ANALYSIS OF SECONDARY SCHOOL CERTIFICATE CHEMISTRY EXAMINATION QUESTIONS CONDUCTED BY NATIONAL BUSINESS AND TECHNICAL EXAMINATIONS BOARD (NABTEB) FOR COGNITIVE COMPLEXITY

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Abstract

Current trends in educational reform laid emphasis on assessing higher order cognitive skills in educational assessment. This study analyzed the cognitive complexity of Chemistry examination questions conducted by NABTEB from 2012 to 2017. The study adopted the content analysis method in which a total of 285 Chemistry questions were analyzed using the revised Bloom's taxonomy. Findings from the study revealed that majority of the questions required students to operate in the lower order cognitive process skills of "remember", "understand", and "apply" while, few of them assessed students in the analyze category. The study therefore concluded that Chemistry examination questions conducted by NABTEB assessed students in the LOCS with very few questions in the "apply" category. It was recommended among others that examination bodies should ensure that questions are distributed across all levels of cognitive domains since most teachers and students rely on these questions for practice.

Keywords: Assessment, Examination, Complexity, Taxonomy.

Introduction

Assessment in education is closely connected to curriculum and instructions. It is described as the bridge between the teaching and learning process. It gives insight to whether instructional activities results to the objectives of teaching (Wiliam, 2013). It serves as a means to provide feedback to teachers and students regarding the progress of their teaching and learning activities. Therefore, it can be regarded as an educational tool that is used to measure teaching and learning effectiveness.

Assessment could be formative or summative (Garrison & Ehringhaus, 2010). Formative assessment provides timely information regarding the teaching and learning processes while instruction is ongoing. However, the summative assessments are periodical assessment given to learners at the end of a course. They are associated with standardized test such as West Africa Senior School Certificate Examinations (WASSCE), Senior School Certificate Examinations (SSCE) and National Business and Technical Examinations Board (NABTEB) examinations. They are also used as part of classroom management in grading processes and used to identify effectiveness of educational programmes.

Senior Secondary Certificate Examinations in Nigeria

Standardized examinations are conducted after completion of a three year secondary school education in Nigeria. The examination bodies saddled with the responsibility of conducting such examinations include the West African Examinations Council (WAEC), National Examinations Council (NECO) and National Board for Technical Education Board (NABTEB). The results of these assessments with a combination of the Unified Tertiary Matriculation Examinations (UTME) are prerequisite to securing admission into any tertiary institution in Nigeria. The WAEC and NECO conduct two series of examinations in a year namely; the West African Secondary School Examination (WASSCE) and Secondary School Certificate Examinations (SSCE) which are conducted in May/ June and November/ December respectively. The May/ June examination is conducted for students who had just completed their secondary school

education while the November/ December are for private candidates.

The WASSCE examination has been autonomous in Nigeria before the establishment of NABTEB in 1992 and NECO in 1999. The establishment of NECO and NABTEB becomes imperative to reduce the work load of WAEC. The NABTEB was established to oversee the craft level examinations which were conducted by City and Guilds, Pittman's and Royal Society of Arts in UK. The NABTEB conducts examination such as National Business Certificate (NBC), National Technical Certificate (NTC), as well as advanced level examinations of NBC and NTC, and Modular Trade Certificate (MTC) Examinations. Owing to the mission of the board to be a globally acknowledge body for craft men and technicians aimed at preparing candidates for the world of work, it is important that the board conducts examinations that adopts the current reforms in educational assessment. This current reform emphasizes on the need to assess students in higher order cognitive skills and metacognitive knowledge. This study therefore is concerned with cognitive complexities of chemistry questions conducted by the National Business and Technical Examinations Board in Nigeria.

Overview of the Revised Bloom's Taxonomy

Bloom's taxonomy is a framework for classifying the intents of teaching and learning. It is a means of facilitating the exchange of test items to create banks of items measuring the same behavioural objectives (Krathwohl, 2002). The taxonomy was originally initiated by Benjamin Bloom and it consists of six categories which are knowledge, comprehension, application, analysis, synthesis and evaluation. These categories are arranged in their order of complexities (simple to complex; concrete to abstract). The Bloom's taxonomy is used to classify curricular objectives and test items to show their intensity across the spectrum of categories. This original taxonomy encapsulates the noun phrase (subject matter) and the verb phrase (what will be done to the subject matter) recognizing one dimension.

