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Content Validity of May/June West African Senior School Certificate Examination (WASSCE) Questions in Chemistry

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Abstract: This study assessed the content validity of May/June West African Senior School Certificate Examination (WASSCE) questions in Chemistry from 1999–2002. The researchers analysed the taxonomic spread of the content of the Senior Secondary School Core Curriculum in the 1999-2002 WASSCE questions in Chemistry. The Core Curriculum for Chemistry and WASSCE Chemistry question papers were the main sources of data. 170 performance objectives from the Core Curriculum and 590 questions from WASSCE examination papers were classified against the cognitive levels. The results indicated that some topics were over-emphasised, under-emphasised or totally ignored in WASSCE whilst the questions emphasised more of such lower levels of the cognitive domain as knowledge and comprehension. Based these findings, it was recommended that teachers should maintain the emphasis accorded the topics in the Core Curriculum at the various relevant cognitive levels; the examiners of WASSCE should employ the services of test experts to ensure adequate use of Table of Specifications in their test development and ensure content validity.
Keywords: WASSCE, Chemistry examination, Content validity, Cognitive domain of learning.

1. Introduction

Chemistry is the core of the basic sciences and plays a vital role in the advancement of technology which is one of the aims of the Nigerian Education Programme. Chemistry is one of the pre-requisite for admission in Nigerian tertiary institutions to study any of the science and science related courses. It is therefore required that a student should obtain at least, a credit in Chemistry in West African Senior School Certificate Examination (WASSCE) to qualify to read courses like Medicine, Pharmacy, Engineering, Industrial Chemistry, Technology and other Applied Science courses in the tertiary institutions. In spite of this importance of Chemistry, a poor performance has been recorded for the subject over many years. Ochonogor (1999) observed that "within a period of over one decade, the highest percentage pass at credit level in Chemistry is 41.42 recorded in 1996.

One of the techniques used in evaluating the academic performance of students is achievement test. The scores students obtained in achievement test are supposed to be representative of the extent to which the subject matter being measures by the test are understood by the testees. A score in a test can only be meaningful and relevant if it actually represents the level of understanding and attainment of the testee in the task presented by the test items.

These items of the test are supposed to reflect the entire topics and behavioural objectives which are expected to be covered in a subject by students. In other words, the items of an achievement test should cover the scope of the topics in the examination syllabus and/or core curriculum and the behavioural objectives it purports to achieve. This is made possible by the use of table of specifications or test blue print. Any examination or test which possesses this quality is said to be valid in content. Relative to this study, WASSCE questions in Chemistry are valid in content only when the questions make a fair coverage of the topics and performance objectives emphasised in the Core Curriculum for SSS Chemistry. It is only with this that the students' achievement in Chemistry in the SSCE will be meaningful and relevant.

The goal of any educational programme is to effect a desirable change in the behaviour of the child, a condition referred to in education as learning. This change can be assessed, measured and evaluated using such tools as achievement tests. However, assessment tools used in educational measurement must be valid before valid evaluation of learning could be attained. Validity has various shades (content, construct, predictive, criterion related, and so on) as evinced in professional literature on educational measurement and evaluation. In view of the critical value of the content validity of measures of academic achievement, this study investigated the content validity of the WASSCE Chemistry questions for Senior Secondary School Students. Specifically, the study examined:

i. The percentage representation of the topics in the Senior Secondary School Chemistry core curriculum in the 1999 – 2002 WASSCE questions;
ii. The percentage assigned to the various levels of the cognitive domain in the Chemistry core curriculum;

iii. The percentage representation of the various levels of the cognitive domain in the 1999 – 2002 WASSCE Chemistry questions.

The following research questions guided the study:

i. What percentage of the topics in the chemistry core curriculum was found in the 1999-2002 WASSCE Chemistry questions?
ii. What percentage of the performance objectives stated in the Chemistry core curriculum where assigned to each level of the cognitive domain?
iii. What is the percentage spread of the various levels of the cognitive domain in the 1999-2002 WASSCE Chemistry questions?

