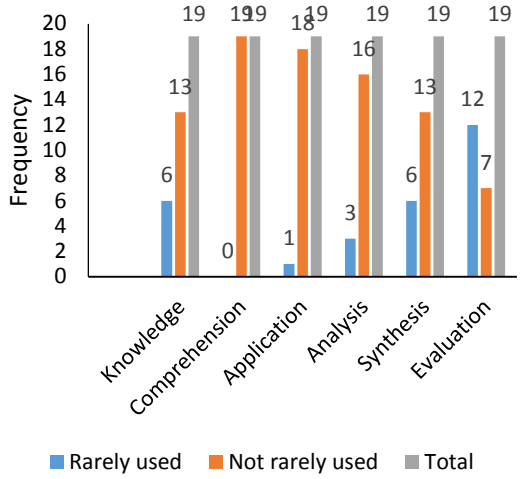

Figure 4: *Bloom's taxonomy levels rarely used*

Table 8 and figure 4 shows that lecturers seldom use evaluation 12 (63.2%) yet it is also one of the levels like analysis, synthesis and application which contain more cognitive complexity. The tasks at these levels require students to use information taught and develop their own ideas, draw conclusion and expand the content in a unique way.

Table 9:*Levels of Bloom's taxonomy that promote higher order thinking skills*

Level	Promote HOT Frequency/Percent	Do not promote HOT Frequency/Percent	Total/ Percent
Knowledge	0 (0)	19 (100)	19 (100)
Comprehension	0 (0)	19 (100)	19 (100)
Application	6 (31.6)	13 (68.4)	19 (100)
Analysis	17 (89.5)	2 (10.5)	19 (100)
Synthesis	16 (84.2)	3 (15.8)	19 (100)
Evaluation	19 (100)	0 (0)	19 (100)

Which levels promote higher order thinking skills?

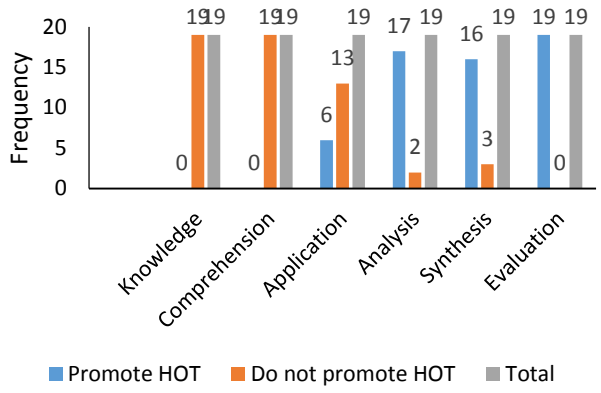

Figure 5:*Levels of Bloom's taxonomy that promote higher-order thinking skills*

Table 9and figure 5 indicates that lecturers know that application, analysis, synthesis and evaluation promote HOTS. The findings show that many lecturers ticked application 6 (31.6%) analysis 17 (89.5%), synthesis 16 (84.2%), evaluation 19 (100%). None ticked on comprehension and knowledge. This is a clear indication that lecturers know that HOTS is regarded as being a crucial component of 21 century. Therefore, there is a necessity for them to focus much on these levels when setting tests. However, this does not agree with what the practice which has been indicated in (table 9) where (12 out of 19) indicated that they commonly use application while (7 out of 19) indicated that they commonly use knowledge and application.

4.4 Analysis from the question papers

Table 10:*Number of questions analysed per college*

College	Frequency	Percent
Chiradzulu	57	24.7
Kasungu	96	41.6
Lilongwe	78	33.8

Table 10 indicates that Kasungu had more questions than Lilongwe despite contributing equal number of question papers. This might be due to differences in marks distribution per question. While Chiradzulu contributed the least questions because it also contributed papers for only two academic years instead of three.

Table 11: *Number of questions per level*

Levels	Frequency	Percent
Knowledge	69	29.9
Comprehension	18	7.8
Application	31	13.4
Analysis	83	35.9
Synthesis	19	8.2
Evaluation	11	4.8

Table 11 shows that questions on analysis level dominated 83 (35.9%), seconded by knowledge 69 (29.9%), followed by application 31 (13.4%), synthesis 19 (8.2%), comprehension 18 (7.8%), the least was evaluation 11 (4.8%). This implies that lecturers asked more questions on medium level followed by lower level and higher level questions were the least. The most least was evaluation. This concurs with what many lecturers answered on question number 5 on the questionnaire: Which asked, "Which level do you rarely use when setting tests?"(Many ticked evaluation)

Table 12:*Number of questions on each level of Bloom's taxonomy per Teacher Training College*

Level	**Teacher Training College**			**Total**
	Chiradzulu	**Kasungu**	**Lilongwe**	
Knowledge	8	32	29	69
Comprehension	7	7	4	18
Application	14	13	4	31
Analysis	19	40	24	83
Synthesis	5	3	11	19
Evaluation	4	1	6	11
Total	57	96	78	231

Table 12 designates that all colleges asked more questions on analysis level. Chiradzulu had 19 out of 57;Kasungu had 40 out of 96. For Lilongwe, questions on analysis came second to knowledge with 24 out of 78. Analysis is among the levels which promote HOTS. It requires students to break down knowledge into parts and show relationships among the parts.