Anderson and Krathwohl (2002) revised the original taxonomy and identified the cognitive process dimension and the knowledge dimension. The knowledge dimension in the revised taxonomy emphasized what the subject matter assesses. It contains four subcategories in order of abstractness. It includes; factual, conceptual, procedural and metacognitive knowledge respectively. The factual knowledge is the least abstractive while the metagcognitive knowledge is most on the taxonomy table. The factual knowledge deals with the knowledge of terminologies, specific details and elements that students should be acquainted with in a discipline. The conceptual knowledge includes knowledge of classification and categories, principles, themes e.t.c while the procedural knowledge includes knowledge of specific skills, techniques, methods and criteria to use appropriate procedures in a given instance. The metacognitive knowledge deals with the knowledge of one's cognition. It includes; strategic knowledge, knowledge about cognitive tasks and self-knowledge (Krathwohl, 2002).

The cognitive process dimension retains the original Bloom's taxonomy with some modifications. The subcategories of knowledge, comprehension and synthesis were renamed as remember, understand and create respectively while application, analysis and evaluation were retained as apply, analyze and evaluate respectively. Hence, categories of the cognitive process dimension in the order of simple to complex include; remember, understand, apply, analyze, evaluate and create. The "remember" subcategory involves retrieving of relevant knowledge from the long term memory. It includes, recognizing and recalling. In the "understand" category, it involves deducing meaning from instruction while, "apply" subcategory demands that students carry out or use a procedure in a given situation. The "analyze" category involves the ability of learners to differentiate, organize and attribute in a specific instance while "evaluate" involves checking and critiquing to make judgment. To create is the most complex of this subcategory and it includes, generating, planning and producing new products. It involves learners' ability to put elements together to form a whole (Krathwohl, 2002).

Research Questions

The following questions have been formulated to guide the study:

i. What cognitive process skills are represented in the Chemistry examination questions constructed by the National Business and Technical Examinations Board?

ii. Are all categories of cognitive process skills represented in the Chemistry examination questions by National Business and Technical Examinations Board?

iii. Are all categories knowledge components featured in the Chemistry examination questions constructed by National Business and Technical Examinations Board?

iv. What percentage of knowledge components is measured in Chemistry examination questions constructed by National Business and Technical Examinations Board?

Review of Related Literature

Several studies have been conducted to assess the cognitive complexities of test items in standardized examinations (Okanlawon, 2016; Okoye & Nwafor, 2009; Upahi, Isreal & Olorundare, 2016; Dempster, 2012; Tikkanen & Aksela, 2012). Dempster (2012) investigated exit-level biology examinations in four countries; Ghana, Kenya, Zambia and South Africa. The study assessed the cognitive demand of the test items using the revised Bloom's taxonomy. Findings from the study revealed that a high percentage of the questions measured remember and factual knowledge and none of the questions measured metacognitive knowledge. This finding was similar to the findings of Okanlawon (2007); Okoye and Nwafor (2009) that compared the cognitive complexity of SSCE and WASSCE chemistry examinations. Okanlawon (2016) utilized the revised Bloom's taxonomy by Anderson and Krathwhol (2002) while Okoye and Nwafor (2009) utilized the original Bloom's taxonomy when they compared SSCE essay questions set by WAEC and NECO in Biology, Chemistry and Physics between years 2004 to 2007.

The findings of a more recent study by Upahi, Isreal and Olorundare (2016) on analysis of WASSCE chemistry examination using the framework of the revised Bloom's taxonomy revealed that 80% of the test items require students to operate on the lower order cognitive domain while 49.4% and 19.5% measured the conceptual and procedural knowledge respectively. This finding is contrary to the findings of Tikkanen and Aksela (2012) that analyzed Finnish chemistry matriculation examination questions who reported that 77% of the examination questions required learners to operate in higher order cognitive skills. Also, 79% of the questions assessed procedural knowledge but none of the question assessed metacognitive knowledge.

