DEVELOPMENT AND VALIDATION OF MEASUREMENT SCALE FOR ASSESSING BIOLOGY STUDENTS' MOTIVATION IN LEARNING IN IDAH EDUCATION ZONE OF KOGI STATE, NIGERIA

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Abstract

The purpose of this study was to develop and validate measurement scale for assessing students' motivation in the learning of biology in Idah education zone, Nigeria. The study was guided by two research questions. The design adopted was Instrumentation and all Biology students in 38 senior secondary schools in Idah education zone, constituted the population for the study, from which 480 was drawn as a sample size. The questionnaire used for data collection was developed by the researchers and titled Students' Motivation for Learning Biology Scale (SMLBS). The instrument was designed on a 4-point rating scale of Strongly Agree; Agree; Disagree; and Strongly Disagree. The face validity of the initial draft instrument (SMLBS) was confirmed through experts' judgement. Based on the advice of experts, the instrument was modified accordingly. The reliability of the instrument was obtained through trial-testing to find out the degree of consistency of the items. Thirty (30) biology students participated in the trial testing. The purpose of trial- testing was to find out the degree of consistency of the items. The items of the instrument were polytomously scored. As a result of this; the reliability was tested using Cronbach's Alpha. The reliability coefficients for clusters A to F were 0.83, 0.83, 0.87, 0.70, 0.88 and 0.71 respectively with an overall reliability coefficient of 0.80. This shows that the instrument was good enough for the study. The instrument was administered and retried at spots by the researchers and two research assistants. Research question one was analysed using factor analysis. Cronbach Alpha was used to analyse research question two. Forty-three (43) items were found to be valid out of the initial 63 items. The findings of this study among others, indicated that, the items of the instrument provided a valid and reliable measure of students' motivation to learn biology. From the findings, the researchers recommended among others that curriculum planners should always involve teachers for effective

implementation of students' motivation in the learning process, because teachers are, to a great extent, the real implementers of secondary school curriculum.

Keywords: Biology, Motivation, Assessment, Development

Introduction

Biology is the branch of science which deals with the study of life and living organisms. As a subject, biology endeavours to enable man understand the major biological processes that take place in the environment (Iji, 2007). It is one of the major science subjects that are needed for a nation's technological development. To this effect, Aniodoh (2000) asserts that proper teaching and learning of biology facilitates students' enrolment in tertiary courses like medicine, pharmacy and nursing. Biology, like other science subjects, is a practical oriented discipline which seeks to develop in a learner, scientific inquiry, knowledge and problem-solving abilities.

The goals of secondary school biology curriculum, based on the National Policy on Education Federal Republic of Nigeria (FRN, 2014) are to prepare students to acquire adequate laboratory and field skills in biology, meaningful and relevant knowledge in biology, ability to apply scientific knowledge to everyday life in matters of personal and community health and agriculture, reasonable and functional scientific attitude. In spite of the importance and objectives of studying biology, students' achievements in the subject have not been encouraging. The poor performance of students' in biology was seen in West Africa Examinations Council (WAEC) Chief Examiner's Report (May/June, 2010-2016), where the pass rate at credit level was 49.65%; 38.50%; 35.66%; 41.39% 47%; 48% and 49.50% in 2010, 2011, 2012, 2013, 2014, 2015 and 2016, respectively.

Students' poor performance in biology may be a result of factors such as, lack of materials for teaching and learning biology like chemicals, charts, apparatus, models, local specimens, laboratories, textbooks and libraries (Ahmad & Alice, 2014).There are also factors bothering on biology teachers, such as poor administration of practical lessons, not allowing students to ask questions in class, not giving prompt feedback on assignments or examinations and inability of biology teachers to make the subject interesting. James (2006) opined that low motivation of students in biology contributes to their poor performance especially in externally conducted examinations like West African Senior Secondary Certificate Examinations and the Senior Secondary Certificate Examinations conducted by National Examinations Council.

