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Analysis of Levels of Thinking Required in West African Senior Secondary School Certificate in Core Mathematics Multiple Choice Items

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Abstract

This study analyzed levels of thinking required by West African Senior School Certificate in core Mathematics Multiple Choice Items (MCI). The purpose of this study to investigate whether this claim by the students is correct. Survey design was adopted for the study and 2013 and 2014 WAEC Mathematics MCI were adopted. Purposive sampling technique was used to select the 2013 and 2014 test items. Data analysis was carried out using frequency and percentage and chi-square test. Findings revealed that the level of thinking required in 2014 Mathematics WAEC multiple choice items from the students were different from one level to another. However, the items that required higher level of thinking were 34 (68%) which is higher than the items requiring lower level of thinking, 16 (32%). Thinking required by 2013 Mathematics WAEC multiple choice items varied, and the items required students to demonstrate both lower and higher level of thinking skills. Thus, the items that required students to think at lower and higher levels of thinking were equal. Also, no significant difference was found in the thinking level required in 2013 and 2014 Mathematics WAEC Multiple Choice Items. It was recommended that WAEC Mathematics items should be adequately distributed across the cognitive domain of Bloom's Taxonomy of educational objectives to improve students' performance in Mathematics.

Keywords: Levels of Thinking, Multiple Choice Items, Mathematics Performance

Introduction

Education is an instrument for national development. This is because it is the instrument used in developing the citizens who in turn contribute to the development of the nation. According to Afolabi (2010), the quality of a nation's education determines the quality of the products of its educational system and by extension the quality and quantity, pace and level of its development. This is probably why every nation tends to invest more into getting their populace educated. However, the integrity of the entire educational system depends, to a large extent, on the quality of its assessment practices.

Assessment is a major tool employed in the process of appraising candidates' achievement; it plays a major role in the educational process and development. It helps to ascertain the extent to which the educational policy is successful and could be a sort of quality control for checking the educational policy vis-à-vis the curriculum. Educational assessment is therefore the totality of the processes involved in making valid judgments about what behavioral characteristics and changes a learner has acquired through the process of teaching and learning. One of the ways of assessing students is using test, which can either be essay or objective. In spite of the fact that the setting of objective test items takes much time, its advantages include wider content coverage, objectivity and easy to mark (it can even be electronically marked).

Examination (internal or external) is a frequently used assessment tool, which provides indices of students' achievement. Gronlund (1971) described evaluation as systematic processes of determining the extent to which instructional objectives are achieved by students. Therefore, the success or failure of an educational practice could be decided, to a large extent, by the degree of students' achievements. It therefore becomes imperative for teachers to make use of best evaluation practices in order to help the students to have better results in internal and external examinations. Imbalance assessment of students' achievement could arise when test items are not spread to cover different levels of learning objectives.

Instructional objectives in education are concrete statements of the goals toward which instructions are directed. The Taxonomy of Educational Objectives are in three categories- cognitive (knowledge based), affective (value, attitude and feeling based) and psychomotor (skill based). This paper focuses on the cognitive domain of Bloom's Taxonomy of Educational objectives. Bloom's Taxonomy offered a classificatory system for educational goals that can be used in test constructions if assessment is to be balanced. It has six levels of thinking process objectives. These are Knowledge, Comprehension, Application, Analysis, Synthesis and Evaluation. Knowledge and Comprehension are lower-level cognitive objectives while application, analysis, synthesis and evaluation are higher-level cognitive objectives. These cognitive objective form a hierarchy, with knowledge being the objective prerequisite to all other objectives and evaluation being the objective to which all other cognitive objectives are prerequisite (Bart, 2008).

