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Construction And Determination Of Chemistry Achievement Test's Indices Of Item Parameters

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ABSTRACT

This study is poised to develop and determine the indices of item parameters of a well validated Chemistry Achievement Test for Senior Secondary students. Instrumentation research design was deployed. A total of 3 843 senior secondary school chemistry students in Bayelsa State, made up the population for the study while the sample size was 380 students. The CAT was trial tested and the "difficulty and discrimination indices of the items" were established. The difficult level of the test items was determined using the classical method and it was found that the difficulty level ranges between 37.1 and 70.8. Furthermore, the well constructed and validated Chemistry Achievement Test with indices between 0.12 and 0.53 has a good discrimination between poor students and good students. It was therefore inferred that Chemistry Achievement Test (CAT) is psychometrically adequate enough to assess high school students, either for prognostic, diagnostic, formative and/or summative purposes.

Keywords: Achievement, psychometric, Parameters, Instrumentation

INTRODUCTION

The sacrosanctity of testing in education cannot be over emphasized (Adeniji, 2017). Test is a critical instrument for evaluating the performance of students (Michael, 2019). Also, Cronbach (1970) defined test as a systematic procedure for describing behavior with the aid of a numerical scale or a category system. A test is a standardized procedure for sampling behaviour and describing it with scores (Gregory, 2006). Tests therefore, enable us to measure and understand a concept, a sample of behaviour or personal attributes. This is adjudged consistent with Anastasi (1976) who defined psychological testing as an objective and a standardized measure of a sample of behavior. But to measure the entire behavior at a time is difficult and therefore, it is only reasonable to measure and obtain a numerical estimate of a single aspect of performance at a time such as achievement, specific aptitude, and artistic performance and so on. Matthew (2019) noted that one of the major techniques used in evaluating the academic performance of students is achievement test. Adeniji and Ilorah (2018:137) 'An achievement test is the type of ability test that describes what a person has learned to do (Thorndike and Hagen, 1969). This test is designed to assess how much of the content of a course an individual has learned over a period of time. Downie (1983) defines an achievement test as any test that measures accomplishments of an individual after a period of training or learning. Hence, it is based on what the testee has learned or been instructed on. It is actually based on what the candidate is expected to have learnt based on a given syllabus. Horrocks and Schoonover (1968) posit that the term achievement indicates the degree of success attained in some general or specific area within the school context. Its construction and design is based on the knowledge commonly taught at different grade levels of the instructional process. This explains why the results of achievement tests are used for selection, placement, diagnosis, promotion, certification, counseling, research and other related uses in schools (Asuru, 2015).' Based on the foregoing, Adeniji (2018) averred that every teaching-learning process ought to be climaxed with at least an achievement test.

Chemistry as a school subject is the fulcrum of the sciences. Matthew (2019:106) 'Chemistry lays a sound foundation for further studies of medicines, engineering, micro-biology and biochemistry at higher level. This is why chemistry is considered as a major requirement for admission into the above disciplines in institutions of higher learning. Chemistry further contributes immensely in the process of manipulation, assimilation and abstract and creative thinking. It is therefore, required that a student should obtain at least a credit in chemistry in the examinations conducted by WAEC and NECO to qualify as student of medicine, engineering and other related disciplines in colleges of Education, Polytechnics and Universities. In spite of the aforementioned importance of chemistry a poor performance has been recorded for the subject over the years.'

The report of the Commonwealth planning seminar, held in Accra in 1973 as quoted in Nworgu (1985) acknowledged the importance of tests and test result in educational decisions making. The report noted with disappointment that there is a widespread feeling that many tests or examinations are constricting, unreliable and unjust, prejudicing the development of more enlightened method of education and stigmatizing as failures in life those persons who may be failures only in their inability to master examination techniques. Their inability to master examination techniques may be due to improper assessment on the subject matter, test planning and administration which is done by teachers who have no professional skills in test construction and validation. This brings to focus the need for determining the adequacy of every examination or test with the aim of recommending the poor ones for improvement.

Construction of Achievement Test

Test construction is the preparation of a test by drawing and compiling series of questions which constitute the task for the testees. Itsuokor (1986) suggested an outline for an effective test construction. According to him, a satisfactory sample is most likely to be obtained when test preparation follows a systematic procedure.

- General statement of instructional objectives
- Making an outline of the content to be covered
- Preparation of a table of specification
- Construction of test items that measures the objectives in the table specified.

