



Development and Validation of Motivational Instrument for Assessing Biology Students' Learning in Senior Secondary Schools in Idah Education Zone of Kogi State, Nigeria

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Abstract

Students' academic performance in biology with one of the science disciplines taught in secondary schools in Nigeria, has been severely hindered. The lack of instruments for determining students' motivation to learn biology is one of the roots of the issue. Therefore, it is necessary to develop and validate an instrument that might be used widely to assess students' motivation levels for learning biology in Nigerian secondary schools. A sample of 281 senior secondary school students was chosen to complete the SMLBS (Students' Motivation Learning Biology Scale) using Taro Yamane's Formula. The data were analyzed using factor analysis, mean and standard deviation, and Analysis of Variance (ANOVA). Results showed that 43 out of 63 items were factorially pure. One item was factorially complex, whereas 19 items were factorially impure. However, there was no discernible difference between class level and the mean evaluations of students' enthusiasm to learn biology as determined by SMLBS. By examining the elements affecting motivation and how they affect student learning, the current study advances the body of knowledge on motivation. The implications include that since learning and motivation have been discovered to be interrelated, it enables biology teachers to pinpoint the elements that spur students to pursue the Subject. The main flaw was that the factor analysis model presupposed that all data to be used were error-free, but in reality, data were subject to bias in selection, sampling, and measurement, as well as disturbances brought on by minute factors that the researchers had not fully anticipated. The researchers acknowledged the possibility of a small inaccuracy as a result of not using error-free data.

Keywords: Development, Learning, Motivation, Students, Validation

Introduction

The goals of the secondary school biology curriculum are to prepare students to acquire adequate laboratory and field skills in biology, meaningful and relevant knowledge in biology, the ability to apply scientific knowledge to daily life in matters of personal and community health and agriculture, and a reasonable and practical attitude toward science (Federal Republic of Nigeria's National Policy on Education, FRN, 2014). Despite the value and goals of learning biology, students' performance in the subject has not been very encouraging. The West Africa Examinations Council's (WAEC) Chief Examiner's Report (May/June, 2018–2023) provides evidence of students' poor performance in biology. The pass rate at the credit level recorded for 2018–2023 is 49.65%, 38.50%, 35.66%, 41.39%, 47%, and 48%, respectively.

The lack of teaching and learning materials, such as chemicals, charts, apparatus, models, local specimens, laboratories, textbooks, and libraries, may be a contributing factor to students' low performance in

biology (Ahmad & Alice, 2014). The authors continued, "Irregularities relating to the Biology teachers, such as irregularity in the administration of practical, class discussion, teachers not allowing students to ask questions, teachers not promptly providing feedback on assignments or examinations, failing to make the Biology subject interesting, and teachers failing to conduct demonstration during practical, also contribute to students' poor performance." The aforementioned are potential causes of students' poor academic performance in biology. In addition to these issues, James (2017) suggested that biology students' low motivation affects their performance, particularly on exams that are administered outside of the classroom, such the West African Senior Secondary Certificate Examination (2018–2023). In accordance with this, Offor, et al. (2020) explained that students' low academic performance was as a result of lack of an instrument for measuring students' motivation to learn biology.

Ngwoke (2010) describes motivation as a psychological concept that explains human action that is purposeful or goal-directed. The internal condition, or mental and psychological state, of an individual, which compel, energize, sustain, and lead the individual's action toward a goal, is what is meant by motivation. Ngwoke went on to say that motivation is a key factor in why some students strive to pass exams while others wait for test fraud. However, the will to succeed may only be seen in the behavior that students value. As a result, different circumstances have varying values for students' achievement (Eccles et al., 2020). Kit-Ling (2019) conducted study on how reading motivation varied by grade among Hong Kong primary and secondary pupils. It was shown that Chinese students in Hong Kong frequently experience a reduction in motivation. A study on the development and validation of tools for evaluating the environment of a mathematics classroom was conducted by Osegbo (2014). According to the results of this instrumentation and ex-post facto research design study, factors in the classroom environment could predict as well as offer solutions to students' cognitive and affective outcomes.