During the 1990s, a new group of cognitive psychologist, led by Lorin Anderson, a former student of Bloom, updated the taxonomy reflecting relevance to 21st century work. Bloom's Revised Taxonomy of Cognitive Objective is useful in planning curriculum that incorporates low to high level of thinking activities (Limbach&Waugh, 2009). In the update, there is a change from nouns to verbs to describe the different levels of taxonomy and the two top levels were interchanged. The categories of the revised version are:

- *Remembering:* Can students recall or remember the information? Words commonly used include duplicate, define, list, memorise, state etc
- *Understanding:* Can students explain ideas or concepts? Words commonly used include classify, describe, discuss explain, identify, locate, translate. etc
- *Applying:* Can students use the information in a new way? Words commonly used include demonstrate, choose, illustrate, interpret, solve, write, use etc
- *Analysing:* Can students distinguish between the different parts? Words commonly used include appraise, compare, contrast, criticize, differentiate, examine etc
- *Evaluating:* Can students justify a stand or decision? Words commonly used are appraise, argue, judge, support, evaluate etc
- *Creating:* Can students create new product or point of view? Words commonly used are create, construct, design, formulate and write, construct etc .

One of the things that distinguish the new model from the old is that it clearly laid out components to be considered. Array of knowledge are now factual (knowledge that is basic to specific disciplines), conceptual (knowledge of classifications, principles, generalizations, theories, models or structures in a particular

discipline), procedural (information that help learners to do something specific to a discipline or particular methodologies), metacognitive (awareness of one's cognition and particular cognitive processes. It is strategic or reflective knowledge about how to solve problems, cognitive tasks, to include contextual and conditional knowledge and knowledge of self) (Anderson & Krathwohl, 2000).

There is a persistent failure of students in mathematics examinations especially the senior school certificate this has called for greater concern among the stakeholders in education (i.e. parents, teachers, government, curriculum planners, the examiners and the students alike). This is because mathematics is so important that it touches the everyday life of every individual in the society. When mathematics is applied in the daily activities and experiences of every member of the society, the usefulness and beauty of the subject are better appreciated by all.

The immense contributions of mathematical sciences to rapid technological advancement in has confirmed the assertion that mathematics reflects the spirit of the times. Nurses or medical personnel have a lot to do with mixing substances of different strengths. They therefore should know relative sizes, volumes, weights and capacities of drugs and medicaments. Business men or women also make decisions about fast selling goods to purchase and decide on placing discount on slow moving items. They also study increase in sales as a result of advertisement and compare that with the cost of advertisement. The bus or truck- driver, carpenter, painter, brick-layer, gardener, farmer etc., all have to put up with a lot of mathematical processes in their daily operations. The value of mathematics in fields of learning such as engineering, architecture, agriculture, etc., can also not be taken for granted. It becomes imperative that students excel in mathematics so as to help them in their work places. Therefore, the poor performance of students in mathematics must be concern.

The poor performance of students in May /June Senior School Certificate Examinations is confirmed by a study conducted by Bello and Oke (n.d). They specifically indicated that the Core Mathematics results of students was not impressive and gave the following statistics to buttress their point. They indicated that for a four year continues period starting from 2006-2009, the average percentage credit passes by Ghanaian students in Core Mathematics were 31.3%, 25.2%, 26.1% and 28.62% respectively. For Nigeria also the same four year periods have the following percentage of passes, 41.92%, 46.75%, 57.27%, 47.04% respectively, Sierra Leone, 3.62%, 4.22%, 3.46%, 3.22% respectively and The Gambia 3.07%, 3.31%, 2.64%, 3.19%. Querying this persistent low performance in mathematics, Ale (1989) submitted that students' blame it on teaching problems, negative attitude and examination difficulty. This presupposes that WAEC mathematics test items are seen by students to be very difficult, perhaps above their thinking levels. But, Rollin (1990) asserted that a person's knowledge and thinking abilities are crucial for that person to function efficiently and successfully in this present age. This therefore has motivated the researchers to investigate the nature of WAEC core mathematics multiple choice test items using Bloom's Taxonomy to see the thinking levels within which the test items are concentrated. Finding of this study would be useful to test developers, students, teachers' researchers and examination bodies.

Research Questions

Answers were sought to the following questions in this study:

1. At what thinking levels are the 2013 Mathematics WAEC Multiple choice items?
2. At what thinking levels are the 2014 Mathematics WAEC Multiple choice items?
3. Is there difference in the thinking level required by the 2013 and 2014 Mathematics WAEC Multiple choice items?