Educational Testing Service (ETS, 1965) suggested a typical sequence of test construction and validation. These sequences are as follows:

- Planning the test
- Writing the items
- Pre-testing the items
- Preparing the final form
- Collecting the validity and reliability evidence
- Developing normative and interpretative materials

Conceptual Model for the Construct of Chemistry Achievement Test

1. Test Planning - Test blueprint
2. Item Writing
3. Pre-testing the items
4. Preparing the final form
5. Validity evidence
6. Reliability evidence
7. Index of Item parameters
   - Difficulty index
   - Discrimination Index
8. Standard Error of Measurement

→ Chemistry Achievement Test

The conceptual model is a representation of the steps that were taken in determining the validity and reliability of Chemistry Achievement Test (CAT). As part of the steps, test planning was considered, followed by item writing, pre-testing the items, preparing the final form, validity evidence, reliability evidence, index of item parameters and finally Standard Error of Measurement. It should be noted that this conceptual model is based on Classical Test Theory (CTT) and Item Response Theory (IRT) and adapted to the ETS Sequence of test construction and validation.

Statement of the Problem

Chemistry is one of the core science subjects offered in Nigerian schools and it is a compulsory subject across board for students who aspire to venture into any of science-oriented professions. Most teacher-made achievement tests lack the required psychometric adequacy. And as such, making use of such tests give has been grossly misleading with respect to students' performance. The lack of standardized tests constructed by experts with adequate psychometric properties in most of the secondary schools also give rise to incorrect performance records in Chemistry for the students.

To reduce the aforementioned scenario to the barest minimum, this study is set out to determine the indices of item parameters of the validated Chemistry Achievement Test (CAT).

Purpose of the Study

The purpose of the study is to compute and establish the indices of item parameters of the well constructed and validated Chemistry Achievement Test (CAT). Specifically, the study achieved the following.

1. To ascertain the difficulty level of the Chemistry Achievement Test for Senior Secondary Schools.
2. To determine the discriminatory index of the Chemistry Achievement Test for Senior Secondary Schools.

Research Questions

The following research questions were formulated to guide this work.

1. What is the difficulty level of Chemistry Achievement Test for Senior Secondary Schools?
2. What is the discrimination index of Chemistry Achievement Test for Senior Secondary Schools?

METHODOLOGY

The design of this study is instrumentation. There are 174 public secondary schools in Bayelsa State with a total population of 39,507 in Junior Secondary School and 38, 069 in Senior Secondary Schools. Out of this population, about 3843 students offers Chemistry in SS2 (Source: Bayelsa State Ministry of Education). The purposive or judgmental method of non-probability random sampling technique was used to select three schools from each senatorial district, making a total of nine schools. Subsequently, the simple random sampling technique was used to select the students, from the nine schools. A total of 380 students was used for the chemistry achievement test. A total of 100 questions were constructed but after trial testing, 50 were used for the research. Each item has four options lettered A - D. Out of the four options, one is correct while the other three are treated as distracters. In order to establish the content validity of the instrument, a table of specifications was drawn.

Moreover, to establish the reliability of the test items, Kuder-Richardson formula 20 was used. The Kuder-Richardson formula 20 can be applied for binary type of data i.e. true/false or dichotomously scored data where the responses are scored either right or wrong, pass or fail. In the binary-type of data the correct answer or option was treated as one (1) while the incorrect or wrong option was treated as zero (0). The research questions were answered with percentages. The first research question addressed the level of validity of the Chemistry Achievement Test by using table of specifications. The content areas and the behavioural domains presented in the test blue print are presented in percentages.

RESULTS

Research Question 1: *What is the difficulty level of Chemistry Achievement Test for Senior Secondary Schools?*

This question was answered using the item analysis. Table 1 below shows the items and the Difficulty Level (DL) in percentages.

Table 1: Difficulty Level of Chemistry Achievement Test

Item No	Description of Item	Difficulty L Level (%)	Decision
1.	State three methods of separating mixtures	60.5	Accepted
2.	Enumerate the fundamental particles in the atom	70.8	Accepted
3.	Two example of phenomena which explains that matter is made up of particles are	52.4	Accepted
4.	One main apparatus used for separating immiscible liquid is	62.6	Accepted
5.	If an element z has an orbital configuration of $Is^2 25^2 2p^6 3S^2 3p^6 4S^1$ and $3d^0$. What is the relative atomic number of z?	52.9	Accepted
6.	State the symbols of the elements: Fluorine, sodium, led and nickel respectively	62.9	Accepted
7.	Distinguish between empirical and molecular formula of a compound	55.3	Accepted
8.	How many atoms are contained in 1 mole of hydrogen molecule	41.1	Rejected
9.	The following are properties of electrovalent compounds except	49.2	Rejected
10.	The correctly written chemical equation for reaction between sodium trioxocarbonate (iv) and hydrochloric acid is	42.9	Rejected
11.	Select the gas law which says that equal volume of all gases contains the same number of molecules at S.T.P	37.1	Rejected
12.	Identify the double salt among the following	43.9	Rejected
13.	How does increase in the volume of a given mass of gas affects pressure at constant temperature	44.2	Rejected
14.	Convert 273^oc to degree Kelvin	48.9	Rejected
15.	A sample of urine turned a moist blue litmus paper red. This of the following is likely to be present in the urine.	48.9	Rejected
16.	$50cm^3$ of hydrogen gas sparked with $30cm^3$ of air to produce steam. What will be the volume of the residual gases?	41.3	Rejected
17.	Rearrange the following solutions in order of increasing acidity.	47.1	Rejected
18.	Identify two products obtained from the destructive distillation of coal.	48.2	Rejected
19.	How is petroleum produced in nature?	45.0	Rejected
20.	Gas prepared by the reaction between methanoic acid and concentrated tetra-oxosulpahate (iv) acid.	44.7	Rejected
21.	All are decomposed by heat except	47.1	Rejected
22.	Which of the following could be considered as a better fuel?	52.6	Accepted
23.	One of the chemicals used in heavy chemical industry is	56.8	Accepted