However, learning could be considered to be determined by motivation. Therefore, educators need to know how to inspire students to learn. Research instruments are tools that are used only for conducting research. They are fundamental and absolutely necessary for any research to be conducted successfully. According to Abonyi (2011), a research instrument should be thought of as a tool for calculating the current value of the quantity being studied. Without an appropriate tool, the value of the amount under inquiry cannot be accurately measured (Offor et al., 2020). Planning the test, preparing the test, running the test, and evaluating the test are the steps in the instrument development process, according to Abonyi (2011). The aforementioned methods were used in this study in order to develop a valid and trustworthy instrument to assess students' motivation for learning biology. The effects of gender and class disparities on the physics attitudes of Nigerian senior secondary school One (SS1) and Two (SS2) students were examined by Ariyo (2019). The author described how students' reading difficulties, low reading engagement, issues with text readability, and poor comprehension skills exist independently of class level. This demonstrates that students' class level and attitude have no discernible impact on their ability to study physics. According to Ovute (2022), class level affects students' proficiency in Igbo language. Therefore, it is necessary

to investigate how students' interest levels for learning biology in secondary school are influenced by their class level.

In practice, research instrument development is the process of developing new tools intended solely for use in research. Any tool developed for education must meet prerequisite requirements. For instance, a blueprint is necessary for the development of an effective tool for assessing students' learning outcomes. The goal of the current study is to develop and validate a tool for evaluating students' motivation. Since social traits that are not derived from a particular universe or domain are not considered content, content validity is inappropriate for this study. However, there are other things that affect students' motivation. Therefore, the motivational variables will serve as the foundation for the Students Motivation to Learn Biology Scale (SMLBS). In relation to class level, the current work developed and validated an instrument for measuring students' motivation to learn biology.

An educational researcher can employ a variety of research methods and tools. Observation, a questionnaire, an interview, and a measuring scale are a few of the methods they employ (Likert, Thurstone, and Guttman). They are fundamental and necessary for any research to be conducted successfully. The value of the amount under inquiry cannot be accurately determined without an appropriate tool (Eze, 2021). For secondary school teachers in Anambra State, Chukwudolue (2022) developed and validated an instrument for the teacher's motivation assessment scale. Based on the findings, it was determined that the instrument's items provided a valid and reliable indicator of secondary school teachers' job motivation. An instrument was developed and standardized by Ugochukwu (2023) to assess the competencies and practical skills needed by nursing students. The tool has strong face and content validity. An assessment of the psycho-social classroom environment perceptions of students and teachers in mathematics in Anambra State, Nigeria, was conducted by Osegbo (2014). The findings revealed: (1) Instruments used to measure the classroom environment are sensitive to differences in class levels and gender. Location, on the other hand, has little impact. Class, on the other hand, accounts for the greatest variances in the classroom environment, whereas sex has the least impact. Olagunju (2021) examined the relationship between gender and class level on students' mathematics achievement in Ondo State, Nigeria, and found that girls' mathematics performance declines as they move up in class level.

Students also preferred a more favorable mathematics classroom environment than was perceived to be actually present. Based on the findings, recommendations and conclusions were made.

There are few studies on the development and validation of motivational instruments for evaluating biology students' learning, despite the fact that prior studies have evaluated students' motivation in learning. Based on the aforementioned, the study adds to the body of literature by accomplishing two goals. First, the study aims to establish the validity of the instrument designed to measure students' biology learning motivation, and second, it explores the impact of class level on this motivation, as evaluated by the SMLBS (Students' Motivation Learning Biology Scale). In this sense, the extent literatures glaringly lack sufficient empirical study. As a result, the research will make a significant contribution to the body of literature. However, the study's research hypothesis was tested at the 0.05 level of significance.

Ho₁: There is no significant difference in the mean ratings of students' motivation to learn Biology as measured by SMLBS with respect to class level.

Methods

The study employed an instrumentation research design. The design was appropriate as the study is purely geared towards the development and validation of measurement instruments in education. The population of the study comprised 950 SS1-3 students offering Biology. The sample size for the study is 281 SS1-3 Biology students using Taro Yamane's

Formula. The sample was drawn using a multi-stage sampling procedure. The first stage involves using a simple random sampling technique to sample two LGAs out four LGAs in the zone. Secondly, a stratified random sampling technique was used to draw four schools each from the two sampled LGAs in the zone. This was to ensure the greater representativeness of the sample relative to the population and guarantee that the majority constituents of the population were represented in the sample.

Finally, a proportionate stratified random sampling technique was also used to draw 35 SS1-3 Biology students from each of the sampled schools making a total of 281 Biology students. A proportionate stratified random sampling technique was used because the population of students in the LGAs is almost the same. The instrument for data collection is a 63-item questionnaire titled "Students' Motivation in the Learning of Biology Scale" (SMLBS). The instrument was developed by the researcher based on the information generated through review of literature. The instrument was designed on a four point-rating scale 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 instrument was administered to SS 1, 2 and 3 Biology students in the sampled schools with the help of their biology teachers who were briefed on the modalities of the administration of the instrument. The instrument was analyze using Factor analysis, mean and standard deviation and analysis of variance (ANOVA).