Ngwoke (2010) describes motivation as a state of mind that explains human behaviour towards a goal. It has to do with the innermost part of mind of an animal which propels, energizes, sustains and directs the activities of the animals towards a purpose. Ngwoke

further explains that motivation is the major reason why some students swat to pass examinations, while others wait for examination malpractice. Motivation explains why some students exercise patience and deny themselves some pleasures in order to attain life objectives Motivation is an activated force that spurs an individual to pursue specific objectives. Individual's needs and desires have a strong impact on their actions. The enthusiasm to attain a goal may manifest in students' values. For instance, a student may be highly impelled to achieve; this may be displayed in sport but not in other school activities. Therefore, students' achievement-attaining values may vary in different situations (Eccles, Alder, Futterman, Goff, Kaczala, Meece, & Midgely, 2003).

Etukudo (2001) studied computer assisted instruments using extensive motivation-based traditional methods (EMBTM) as the instruments. It was discovered from the study that male students outperformed their female counterparts in computer assisted instruments. Kit-Ling (2009) researched grade differences in student's reading motivation among Hong Kong primary and secondary school students and discovered that, there was motivational decline among Chinese students in Hong Kong. Differential attainment of students from urban and rural areas was also reported by Adebayo (2000). The results obtained showed that students from urban areas had higher mean ratings than those from rural environments, although the difference was not statistically significant. Osegbo (2005) conducted a study on development and validation of instruments for assessing mathematics classroom environment and found that classroom environment variables could predict as well as provide answers to students' cognitive and affective outcomes.

In any research work, data collection is very essential. All scientific process in research involves the development and standardization or validation of appropriate and reliable instrument for the collection of pertinent data. Ali (2006) remarked that the aim of developing test instruments, new curricula, techniques of investigating issues and so on, intended for use in collecting data necessary for improving society as well as teaching and learning is classified as developmental or instrumentation studies or design. It is the type of data to be collected that would partly determine the type of instrument to be developed. Data collection depends on the type of research work and from where to get the information Instruments are tools, which are specifically used for specific purposes. There are many research methods and measuring scales that researchers use. They include observation, questionnaire, interview and measuring scales like Likert, Thurstone and Guttman. They are indispensable for the successful conduct of any research. Without a suitable instrument, the value of the quantity under investigation cannot be adequately assessed (Eze, 2005). Chukwudolue (2002) developed and validated an instrument (63-items) for teacher's motivational assessment scale for secondary schools in Anambra State. From the results obtained, it was concluded that the items of the instrument provided a valid and reliable measure of secondary school teacher's motivation on their job.

Ugochukwu (2015) developed and standardized an instrument (45-items) for evaluating the practical skills and competences that are required by nursing students. The study discovered that; the instrument possesses good face and content validity. Garba (2017) developed an instrument for evaluating practical projects in woodwork. The research was conducted in 16 states in the Northern part of Nigeria. The instrument, Technical Evaluation of Practical Projects in Woodwork (TEPPW) was face-and content validated by experts in industrial, technical/ vocational education, measurement and evaluation. Reliability coefficients of the various sections of the instrument ranged from 0.56 to 0.81 while the instrument as a whole yielded an internal consistency of 0.91 which is valid and reliable for the study. On the other hand, development is the process of producing or creating something new or more advanced. Operationally, research instrument development is the process of producing new tools which are specifically used for research purposes. Any instrument developed for learning must satisfy necessary conditions. For instance, the development of a good instrument for evaluating learning outcomes of students must begin with a blueprint. The present study is to formulate and validate a scale for assessing students' motivation, there is no content because, social attributes which are not drawn from a specific universe or domain are not content bound. Therefore, content validity is not appropriate for this study. But there are factors which determine students' motivation. The blue print for developing the Students' Motivation to Learn Biology Scale (SMLBS) will, consequently, be built around the factors of motivation.

Science subjects like biology in Nigerian senior secondary schools has been plagued by serious problems of poor academic achievement by the students. The West Africa Examination Council (WAEC) Chief Examiners' Reports (2010 – 2016) reveal an alarming poor performance status in senior secondary school achievement in biology. The low achievement in biology has been partly attributed to poor motivation of students in the learning process (James, 2006). The problem stems from the paucity of measuring scale for assessing students' motivation to learn biology. The conventional approach used by researchers has proved unsatisfactory, hence, the main problem in motivational studies is its measurability due to lack of reliable measuring scale. This highlights the need to develop and validate a measuring scale which could be generally applied to determine the motivational status of students towards learning biology. The major concern of this exercise is to establish and certify a measuring scale for assessing students' motivation to learn biology in senior secondary schools. The general objective of this study therefore is to develop and validate an instrument for assessing students' motivation in the learning of biology in senior secondary schools. Specifically, the study sought to:

1. develop an instrument for measuring students' motivation in the learning of biology
2. determine the reliability coefficient of the instrument developed to measure students' motivation in the learning of biology.