2. Review of Related Literature

Test is one of the techniques used in carrying out the process of evaluation. Tests can be defined as a systematic procedure for measuring a sample of behaviour (Joshua, 2005). Generally, there are two broad types of test items namely: objective test and essay test. The West African Examinations Council (WAEC) employs the two in examining students.One of the merits of multiple – choice question, a type of objective test that is of interest to this study, is that it helps the teacher/examiner to cover all the topics taught because they contain numerous questions. In the light of this, it could be said that this type of test enhances the achievement of the content validity of a test. Tests, including examinations, serve several functions which may be grouped under classroom, guidance and administrative functions. In addition, tests are used for certification. West African Examination Council conducts Senior School Certificate Examination in order to issue certificates to students.

Onukwo (2000) pointed out that qualities characteristic of good measurement instruments are validity, reliability, and usability. Validity which is the main theme of this study has been defined in various ways which, in convergence, refer to the extent to which a test measures what it is expected to measure and generate correct data for analysis. Suen (1990) define validity as an integrated evaluative judgement of the degree to which empirical evidence and theoretical rationale supports the adequacy and appropriateness of inferences and actions based on test scores or other modes of measurement. Onukwo (2000) asserted that validity of an instrument means the degree to which the instrument measures the qualities, abilities, skills, traits, and information it is designed to measure. WASSCE questions on chemistry, for instance, which purports to measure achievement of students in chemistry will only be valid if it measures this achievement and nothing but the achievement of students in chemistry. Content validity of a measuring instrument involved implies adequate coverage of the subject matter and behavioural objectives as outlined in a particular syllabus, core curriculum or scheme of work of that subject area. Hence, Aiken (2000) opines that content validity is concerned with whether the content of a test is capable to elicit responses that are representative of the entire domains or universe skills, understandings, and other behaviour that the test is supposed to measure. Content validity of an achievement test, therefore, is determined by evaluating the extent to which the composition of the test represents the objectives of instruction. One of the ways of doing this is to compare the test's content with an outlined table of specification concerning the subject matter to be covered by the test.

Abayomi (1999) asserts that the Table of Specifications ensure the content validity of a test right from the construction stage. All these imply that for a test to be valid, the test planner should aim at a systematic coverage of the whole subject matter area and the instructional objectives. Therefore, achievement tests are designed to measure how well a candidate has mastered a specific course of study.

Cognitive domain is concerned with mental activities such as reasoning, intellectual activities and thinking process (Onunkwo, 2000). A prominent method for assessing the cognitive domain of learning is through the use of Bloom's Taxonomy which contains in hierarchy: knowledge, comprehension, application, analysis, synthesis and evaluation. These six levels of cognitive domain produce a hierarchy of mental skills from lowest level of knowledge to highest level of evaluation. Items of an achievement test should be made to assess each of these six categories for such assessment to be comprehensive.

Olisa (1992) conducted a study with 15 Secondary Schools in Awka Local GovernmentArea in Anambra State, Nigeria, to determine the extent to which table of specification was used by Chemistry teachers and hence the content validity of the teacher made test in Chemistry. The result showed that teachers over-emphasised lower cognitive levels and under-emphasised or ignore higher cognitive levels; and they seemed not to have made use of a table of specification. Agwuncha (1998) who studied validity of teacher-made test in economics exposed the fact that teacher-made tests lack content validity. Surprisingly, Joseph and Udosen (1998) concluded that teacher-made test in English language can be used to fairly predict students' performance in SSCE, therefore a challenge to make teacher-made test more seriously.

The study of Onunkwo (1990) on the content validity of Junior School Certificate Examination (JSCE) questions in Integrated Science in Anambra State revealed that authors of the core curriculum for Integrated Science and examiners of JSCE do not make use of a table of specification; therefore, the questions are not valid in content.

Bassey and Ikwa (1999) carried out a research aimed at explicating the concept of validity and making an advocacy for greater teacher/evaluator involvement in test validation. They concluded their findings by pointing out that, public examiners like WAEC should develop comprehensive syllabuses, prepare tables of specification and pursue both logical and empirical validation processes. Joseph (2000) conducted a study aimed at identifying and classifying the multiple choice questions of Chemistry paper 2A SSCE for 1997—1999 according to the cognitive process involved in the question and comparing the cognitive spread for each set of questions. The result revealed that items for each year concentrated on comprehension questions followed by knowledge questions to the detriment of the other levels of the cognitive domain. This observation is as a result of WAEC employing practicing teachers who may not be experts for item writing.