Research Hypothesis

Ho_1: *There is no significant difference in the thinking level required by 2013 and 2014Mathematics WAEC Multiple Choice Items*

Hi_2**:** *There is significant difference in the thinking level required by 2013 and 2014 Mathematics WAEC Multiple Choice Items*

Methodology

The research design adopted for this study was descriptive survey. The data were gathered with the use of multiple-choice tests of WAEC for the 2013 and 2014 Senior Secondary School Certificate Examination (SSSCE) in mathematics. Purposive sampling technique was used to select the 2013 and 2014 tests: this was because they were the most current test items by the time this study was conducted. The unit of analysis consisted of all the hundred test items for both 2013 and 2014. Data analysis was done by using frequency and percentage; and chi-square statistics was used to analyse the hypothesis raised.

Results

Research Question One: At what thinking levels are the 2013 Mathematics WAEC Multiple choice items?

Table 1: Frequency and Percentage of thinking levels of 2013 Mathematics WAEC Multiple Choice Items

Level of Thinking	Frequency	Percentage
Remembering	9	18.0
Understanding	8	16.0
Applying	8	16.0
Analyzing	13	26.0
Evaluating	9	18.0
Creating	3	6.0
Total	**50**	**100.0**

Table 1 shows the frequency and percentage of thinking levels required in 2013 Mathematics WAEC multiple choice items. From the table, 9 (18.0%) of the 2013 Mathematics WAEC multiple choice items required students to think at remembering level, 8(16%) required students to think at understanding level, 8(16%) required students to think at applying level, 13(26%) required students to think at analyzing level, 9(18%) required students to think at evaluating level and 3(6%) required students to think at creating level.

Table 2: Order of Thinking Required by 2013 Mathematics WAEC Multiple Choice Items

Order of Thinking	**Frequency**	**Percentage**
Lower Order	25	50
Higher Order	25	50
Total	**50**	**100**

The analysis in table 1 and 2 shows that 25 (50%) 2013 Mathematics WEAC multiple choice items required students to think at lower order while 25 (50%) required students to think at higher order.

Research Question Two: At what thinking levels are the 2014 Mathematics WAEC Multiple choice items?

Table 3: Frequency and Percentage of thinking levels of 2014 Mathematics WAEC Multiple Choice Items

Level of Thinking	**Frequency**	**Percentage**
Remembering	7	14.0
Understanding	6	12.0
Applying	3	6.0
Analysing	20	40.0
Evaluating	4	8.0
Creating	10	20.0
Total	**50**	**100.0**

Table 3 shows the frequency and percentage of thinking levels required of 2014 Mathematics WAEC multiple choice items. From Table 3, 7 (14.0%) of the 2014 Mathematics WAEC multiple choice items required students to think at remembering level, 6(12%) required students to think at understanding level, 3(6%) required students to think at applying level, 20(40%) required students to think at analyzing level, 4(8%) required students to think at evaluating level and 10(20%) required students to think at creating level.

Table 4: Order of Thinking Required in 2014 Mathematics WAEC Multiple Choice Items

Order of Thinking	**Frequency**	**Percentage**
LowerOrder	16	32
Higher Order	34	68
Total	**50**	**100**

The analyses in Table 3 and 4 shows that 16 (32%) 2014 Mathematics WEAC multiple choice items required students to think at lower order while 34 (68%) required higher order thinking.