Research Questions

The following research questions were posed to guide the study:

1. What is the construct validity of the instrument developed to measure students' motivation in the learning of biology?
2. What is the reliability coefficient of the instrument developed to measure students' motivation in the learning of biology?

Methods

This study employed instrumentation research design. According to Nworgu (2018), instrumentation research design is a study which is purely geared towards the development and validation of measurement instruments in education. This study therefore meets the requirement for instrumentation study because a measurement instrument was developed and validated to measure students' motivation to learn biology.

The study was carried out in Idah Education Zone of Kogi State in the North-Central Zone of Nigeria. The researchers chose this area for the study because literature available shows that none of the research studies on students' motivation done in this part of the country. The zone consists of four local government areas, namely: Idah, Ibaji, Igala-mela and Ofu. In the zone, there are thirty-eight (38) public senior secondary schools made up of thirty-three (33) co-education and five (5) single-sex schools. Thirteen (13) of the schools are urban while twenty-five (25) are rural schools (Secondary Education Management Board (SEMB) Idah, 2018/2019).

The study population comprised all the SS 2 students taking Biology in Idah Education Zone of Kogi State (SEMB, 2018/2019). Four hundred and eighty (480) SS 2 biology students were used as the sample size for the work. The sample was drawn using multi-stage sampling technique. The first stage involves using simple random sampling to sample two LGAs out of the four LGA in the zone. At the second stage, four schools were draw from each of the sampled LGAs using simple random sampling technique. The population of the students in the eight sampled schools formed the sample size of the study.

The instrument for data collection was a 63-item questionnaire titled 'Students Motivation in the Learning of Biology Scale' (SMLBS) and developed by the researchers from the information generated through review of literature. In developing the instrument, the following steps were taken:

Instrument Development

A questionnaire was used for data collection. Stages in the development of the instrument are as follows:-

STAGE 1: Assembling items

In this stage the researchers collected and assembled numerous conditions from literature on factors that may lead to Students' Motivation to Learn Biology Scale (SMLBS). The researchers equally requested the help of biology teachers on the modalities of the administration of the instrument. A combination of the above led to the assemblage of six factors from which 63 items were extracted: The six motivational factors are: teacher's personality, classroom environment, Students' Personal Factors, parents/family factors, and career needs.

STAGE 2: Organization of Items

The researcher realised that there was no need to reduce the factors from 6. This was done on close scrutiny. Some items seen as unnecessary were deleted based on the result of the factor analysis. Items which loaded 0.35 and above were retained as being valid (Factorially Pure, FP), but items with factor loadings of less than 0.35 (Factorially Impure, FI) and items which loaded up to 0.35 in two or more factors (Factorially Complex, FC) were dropped based on Meredith's (1969) proposal that minimum loading of 0.35 should be accepted for any item. The discussion and elimination exercise brought down the items to 43.

The instrument was designed and weighted as follows: Strongly Agree (SA = 4points), Agree (A = 3points), Disagree (D = 2points), Strongly Disagree (SD = 1point) for positively worded items, and vice versa for negatively worded items. The questionnaire was sub-divided into Sections A and B. Section A, was on the personal information of the students', while Section B contained items on students' motivation to learn biology. Section B had six clusters. Cluster A sought information on the teachers' personality factors in students' motivation. This cluster had ten items. Cluster B sought information on classroom environmental factors of students' motivation. The cluster had eleven items. Cluster C, with eleven items, sought information on students' personal factors. Cluster D sought to determine parents/family factors of students' motivation. This has seven items. Cluster E, with thirteen items, tried to determine peer factors of student's motivation. Cluster F which contained eleven items solicited information on career needs factor of students' motivation.