Table13: *Recoded Bloom's taxonomy into low, medium and high per Teacher Training College*

College	Recoded Bloom's taxonomy						Total	
	Lower level		Medium level		Higher level			
	F	P	F	P	F	P	F	P
Chiradzulu	15	26.3	33	57.9	9	15.8	57	100
Kasungu	39	40.6	53	55.2	4	4.2	96	100
Lilongwe	33	43.3	28	39.9	17	21.8	78	100

F= Frequency P= Percentage

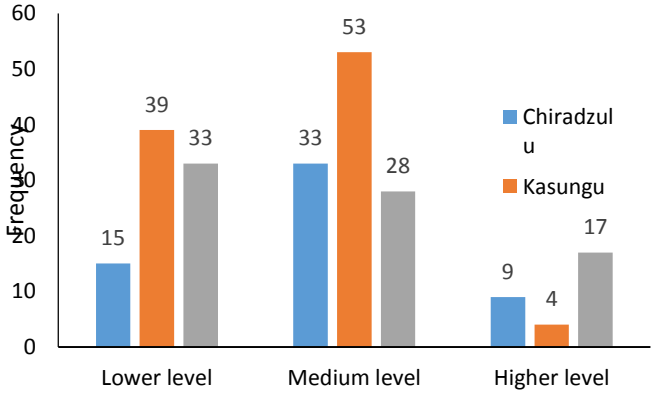

Figure 6: *Recoded cognitive levels of Bloom's taxonomy*

Table 13and figure 6 stipulates that the colleges had 87 (37.7%) lower level questions, 114 (49.4%) medium and 30(13%) higher level questions. Lower level comprises of

knowledge and comprehension, medium level comprises of application and analysis while higher level includes synthesis and evaluation. The table further reveals that Chiradzulu and Kasungu colleges had more questions on medium level [33(57.9%) n=57, 53(55.2%) n=96] respectively, while Lilongwe had more questions on knowledge level [33(42.3%) n=78]. Among the three colleges, Lilongwe had the highest number of questions on higher level, followed by Chiradzulu and then Kasungu.

Table 14:*Cognitive levels in question papers per year*

Level	2014	2015	2016	2017	Total
Knowledge	12	20	18	19	69
Comprehension	3	5	2	8	18
Application	3	10	5	13	31
Analysis	13	16	22	32	83
Synthesis	2	4	5	8	19
Evaluation	0	2	5	4	11
Total	33	57	57	84	231

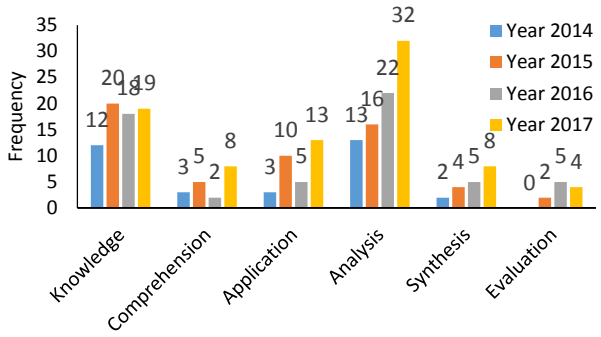

Figure 7: *Cognitive levels per year*

According to the data in Table 14 and depicted in Figure 7, 2014 had more questions on analysis level 13 (n=83), followed by knowledge 12 (n=69). There was none on evaluation. Comprehension and application each accounted for 3 while synthesis had 2 (n = 19).2015 had more questions on knowledge level 20, (n =69). The least used level was evaluation accounting for 2 (n=11).2016 had also more questions on analysis which accounted for 22(n=83), followed by knowledge with 18(n=69). Application, synthesis and evaluation each accounted for 5 (n=, 31, 19, 11, respectively).2017 had also more questions on analysis level which constituted 32(n=83), followed knowledge 19(n=69).Questions on evaluation level were also least used in 2017.