From review of literature, no study has been carried out on the content validity of WASSCE Chemistry questions hence the necessity of this study.

3. Methodology

Design: This research employed the descriptive survey because a group of items (questions) was studied by collecting and analysing data from only a few items which represents the entire group. The population of the study consist of all the May/June Senior School Certificates Examination questions in Chemistry. All objective tests, essay and practical questions were used to have a base for content coverage. SSCE questions in Chemistry from 1999 – 2002 were purposively selected to ensure uniformity since the pattern of setting questions changed from 1999.

Data: Data for the study were the drawn from the Chemistry Core Curriculum for Senior Secondary Schools and the May/June West African Senior School Certificate Examination (SSCE) question papers in Chemistry for 1999 through 2002. The data was validated by classifying the 170 performance objectives stated in the Chemistry Core Curriculum against the levels of cognitive domain it emphasised. Copies of the classified performance objectives were given to experts in Measurement and Evaluation for face validation. 150 questions from the May/June WASSCE 1999–2002 were classified against the topics they were drawn from in the Chemistry Core Curriculum. The 150 questions were also classified against the particular level of cognitive domain they tested. Copies of the classified questions were subsequently given to experts in Measurement and Evaluation who face validated it. The reliability of the data was established using the method for calculating the inter-rater (inter-coder) reliability coefficient for normal data. The 170 performance objectives classified by the researchers against the particular cognitive level it emphasised was given to experts in Measurement and Evaluation who sampled about 30 performance objectives and classified accordingly. The inter-rater reliability coefficients between the researchers' classification and the classification of the experts computed yielded 0.86 and 0.84.

The 150 questions classified against the topics from which they were set in the Core Curriculum were given to experienced Chemistry teachers who also classified a sample of about 30 questions. Consequently, the inter-rater reliability coefficient between the researchers' classifications and the classifications of the subject specialists were computed and the values yielded were 0.84 and 0.83.

The researchers also classified each of the 150 questions against the particular level of cognitive domain it tested. This was then given to experts in Measurement and Evaluation who sampled 30 questions and classified accordingly. The inter-rater reliability coefficients between the researchers' classifications and the classifications of the experts were then computed. The values obtained were 0.86 and 0.90.

The researchers then obtained all the topics expected to be tested in WASSCE from the Core Curriculum for Chemistry. The actual topics tested in WASSCE over the four years under study were obtained from May/June WASSCE questions papers in Chemistry from 1999–2002. For each year there were two papers: paper 1 (practical) and paper 2 (objective and essay). For the four years under study, there were altogether 509 questions. The sum of questions set for each topic of the Core Curriculum was determined and this became the observed weight of the topics tested by May/June WASSCE in Chemistry over the period under study. The cognitive domain as outlined in Bloom's taxonomy of educational objective was used in classifying the performance objective stated in the Core Curriculum for Chemistry and all the 509 questions used in this study against the various levels of cognitive domain they tested.

The researchers assigned weights to the topics in the core curriculum for Chemistry based on the emphasis placed on them. The emphasis depends on how broad or voluminous a topic is with respect to the number of weeks teachers spent in teaching it. The sum of each cognitive level of the classified performance objectives stated in the core curriculum was calculated. The sum of a particular cognitive level was converted to the proportion of the total number of 509 questions involved in the study. The value obtained becomes the expected weight of the cognitive levels required to be tested by WASSCE Chemistry.

The observed weights of the cognitive levels were determined by calculating the sum of each cognitive level tested in the May/June WASSCE Chemistry question over the period under study.

4. Results

The research questions posed were answered using simple percentages as presented infra:

Research question one: What percentage of the topic in the chemistry core curriculum was found in the 1999 – 2002 WASSCE chemistry questions?