It is therefore evident from literature that chemistry examination questions conducted in Nigeria have focused its attention on measuring the lower order cognitive skills of learners without emphasis on their metacognitive knowledge. Hence, it is expected that examination bodies like the NABTEB that deals with technical and craft level examinations will differ from others, owing to their mandate. Therefore this study sets out to analyze the cognitive complexity of the board's chemistry examination questions.

Methodology

The study utilized the content analysis method. Purposive sampling technique was used to select May/June National Business and Technical Certificate Examinations questions in Chemistry conducted between the periods of 2012 to 2017. Specifically, the section B of Paper code; 005-1 Chemistry questions for the selected years were analyzed. The questions were designed such that each of them has a sub unit. However, in this study, each of the sub units was recognized as independent questions for ease of analysis. The sample for this study consisted of two hundred and eighty five (285) chemistry questions of the senior school certificate examination for the period of five years. The revised Bloom's taxonomy by Anderson and Krathwohl (2001) was used to categorize the questions into their cognitive complexities. Questions in "remember", "understand" and "apply" are categorized as lower order cognitive skills (LOCS) while the questions in "analyze", "evaluate" and "create" are categorized as higher order cognitive skills (HOCS).

To ensure validity of the items, an inter rater reliability was conducted by randomly selecting 20% of the items for two raters that have an understanding of the revised Bloom's taxonomy. The reliability was calculated using Cohen Kappa statistics. k-values of 0.71 and 0.62 were obtained for the knowledge and cognitive process dimension respectively which signifies a substantial agreement between the two raters.

Data Analysis and Results

Research Question 1: What cognitive process skills are represented in the Chemistry examination questions constructed by the National Business and Technical Examinations Board?

Table 3 presents the distribution of the 285 chemistry questions according to the years of the examinations and the cognitive process skills such examination questions were designed to measure. Only 12.7% of the chemistry questions were at the higher levels of the cognitive domain (analyze and evaluate) while none of the test items measures "create" category. On the other hand, 87.3% of the questions were at the lower levels of the cognitive domain (25.6%, 36.5% and 22.3%) of the questions as they require students to "remember", "understand" and "apply" respectively.

Table 3: Distribution of Chemistry examination questions constructed by NABTEB according to year and the cognitive process dimension

Year	Remember		Understand		Apply		Analyze		Evaluate		Create		Total	
	Freq.	%	Freq.	%	Freq.	%	Freq.	%	Freq.	%	Freq.	%	Freq.	%
2012	8	23.5	12	35.3	8	23.5	6	17.6	0	-	0	-	34	11.9
2013	10	28.6	15	42.9	4	11.4	6	17.1	0	-	0	-	35	12.3
2014	17	34.0	14	28.0	8	16.0	11	22.0	0	-	0	-	50	17.5
2015	8	15.0	22	41.5	16	30.2	7	13.2	0	-	0	-	53	18.6
2016	11	28.2	14	35.9	11	28.2	3	7.7	0	-	0	-	39	13.7
2017	29	39.1	33	44.6	9	12.2	2	2.7	1	1.4	0	-	74	26.0
Total	**83**	**29.1**	**110**	**38.6**	**56**	**19.6**	**35**	**12.3**	**1**	**0.4**	**0**	-	**285**	**100**

Research Question 2: Are all categories of cognitive process skills represented in the Chemistry examination questions by National Business and Technical Examinations Board?

Table 4 presents the distribution of the number of questions that assess the students' Lower Order Cognitive Skills (LOCS) and Higher Order Cognitive Skills (HOCS). The percentages of questions that assess students' in HOCS are represented in the "analyze" and "evaluate" category only. This category (HOCS) recorded the highest percentage in 2014 showing 22% of the questions in the "analyze" level while the lowest was recorded in 2017 with 4.1%. However, none of the questions assessed the HOCS in "create" level. In the LOCS category featuring "remember", "understand" and "apply" level, the highest percentage of questions was recorded for 2017 (95.9%) while the lowest was recorded in 2014 (78.0%).