Table 15:*Cognitive levels in questions per section*

Level	Section A	Section B	Total
	Frequency (n, %)	Frequency (n, %)	
Knowledge	29 (42%)	40 (58%)	69
Comprehension	3 (16.7%)	15 (83.3)	18
Application	8 (25.8%)	23 (74.2%)	31
Analysis	80 (96.4%)	3 (3.6%)	83
Synthesis	1 (5.3%)	18 ((94.7%)	19
Evaluation	6 (54.5%)	5 (45.5%)	11
Total	127	104	231

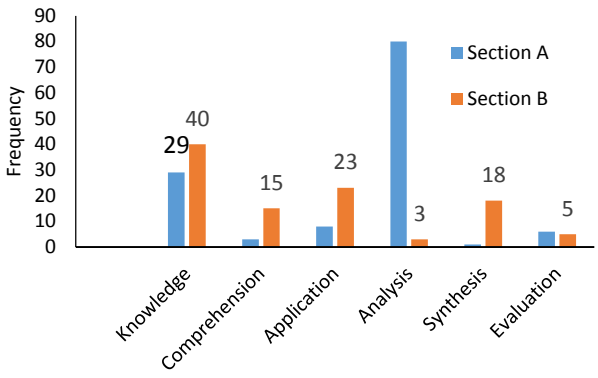

Figure 8: *Cognitive levels per section*

According to data in Table 15 and as depicted in Figure 8, questions on knowledge dominated in section B. There were 40 questions (n=69) while in section A, questions on analysis dominated at 80 (n=83).Section B had also more questions on application than section A. The reason could be, section consists of questions on content while section B most of the time consists of questions on methodology. Therefore students are required to apply what they learnt.

4.5 Results from chi square test using the recoded levels

Chi square = 17.745, df 4, P < 0.05

Calculated value 17.745, critical value/table value was 9.488 The test provides that there is a statistically significant difference. Lecturers promote higher order thinking skills by asking more questions from medium, followed by lower level and the least from higher level. This outcome is in support of what lectures indicated on the questionnaire that they follow Bloom's taxonomy when setting tests, they also indicated that analysis, synthesis and evaluation are the levels which promote HOTS. This partly agrees with [21]' study who found that teachers who defined higher order thinking as involving problem solving, discovering patterns, interpreting information and conceptual understanding were much more likely to formulate higher order thinking items than teachers who did not use those terms.

5. Discussion of the findings

Although the findings are restricted to 3 public Teacher Training colleges, the finding of this study revealed that 19 lecturers who completed the questionnaire, 100% are aware of the BT, 100% know the different levels of BT and 100% follow the BT when setting tests. Many lectures have concept on the levels that promote HOTS. The study further revealed that lectures frequently used HOTS questions especially the analysis level which dominated, although the percentage of HOTS (62.3 %) was not enough for a higher learning institution. This is line with the study of [11] who found that proportion of questions pertaining to HOTS is much less than the expected of higher institution. It is necessary to encourage lectures to distribute number of questions on each level uniformly. Synthesis and evaluation were not very much put into consideration as levels that promote HOTS. To assess that student can demonstrate mastery, lectures need to plan assessment items that allow students to use all the skills of BT especially those promote HOTS (application, analysis, synthesis and evaluation).

These levels encourage students to think more deeply and critically and also stimulate them to seek information on their own.

6. Summary

They study was analyzing Mathematics question papers for term two in 3 public TTCs to find out if lectures promote higher- order thinking skills during written assessment and also to find out if they are aware of levels of Bloom's taxonomy of cognitive objectives. A mixed method was used to collect data thus survey and historical. The target population was 3 public TTCs which were randomly selected. The sample size consisted of all lecturers who teach mathematics in the department of science and technology who answered the questionnaire. It was a self-administered questionnaire. All mathematics question papers from 2014-2017 were collected from the 3 TTCs. A total of 231 questions were examined and categorized according its level of difficult using the framework of Bloom's taxonomy of cognitive of objectives. The study revealed that all levels of questions were evident in the question papers. 69 (29.9%) knowledge, 18 (7.8%) comprehension, 31(13.4%) application, 83(35.9%) analysis, 19(8.2%) synthesis and 11(4.8%) evaluation. The findings in this study reflected a difference in HOTS (62.3%) and LOTS (33.7%) which is good. Lecturers have to promote HOTS since they train future teachers who are to teach children of 21 century. [10]states that people need HOTS, both in school and in the world, so that they will not be told what to think and what to do.

7. Conclusion

One of the key objectives of education is to develop students' intellectual through teaching and assessment. This is done through the use on a framework like BT which focuses on cognitive. This study analysed Mathematics question papers and categorized each question using Bloom's taxonomy to find out if lecturers promote HOTS. The study also wanted to find out if lecturers have concept on the taxonomy. According to the findings of this study, lecturers (100%) indicated that they are aware of BT 100% indicated that they use BT when setting tests, and they also promote higher-order thinking by asking questions from higher level of BT. The majority of lecturers mentioned evaluation, synthesis and analysis as levels which promote HOTS. The HOTS questions accounted for 62.3%. However, they study demonstrated that lecturers concentrated mainly on analysis level constituting 35.9%.

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