24.	Silicon belongs to group	58.2	Accepted
25.	The following oxides reacts with water except	54.7	Accepted
26.	Which of the following are petroleum and coal	43.7	Rejected
27.	Point out the element among these with the lowest ionization energy	44.7	Rejected
28.	Consider the following reactions. The above reactions shows that the trioxocarbonate(iv) of	41.6	Rejected
29.	Name the electrolyte for the Nickel-cadmium alkaline cell	45.5	Rejected
30.	Which of the following metals will react with cold water to produce hydrogen	52.9	Accepted
31.	One of these is not a property of oxygen	42.4	Rejected
32.	What is the change of oxidation number of Mn in the following reaction …	37.9	Rejected
33.	Which of these is correct	42.4	Rejected
34.	The molar gas volume at S.T.P. and vogadio's Number of particles are …	49.7	Rejected
35.	In the titration of acid against base solution, averaging must involve	45.0	Rejected
36.	The following reading were obtained from titration experiment … Estimate the readings in a more appropriate form	48.7	Rejected
37.	Calculate the number of moles present in 104g of ethyne	49.7	Rejected
38.	Consider the equation: $4NH_{3(g)} + 5O_{2(g)} \rightarrow 4NO_{(g)} + 6H_2O_{(g)}$	58.4	Accepted
39.	A student tried to carry out two different acid-base titration. In titration I … II ….	55.5	Accepted
40.	A measure of the degree of disorderliness in a chemical system is known as	49.2	Rejected
41.	The minimum amount of energy requires for a chemical reaction to occur is known as ….	53.7	Accepted
42.	A catalyst which increases the rate of a chemical reaction does so by ….	48.9	Rejected
43.	Calculate the equilibrium constant of the reaction:	47.1	Rejected
44.	The law of mass action can be illustrated as …	44.5	Rejected
45.	Reactions are generally faster at higher temperature because	40.5	Rejected
46.	Identify the reagent that can be used to differentiate between ethane and Ethyne	42.4	Rejected
47.	The following are examples of alknols except	42.9	Rejected
48.	Which of the following is readily soluble in water?	51.3	Accepted
49.	Rearranging the following in order of increasing boiling point …C_5H_{12}, $C_{10}H_{22}$, C_8H_{18}, C_6H_{74}	52.6	Accepted
50.	Which of the following accounts for the volatile nature of hydrocarbons?	56.1	Accepted

The difficulty level of the Chemistry Achievement Test for Senior Secondary School ranges from 37.1 to 70.8. Considering the mean difficulty level of the Chemistry Achievement Test to be 50%, 9 of the items falls above the average, 18 of the items falls below the average while 23 falls around the average (i.e. 5.0 above and below the mean).

Research Question 2: *What is the discrimination index (DI) of the Chemistry Achievement Test for Senior Secondary Schools?*
This research question was also answered using item analysis. Table 2 below shows the items and the discrimination index