Table 1: Frequency and percentage spread of topics in the Core Curriculum as represented in WASSCE Chemistry

S/N	Topics in the Core Curriculum for Chemistry	Year of Examination				Total Spread	% Spread
		1999	2000	2001	2002		
1	Separation technique of mixtures	1	3	1	0	5	0.98
2	Wave/particulate nature of matter	13	16	20	18	67	13.16
3	Chemical combination	5	8	4	1	19	3.73
4	Gaseous state and gas laws	11	7	3	4	25	4.91
5	Acids, bases and salts	8	10	10	10	38	7.47
6	Carbon and its compounds	7	2	2	1	12	2.26
7	Quantitative aspect of chemical reaction	25	21	31	25	102	20.04
8	Rates, energy and chemical equilibrium	7	10	8	12	37	7.27
9	Non-metals and their compounds	18	21	12	22	73	14.34
10	Organic chemistry	19	20	26	25	90	17.68
11	Metals and their compounds	5	6	4	8	23	4.52
12	Chemistry, industry and environment	3	3	5	7	18	3.54
	Total	**123**	**127**	**126**	**133**	**509**	
	Percentage Spread	**23.97**	**24.95**	**24.75**	**26.13**		**100**

The answer to research question one as provided in Table 1 above shows that out of the twelve major parts of the Core Curriculum for Chemistry, topic 7, quantitative aspects of chemical reaction has the highest percentage of questions (20. 04%) followed by topic 10, organic chemistry (17.68%). Topic 2 and 9, wave/particulate nature of matter and non-metals and their compounds have the percentages of 13.16% and 14.34% respectively while topic 1, separation techniques of mixtures had the lowest percentage of 0.98%.

The high percentage spread of topic 7 and 10 could be as a result of the weight assigned to them in the Core Curriculum. The high weights assigned to topic 2 and 9 were greatly higher than those assigned to these topics in the Core Curriculum. The researchers could not account for this observation. Some topics like separation techniques of mixtures, chemical combination, carbon and its compounds, metals and their compounds and chemistry, industry and environment contributed very low to the 509 question covered by the years under study. It is expected in the opinion of the researchers, that WAEC (West African Examinations Council) would have adequately emphasised these topics in view of their respective utility values to students' daily activities.

Research question two: What percentage of the performance objectives stated in the Core Curriculum for Chemistry was assigned to each level of the cognitive domain?

Table 2: Frequency and percentage spread of various levels of the cognitive Domain in the core curriculum

S/N	Major Divisions Of The Core Curriculum For Chemistry	Levels Of Cognitive Domain						
		Know	Comp	App.	Ana.	Syn.	Eva.	Total
1	Separation technique of mixtures	0	0	3	0	1	0	4 (2.35%)
2	Wave/particulate nature of matter	4	5	5	5	3	2	24 (14.12%)
3	Chemical combination	2	0	0	3	0	0	5 (2.94%)
4	Gaseous state and gas laws	2	0	5	2	1	0	10 (5.88%)
5	Acids, bases and salts	1	0	1	2	2	1	7 (4.11%)
6	Carbon and its compounds	0	1	1	1	2	0	5 (2.94%)
7	Quantitative aspect of chemical reaction	3	5	8	6	2	3	27 (15.88%)
8	Rates, energy and chemical equilibrium	2	2	3	3	2	1	13 (7.65%)
9	Non-metals and their compounds	3	6	1	8	5	2	25 (14.71%)
10	Organic chemistry	3	4	7	5	4	3	26 (15.29%)
11	Metals and their compounds	3	1	0	2	5	1	12 (7.06%)
12	Chemistry, industry and environment	1	1	6	1	3	0	12 (7.06%)
	Total	**24**	**25**	**40**	**38**	**30**	**13**	**170**
	Percentage spread	**14.12**	**14.71**	**23.53**	**22.35**	**17.65**	**7.65**	**100**

The answer to question two as shown in Table 2 indicates that performance objectives were highest at the application level of the cognitive domain (23.53%) in the core curriculum followed by analysis level (22.35%). Evaluation level weighed least (7.65%). Knowledge and comprehension were weighed 14.12% and 14.71% respectively. A survey of the result presented showed that performance objectives stated in the Core Curriculum for Chemistry were assigned differently to the six levels of cognitive domain. The application level was assigned highest percentage (23.53%) of the performance objectives followed by analysis level (22.35%). Application, analysis, synthesis and evaluation levels have been classified as higher cognitive level, knowledge and comprehension as lower cognitive level (Onunkwo, 2000). The result is expected because the senior secondary school students are at the higher age of cognitive development, based on their average age of 16 years. The spread of performance objective for knowledge and comprehension are 14.125 and 14.71% respectively. This can be attributed to the cognitive stage of development of the students.