The measuring scale was certified by the three experts. Two were from Measurement and Evaluation and one from Biology Department in Science Education Department, Faculty of Education, University of Nigeria, Nsukka. They were required to validate the instrument with respect to items clarity, relevance, appropriateness of the identified factors, and the appropriateness of items under each of the factors. On the basis of the experts' comments, corrections and suggestions, the instrument was modified. To determine the construct validity of the instrument, factor analysis was employed. Construct validity was determined by subjecting the modified instrument (SMLBS) of ninety (90) items to factorial validation using factor analysis.

From the result of the factor analysis, items which loaded 0.35 and above were retained as valid (Factorially Pure, FP), while items with factor loadings of less than 0.35 (Factorially Impure, FI) and items which loaded up to 0.35 in two or more factors (Factorially Complex, FC) were dropped based on Meredith's (1969) proposed that a minimum loading of 0.35 should be accepted for any item. The factorial validation revealed that; items (1, 2, 3, 6, 7, 9, 10, 12, 13, 15, 16, 17,18, 19, 20, 21, 23, 24, 28, 29, 30, 31, 32, 33, 34, 36, 37, 38, 39, 42, 44, 45, 46, 47, 48, 51, 52, 56, 59, 61, 62, 63, 64, 65, 66, 67, 68, 71, 72, 73, 74, 75, 76, 77, 79, 80, 81, 82, 86, 87, 88, 89 and 90) were factorially pure (FP) while items (4, 5, 11, 14, 22, 25, 26, 27, 35, 40, 43, 49, 50, 53, 54, 55, 57, 58, 60, 69, 70, 78, 83, 84, and 85) were factorially complex (FC) and item (8 & 41) were factorially impure (FI). The twenty-seven items which were FC and FI were discarded. Thus, the researcher was left with only sixty-three items which were renumbered serially.

The internal consistency of the instrument was determined by administering the questionnaire to 30 SS 2 biology students of Dekina Education Zone which was not one of the zones under study. The scores obtained from the administration of the instrument were recorded and subjected to Cronbach-alpha method. The results show the reliability coefficient of 0.83, 0.83, 0.87, 0.70, 0.88, and 0.71 for clusters A; B; C; D; E and F while the overall reliability coefficient (Cronbach-alpha method) of 0.80 was obtained.

The administration of the instrument to SS 2biology students in the sampled schools was carried out with the help of their biology teachers who were told the modalities of how to administer the questionnaire. The instrument was administered and collected on the spot. In analysing the data collected, factor analysis was used to answer Research Question 1 while Research Question 2 was answered using Cronbach-Alpha.

Results

Research Question 1: What is the construct validity of the instrument developed to measure biology students' motivation in learning?

Table 1: The Varimax rotated factor loadings of the items of SMLBS

S/N	Item Statement	Component factors 1	2	3
1	I pay attention in Biology class to avoid punishment by my teacher.	0.066	0.453	0.036
2	I am encouraged by the teacher's high skill of knowledge in Biology.	0.422	0.142	0.187
3	My Biology teacher uses different teaching styles and that helps me to learn more in Biology.	0.436	0.329	0.121
4	My Biology teacher gives us explicit explanation in biology.	-0.084	0.269	0.627
5	My teacher encourages active participation in biology class.	-0.257	0.092	0.396
6	My biology teacher calls on me more often to answer question in biology class.	0.328	0.216	0.515
7	The organization of the lesson by my biology teacher to ensure maximum learning helps me to learn more in biology.	0.178	0.488	0.275
8	The kind of chalkboard we used in our biology classroom discourages me from working hard in biology.	0.007	0.378	0.215
9	I was motivated to become a biologist when I saw the equipments they used in biology classroom.	0.243	0.368	0.027
10	The arrangement of desks in biology classroom motivated me to learn biology.	0.002	0.428	0.085
11	The cold temperature in our biology classroom makes me to like biology.	0.016	0.116	0.578
12	Lack of laboratory apparatus in our biology classroom makes me to hate biology.	0.622	0.118	0.286
13	I hate our biology classroom due to lack of ceiling fan.	0.534	0.333	0.071
14	I like our biology classroom because of the floor.	0.653	0.084	0.082
15	Taking first in the Biology test makes me to work harder.	0.619	0.218	0.338
16	I pay attention during Biology instruction in order to be among the top 5 person in my class.	0.515	0.211	0.075