Table 2: Discrimination index of Chemistry Achievement Test

Item No	DESCRIPTION OF ITEM	Discrimination Index
1.	State three methods of separating mixtures	0.26
2.	Enumerate the fundamental particles in the atom	0.18
3.	Two example of phenomena which explains that matter is made up of particles are	0.30
4.	One main apparatus used for separating immiscible liquid is	0.45
5.	If an element z has an orbital configuration of $Is^2 25^2 2p^6 3S^2 3p^6 4S^1$ and $3d^0$. What is the relative atomic number of z?	0.21
6.	State the symbols of the elements: Fluorine, sodium, led and nickel respectively	0.26
7.	Distinguish between empirical and molecular formula of a compound	0.35
8.	How many atoms are contained in 1 mole of hydrogen molecule	0.20
9.	The following are properties of electrovalent compounds except	0.31
10.	The correctly written chemical equation for reaction between sodium trioxocarbonate (iv) and hydrochloric acid is	0.22
11.	Select the gas law which says that equal volume of all gases contains the same number of molecules at S.T.P	0.31
12.	Identify the double salt among the following	0.41
13.	How does increase in the volume of a given mass of gas affects pressure at constant temperature	0.36
14.	Convert 273^oc to degree Kelvin	0.53
15.	A sample of urine turned a moist blue litmus paper red. This of the following is likely to be present in the urine.	0.29
16.	$50cm^3$ of hydrogen gas sparked with $30cm^3$ of air to produce steam. What will be the volume of the residual gases?	0.12
17.	Rearrange the following solutions in order of increasing acidity.	0.49
18.	Identify two products obtained from the destructive distillation of coal.	0.22
19.	How is petroleum produced in nature?	0.41
20.	Gas prepared by the reaction between methanoic acid and concentrated tetra-oxosulpahate (iv) acid.	0.35
21.	All are decomposed by heat except	0.37
22.	Which of the following could be considered as a better fuel?	0.27
23.	One of the chemicals used in heavy chemical industry is	0.40
24.	Silicon belongs to group	0.30
25.	The following oxides reacts with water except	0.38
26.	Which of the following are petroleum and coal	0.28
27.	Point out the element among these with the lowest ionization energy	0.36
28.	Consider the following reactions. The above reactions shows that the trioxocarbonate (iv) of	0.37
29.	Name the electrolyte for the Nickel-cadmium alkaline cell	0.36
30.	Which of the following metals will react with cold water to produce hydrogen	0.37
31.	One of these is not a property of oxygen	0.36

32.	What is the change of oxidation number of Mn in the following reaction …	0.28
33.	Which of these is correct	0.33
34.	The molar gas volume at S.T.P. and vogadio's Number of particles are …	0.37
35.	In the titration of acid against base solution, averaging must involve	0.43
36.	The following reading were obtained from titration experiment … Estimate the readings in a more appropriate form	0.33
37.	Calculate the number of moles present in 104g of ethyne	0.28
38.	Consider the equation: $4NH_{3(g)} + 5O_{2(g)} \rightarrow 4NO_{(g)} + 6H_2O_{(g)}$	0.25
39.	A student tried to carry out two different acid-base titration. In titration I … II ….	0.34
40.	A measure of the degree of disorderliness in a chemical system is known as	0.31
41.	The minimum amount of energy requires for a chemical reaction to occur is known as ….	0.33
42.	A catalyst which increases the rate of a chemical reaction does so by ….	0.47
43.	Calculate the equilibrium constant of the reaction:	0.53
44.	The law of mass action can be illustrated as …	0.34
45.	Reactions are generally faster at higher temperature because	0.26
46.	Identify the reagent that can be used to differentiate between ethane and Ethyne	0.35
47.	The following are examples of alkanols except	0.38
48.	Which of the following is readily soluble in water?	0.38
49.	Rearranging the following in order of increasing boiling point …C_5H_{12}, $C_{10}H_{22}$, C_8H_{18}, C_6H_{74}	0.32
50.	Which of the following accounts for the volatile nature of hydrocarbons?	0.35

The item discrimination index ranges from 0.12 to 0.53

DISCUSSION OF FINDINGS

The difficult level of the test items was determined using the classical method and it was found that the difficulty level ranges between 37.1 and 70.8. This means that some of the students performed poorly compared to others who performed very well. From the difficulty level of 50% as the benchmark, the items difficulty level is normally distributed about the mean and the skewness of the curve is near symmetric.

According to Ughamadu (1991), a test discriminates if more good students answer it correctly than poor students for each item. According to Nworgu (2003), the value of discriminating index ranges from -1.00 to +1.00. Items with high positive discriminating indices are preferred. For large sample (N>150) discriminating indices from 0.22 and above are recommended (Ohuche and Akeju, 1977). From the above literature, it is shown that the constructed and validated Chemistry Achievement Test with indices between 0.12 and 0.53 has a good discrimination between poor students and good students.

CONCLUSION

Based on the results of the item-by-item analysis, it is inferred that the items of Chemistry Achievement Test (CAT) are suitable in terms of its difficulty and discrimination indices. Moreover, it was found that there is similarity in the performance of male and female students.

This similarity was evident in the performance of students in rural as well as urban schools in the multiple choice Chemistry Achievement Test.

RECOMMENDATIONS

From the study, the researchers wish to make these recommendations:

1. The Chemistry Achievement Test (CAT) should be used by high school teachers for assessment of their students, either prognostic, diagnostic, formative or summative purposes.
2. The Chemistry Achievement Test (CAT) should be used as a model for achievement test in Chemistry for the qualification of students for their Senior School Certificate Examinations.

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