Table 4: Distribution of the number of questions that assess the students' LOCS and HOCS

Years	LOCS		HOCS		Total	
	Freq	%	Freq	%	Freq	%
2012	28	82.4	6	17.6	34	11.9
2013	29	82.9	6	17.1	35	12.3
2014	39	78.0	11	22	50	17.5
2015	46	86.8	7	13.2	53	18.6
2016	36	92.3	3	7.7	39	13.7
2017	71	95.9	3	4.1	74	26.0
Total	**249**	**87.4**	**36**	**12.6**	**285**	**100**

Research Question 3: Are all categories knowledge components featured in the Chemistry examination questions constructed by National Business and Technical Examinations Board?

Table 5 presents the distribution of the questions based on the knowledge dimension. The questions under the year of study featured the factual, conceptual and procedural knowledge. However, none of the questions assess the students' metacognitive knowledge about chemistry.

Table 5: Distribution of Chemistry examination questions according to year and the knowledge dimension

Year	Factual		Conceptual		Procedural		Total	
	Freq	%	Freq	%	Freq	%	Freq	%
2012	8	23.5	15	44.1	11	32.4	34	11.9
2013	7	20	17	48.6	11	31.1	35	12.3
2014	14	28	21	42	15	30	50	17.5
2015	6	11.3	30	56.6	17	33.1	53	18.6
2016	10	25.7	19	48.7	10	25.6	39	13.7
2017	26	35.1	30	40.1	18	24.3	74	26.0
Total	**71**	**24.9**	**132**	**46.3**	**82**	**28.8**	**285**	***100***

Research Question 4: What percentage of knowledge components is measured in Chemistry examination questions constructed by National Business and Technical Examinations Board?

Table 5 shows the distribution of the questions based on the years of examination and the knowledge dimension assessed by the questions. It revealed that 24.9%, 46.3% and 28.8% of the examination questions assessed the factual, conceptual and procedural knowledge respectively. However, metacognitive category of knowledge dimension was not featured in the questions across the years.

Discussion

Findings on the cognitive process skills measured by these examination questions revealed that few (12.6%) of the chemistry questions assessed the higher order cognitive skills. This implies that a large number (87.4%) of chemistry questions requires learner to operate at the lower level of cognitive process skill. This could be attributed to the fact that, not so much emphases is placed on the development of students' HOCS during teaching; hence students are not assessed based on these skills. This finding is contrary the findings of Tikkanen and Aksela (2012) who reported that majority of the Chemistry examination questions required higher order cognitive skills in university entrance and matriculation examination questions. On the other hand, the findings are similar to the findings of Upahi, Isreal and Olorundare (2016) and Okanlawon (2016), that reported that the cognitive levels of understand and apply were over-represented in chemistry examinations.

The findings on the subcategories of the knowledge dimension measured by the Chemistry questions revealed that 24.9% of the examination questions measured factual knowledge, 46.3% of the examination questions measured conceptual knowledge, while 28.8% measured procedural knowledge of algorithms and experimental procedures. These findings contradicts the findings of Tikkanen & Aksela (2012) that reported a high proportion of questions that measured procedural knowledge in chemistry examination. However, similar proportion of examination questions that measured conceptual and metacognitive knowledge was reported. The poor representation of metacognitive knowledge in the questions could be because assessing students' metacognitive knowledge could be a tedious task in a summative assessment like the National Business and Technical Examination Board (NABTEB) Examination.

Conclusion

The study therefore concluded that majority of the chemistry examination questions do not seek to assess students' higher order cognitive skills (HOCS) and none of the questions assessed the metacognitive knowledge of the students. The uneven distribution of the chemistry examination

questions observed in this study could possibly impact on curriculum and instruction. This is because of the likely event that students and teachers will rely on such questions for practice and assessment.

Recommendations

Based on the findings of this study, the following recommendations are made:

(i) Examination bodies should ensure that examination questions are evenly distributed among the categories of the cognitive process skills and the knowledge dimension; as such, students should be presented with questions that assess higher order cognitive skills;

(ii) Chemistry teachers should teach and prepare their classroom examination questions using the framework of the revised Bloom's taxonomy.

(iii) Teacher education programmes in Nigerian universities should provide adequate theoretical and practical training to prospective teachers on assisting learners to operate at various levels of cognition.

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