17	I'm encouraged to work harder after executing any Biology task correctly.	0.644	-0.063	0.122
18	I participate well in the Biology class in order to understand biology concepts.	0.593	-0.168	0.253
19	I do not put effort to succeed in Biology.	0.628	-0.013	-0.052
20	I study hard to avoid failure in Biology exams.	0.503	-0.411	-0.026
21	I find satisfaction in learning Biology.	0.452	-0.105	0.148
22	I expect praises when I did well in Biology test.	0.370	-0.157	0.240
23	I persevere even if Biology learning is difficult.	0.095	-0.118	0.378
24	My parent's background in science makes me to study Biology.	0.414	-0.050	0.311
25	My parents want science background in the family makes me to study Biology.	0.199	-0.016	0.489
26	My parent's buy me Biology textbooks.	0.071	-0.002	0.464
27	My parent's convinced that Biology is lucrative.	0.293	0.075	0.439
28	My classmates told me that Biology is important to study.	0.115	-0.145	0.506
29	I joined my friends to learn Biology.	0.178	0.168	0.520
30	My success in learning Biology will depend on the cooperation of my classmates.	0.462	0.324	0.293
31	My friend has passion for Biology.	0.296	0.426	0.186
32	The performance of my friend in Biology motivated me to work hard in biology.	0.273	0.363	0.121
33	My friend encourages me to read hard in biology.	0.260	0.451	-0.167
34	The lucrative nature of friend in biology helps me to work harder	0.335	0.376	-0.203
35	My classmate discourages me to become biologist.	0.111	0.425	-0.103
36	My friend told me that biology is not important to learn	-0.022	0.513	0.213
37	My friend praises me for any good performance in Biology.	-0.096	0.384	0.040
38	I am desirous to become a biologist.	0.220	0.363	0.038

39	I am determined to become a researcher in Biology.	-0.022	0.492	-0.161
40	I want to become a Biology teacher.	0.010	0.492	-0.190
41	I want to become a geneticist	-0.038	0.421	-0.107
42	I am working hard to become Biochemist.	-0.003	0.450	0.131
43	I want to become an Agriculturist.	0.415	0.257	-0.082

To answer the first research question, responses of the students to the questionnaire were subjected to Varimax rotated factor loading to determine the construct validity of the instrument. The rotated factor matrix presented in Table 1 revealed that forty-three items were factorially pure. The reason is that, the minimum loading of up to 0.35 was forty-three items as recommended by Meredith (1969). The factorially pure items were 1, 3, 4, 5, 7, 9, 10, 12, 13, 14, 16, 19, 20, 21, 22, 24, 25, 26, 27, 28, 29, 30, 31, 33, 34, 35, 39, 41, 42, 43, 46, 47, 48, 49, 50, 51, 52, 53, 55, 57, 59, 60, and 62.

However, nineteen items (that is, items 2, 6, 8, 11, 15, 17, 18, 23, 32, 36, 37, 38, 40, 44, 54, 56, 58, 61 & 63) had not attained the minimum loading of 0.35 on any of the three factors and were considered to be factorially impure. In the same vein, one item (item 45) was considered factorially complex because it loaded on more than one factor. The factorially complex and the factorially impure were discarded. Therefore, a total of forty-three items were considered as valid.

Research Question 2: What is the reliability coefficient of the instrument developed to measure students' motivation in the learning of biology?

The reliability estimate of the various sub-scales of the instrument was carried out using Cronbach alpha.

Table 2: The reliability coefficient of the various sub-scales of the instrument

S/N	Clusters		Reliability	
1	Cluster A:	Teacher's Personality as a Motivational Factor for students	.83	0.83
2	Cluster B:	Classroom Environment as a Motivational Factor for students	.83	
3	Cluster C:	Students' Personal Motivational Factor for students	.87	
4	Cluster D:	Parents/Family Motivational Factor for students	.70	
5	Cluster E:	Peers Motivational Factor for students	.88	
6	Cluster F:	Career Needs as a Motivational Factor for students	.71	
		Overall Reliability Coefficient	**.80**	

The reliability estimate of the various sub-scales of the instrument was carried out using Cronbach alpha. A summary of the sub-scales indicated that six clusters of Students' Motivation Learning Biology Scale (SMLBS) had alpha level coefficients of 0.83, 0.83, 0.87, 0.70, 0.88 and 0.71 for each of the clusters, with an overall reliability coefficient of 0.80.