Evaluation has the lowest percentage of 7.65%. Okoye (1996) classified evaluation level as the highest cognitive domain which is concerned with the ability to judge the value of an idea, principle, law and theory. The students being in intermediate stage of development cannot engage in much value judgment.

Research question three: What is the percentage spread of the various levels of cognitive domain in the 1999 – 2002 WASSCE Chemistry questions?

Table 3: Frequency and percentage spread of the various levels of the cognitive domain in the 1999 – 2002 WASSCE Chemistry questions

S/N	Levels of Cognitive Domain	Year of Examination				Total Spread	% Spread
		1999	2000	2001	2002		
1.	Knowledge	30	40	49	48	176	34.58
2.	Comprehension	36	32	35	44	147	28.88
3.	Application	21	25	18	12	76	14.93
4.	Analysis	13	22	12	17	64	12.57
5.	Synthesis	10	5	11	11	37	7.27
6.	Evaluation	3	3	1	2	9	1.77

The responses shown on Table 3 clearly reveal that the knowledge level of cognitive domain had highest percentage of 34.58%. All other levels of cognitive domain had percentage spread decreasing as they go to higher levels. Comprehension (28.88%), application (14.93%), analysis (12.57%), synthesis (7.27%) and evaluation (1.77%). The implication of the result is that out of the 509 questions involved in the study, more than half tested the lower cognitive levels. The result is surprising because Senior School Students are of a higher

cognitive stage of development and so high cognitive levels should be emphasised in the questions. From the result of this study, the reverse is the case. These results show that examiners of WASSCE may not have used Tables of Specifications in constructing the questions used in examining students for the four years under study. As a result of this, the WASSCE Chemistry questions for the period under study have low content validity. Onunkwo (1990) and Joseph (2000) in their studies confirmed that Junior School Certificate Examination (JSCE) and Senior School Certificate Examination (SSCE) respectively possess low degree of content validity. They attributed this to the fact that examining bodies do not use Tables of Specifications and they employ non-test experts in the construction of their test items. In the area of teacher-made test, Olisa (1992) and Agwuncha (1998) in their respective studies on the validity of teacher-made test asserted that they lack content validity.

5. Conclusion

This study assessed the content validity of May/June West African Senior School Certificate Examination (WASSCE) in Chemistry. From the outcome of the study as presented supra, the following conclusions are reached by the researchers:

- The May/June WASSCE in Chemistry for the period under evaluation lacks content validity.
- The revealed lack of content validity of WASSCE Chemistry might not be unconnected with the examiners use of non-professionals to set their examinations.
- The non-representativeness of the Core Curriculum's content in the Taxonomic spread of the WASSCE Chemistry questions with particular reference to the weights assigned to each topic in the Core Curriculum betrays failure on the part of the examiners to use Table of Specification in the test construction procedure.
- The exposed lack of content validity of the May/June WASSCE has implications for the usability of the results obtained from the test, especially where candidates' knowledge, comprehension and mastery of the subject is to be evaluated or judged.

6. Recommendations

Based on the findings of this study and the relevance of the content validity of test instruments, the researchers put forward the following recommendations:

- School teachers should be made, by responsible supervisory bodies, to consistently and persistently maintain the spread of topics and various cognitive levels in the Core Curriculum for Chemistry while teaching students.
- Teachers should be made to understand, through re-training and supervision, the implication of either over-emphasising or under-emphasising some topics or cognitive levels when teaching.
- The examiners of WASSCE and other Senior School Certificate Examinations (SSCE) should employ the services of test experts in constructing the test items used in examining the students if they hope for such examination to be valid for evaluation.
- Test experts should make correct and consistent use of Tables of Specifications (also known as Test Blue Print) and hence avoid over-emphasis or under-emphasis of either the topics or cognitive levels.

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