Hypothesis One: There is no significant difference in the thinking level required in 2013 and 2014 Mathematics WAEC Multiple Choice Items

Table 5: Chi- square Analysis of Thinking Levels of 2014 Mathematics WAECMultiple Choice items

Level of Thinking		**2013**	**2014**	**Total**	**df**	$X^2 -$ value	**p- value**
Remembering	Count	9	7	16			
	Expected	8.0	16.0				
Understanding	Count	8	6	14			
	Expected	7.0	14.0				
Applying	Count	8	3	11			
	Expected	5.5	11.0				
Analysing	Count	13	20	33	5	9.986	0.76
	Expected	16.5	33.0				
Evaluating	Count	9	4	13			
	Expected	6.5	13.0				
Creating	Count	3	10	13			
	Expected	6.5	13.0				
Total	Count	50	50	100			
	Expected	50.0	100.0				

Result in Table 5 shows chi-square calculated value of 9.986 with 0.76 p-value at 0.05 alpha level. On this basis, the null hypothesis that there is no significant difference in the thinking level required by 2013 and 2014 Mathematics WAEC Multiple Choice Items is accepted because the p-value 9.986 is greater than 0.05 alpha level (9.986 >0.05).

Discussion

Based on findings of the study, it was revealed that the level of thinking required in 2013 Mathematics WAEC multiple choice items varied. Also, it was observed that, the items required students to demonstrate both lower and higher levels of thinking skills. Analysis of 2013 showed equal numbers of items for both the lower level and the higher level of thinking. This could be to strike balance between upper and lower ability group of testees, which is not appropriate at senior secondary education. WAEC must aimed at developing higher thinking skills of students by setting questions at the higher thinking levels. It was observed that much of today's classroom learning focuses on activities by which the learners acquire facts, rules and action sequences and the majority of lessons require outcomes only at the lower level of cognition: knowledge, comprehension

and application. Freiberg (1999) observed that when teachers-centered approaches are used in these classrooms compliance is valued on initiative and passive learners over active learners hence it may deprive learners of critical thinking opportunities. Thomas (1992) suggested that different teaching strategies, alternative assessment methods, and new ways of teacher preparation are needed.

In addition, the finding revealed that the level of thinking required in 2014 Mathematics WAEC multiple choice items from the students were different from one level to another. However, the percentage of items that required higher level of thinking 34 (68%) was higher than the items required at lower level of thinking 16 (32%). This finding was supported by Harrow (1972) who observed that unless students can be brought to the higher levels of thinking which are analyzing, evaluating and creating, it is unlikely that transfer of knowledge will take place. Though, encouraging critical thinking necessitates that more items that require higher level of thinking should be included in test. A larger proportion of items that require higher level of thinking would be expedient at tertiary level of education. This however was of good practice by WAEC in developing students' critical thinking skills.

Conclusion

There have been a lot of concerns with regard to the low performance of students in examinations conducted by WAEC especially in core mathematics. Students' seem to hold the opinion that their failure in this core subject is due to difficult of items among others. The analysis of the thinking levels of 2013 and 2014 WAEC multiple choice items agreed with the complaints of the students as one of the stakeholders. The test items seem to have been constructed for brilliant students to pass without taking care of the average and dull students because the bulk of the questions fall within the higher order level of thinking. This shows that the questions are drawn in favour of the high academic achievers and not in favour of low academic achievers i.e. the questions are in the higher cognitive levels for the brilliant students.

To improve students' critical thinking, WAEC Mathematics items must include higher order items to challenge students in our schools.

Recommendations

Based on the findings of this study, the following recommendations are made to relevant educational authorities and examination bodies and other stakeholders in education.

1. Critical thinking skills should be included into school curriculum at all levels
2. Teachers and item writers should be trained to be highly skilled in item writing and how to include critical thinking skills in their daily lessons plan.
3. Teachers should make use of classroom assessment techniques to enhance and facilitate critical thinking skills among their students
4. Critical thinking skills should be included into teacher education programme to improve the quality of teacher training and enhance the teaching of critical thinking in our schools
5. Teachers should make use of classroom assessment techniques to enhance and facilitate critical thinking skills among their student
6. WAEC should review their Mathematics multiple choice items to take care of higher and lower achiever students in the school and
7. WAEC Mathematics items should be adequately distributed across the cognitive domain of Bloom's Taxonomy of educational objectives to increase students' performance in Mathematics.

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Contributions

Andrews…… originator of topic and introduction

Dorcas……..... collection of data and the analysis

Henry…… formulation of hypotheses and discussions of findings

Adekunle……..conclusion, recommendations and references