Discussions of Findings

The items of the Students' Motivation Learning Biology Scale (SMLBS) displayed adequate validity. From the results of the factor analysis, items which loaded 0.35 and above were accepted as being valid (Factorially Pure, FP), but items with factor loadings of less than 0.35 (Factorially Impure, FI) and items which loaded up to 0.35 in two or more factors (Factorially Complex, FC) were rejected. Meredith (1969) stated that any item that loaded up to 0.35 should be accepted as the minimum factor loading for any item. The factorial validation revealed that items (1, 3, 4, 5, 7, 9, 10, 12, 13, 14, 16, 19, 20, 21, 22, 24, 25, 26, 27, 28 ,29, 30, 31, 33, 34, 35, 39, 41, 42 ,43 ,46, 47, 48, 49, 50, 51, 52, 53, 55, 57, 59, 60, & 62) were factorially pure (FP) while item (45) was factorially complex (FC) and item (2, 6, 8, 11, 15, 17, 18, 23, 32, 36, 37, 38, 40, 44, 54, 56, 58, 61 and 63) were factorially impure (FI). The twenty items which were FC and FI were discarded. Thus, the researcher was left with only forty-three valid items out of the initial 63 items.

The factor analysis used in this study was specifically employed to ascertain the minimum number of hypothetical factors that can account for observed co-variation and as a means of exploring the data for possible data reduction. As it was applied in the students' motivation learning biology scale, it explored the underlying factors that explained students motivation and the extent to which the forty-three surviving items of the SMLBS were justifiable. The validity of the surviving items in this study agrees with the findings of Chukwudolue (2002) who developed and validated an instrument of 63 items for teacher's motivational assessment scale for secondary schools in Anambra State. From the results obtained, it was concluded that the items of the instrument provided a valid and reliable measure of secondary school teacher's motivation on their job.

The forty-three items of SMLBS that survived factor analysis were classified into six clusters where they originally belonged and each cluster was subjected to a test of internal consistency using Cronbach Alpha method. A summary of the data analysis result was shown in Table 2. This analysis indicated that the sub-scales of SMLBS exhibited sufficiently high coefficients of reliability. The indices of reliability of the clusters on teacher's personality, classroom environment, students' personal motivation, parents/family motivation, peer motivational factors and career needs as motivational factors for students were 0.83, 0.83, 0.87, 0.70, 0.88, and 0.71 respectively. This showed evidence of the internal consistency of the instrument. The findings agree with those of Chukwudole (2002) and Ugochukwu (2015) which indicated that the reliability of a scale's short form was approximately 0.1 less than the corresponding long form. The study also relates to Garba's high reliability of developed instrument to stand a test of time when it is approximately developed.

Conclusion

From the findings of the study, it was concluded that, forty-three (43) items were found to be valid out of the initial 63 items. The reliability coefficients of the instrument developed to measure students' motivation in the learning of biology were found to be valid and reliable. This implied that the instrument was valid and reliable to measure student's motivation in the learning of biology. Also the norming of the instrument was ascertained using grade equivalent norm and 5.2 was obtained. This indicated that student performance is comparable to a student in second month of SS2.This type of scoring is best used to see the yearly progress of students and how they compare with their peers. Just because a student scores at a higher grade level in one area doesn't mean that they belong to that grade. This guideline was use in the norming processes of the present study.

Recommendations

On the basis of this study, the following recommendations were made.

1. In order to promote students motivation, government and other stakeholders in education ought to create adequate predictors of motivation in secondary schools. This will make students to derive motivation from their studies so as to ensure maximum productivity and efficiency in the schools.
2. The findings of this work could be made available to authorities responsible for making educational policies and a reference point on policy decisions on motivation of students to learn.
3. All other researchers in the area of motivation should adapt this instrument and use it as a major reference point especially in collecting data on students' motivation in the learning of biology.
4. The researchers also recommended that norming should be carried out in any instrumentation work in other to make the outcome standard.

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