Results

What is the construct validity of the instrument developed to measure students' motivation in learning of Biology?

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

S/N	Item Statement	Component factors		
		1	2	3
1	In order to get out of trouble with my teacher, I pay attention in biology class.	0.066	0.453	0.036
2	I comprehend the biology lessons the teacher is teaching.	0.003	0.085	-0.027
3	The teacher's strong biological understanding gives me hope.	0.422	0.142	0.187
4	I am able to learn more about biology since my biology teacher employs a variety of teaching methods.	0.436	0.329	0.121
5	My biology teacher clearly explains things to us.	-0.084	0.269	0.627
6	When the bell rings, my biology teacher shows up for class.	-0.045	0.226	0.039



7	Active engagement in biology class is encouraged by my teacher.	-0.257	0.092	0.396
8	Our biology teacher gives me attention in biology class.	0.004	0.259	0.249
9	My biology teacher calls on me more often to answer question in biology class.	0.328	0.216	0.515
10	The organization of the lesson by my biology teacher to ensure maximum learning helps me to learn more in biology.	0.178	0.488	0.27
11	The conduciveness of our biology classroom motivates me to work hard in biology.	0.027	0.309	0.222
12	The kind of chalkboard we used in our biology classroom discourages me from working hard in biology.	0.007	0.378	0.215
13	I was motivated to become a biologist when I saw the equipment they used in biology classroom.	0.243	0.368	0.02
14	The arrangement of desks in biology classroom motivated me to learn biology.	0.002	0.428	0.085
15	The high temperature in our biology classroom makes me to hate biology.	-0.053	0.178	0.219
16	The cold temperature in our biology classroom makes me to like biology.	0.016	0.116	0.578
17	The introduction of using whiteboard marker in our biology classroom attracts me to learn more in biology.	0.110	0.337	0.187
18	I love studying in biology classroom when the environment is not noisy.	0.003	0.284	0.328
19	Lack of laboratory apparatus in our biology classroom makes me to hate biology.	0.622	0.118	0.286
20	I hate our biology classroom due to lack of ceiling fan.	0.534	0.333	0.071
21	I like our biology classroom because of the floor.	0.653	0.084	0.082
22	Taking first in the Biology test makes me to work harder.	0.619	0.218	0.338
23	The urge to read my Biology book is always strong.	0.296	-0.017	-0.078
24	I pay attention during Biology instruction in order to be among the top 5 person in my class.	0.515	0.211	0.075
25	I'm encouraged to work harder after executing any Biology task correctly.	0.644	-0.063	0.122
26	I participate well in the Biology class in order to understand biology concepts.	0.593	-0.168	0.253
27	I do not put effort to succeed in Biology.	0.628	-0.013	-0.052
28	I study hard to avoid failure in Biology exams.	0.503	-0.411	-0.026
29	I find satisfaction in learning Biology.	0.452	-0.105	0.148
30	I expect praises when I did well in Biology test.	0.370	-0.157	0.240
31	I persevere even if Biology learning is difficult.	0.095	-0.118	0.378
32	I make sure that I am successful in Biology class.	0.108	-0.130	0.345
33	My parent's background in science makes me to study Biology.	0.414	-0.050	0.311
34	My parents want science background in the family makes me to study Biology.	0.199	-0.016	0.489
35	My parent's buy me Biology textbooks.	0.071	-0.002	0.464

36	My parent's relates my success in Biology to my effort.	0.058	-0.118	0.187
37	My father as a Biology teacher also motivated me to learn biology.	0.150	-0.312	0.237
38	My parent's encouragement improves my effectiveness in the learning of Biology.	0.065	-0.133	0.313
39	My parent's convinced that Biology is lucrative.	0.293	0.075	0.439
40	My classmates told me to read Biology.	0.195	0.121	0.288
41	My classmates told me that Biology is important to study.	0.115	-0.145	0.506
42	I joined my friends to learn Biology.	0.178	0.168	0.520
43	My success in learning Biology will depend on the cooperation of my classmates.	0.462	0.324	0.293
44	My friend is motivated to study Biology.	0.319	0.128	0.247
45	My friend encouraged me to become a Biology teacher.	0.475	0.384	-0.059
46	My friend has passion for Biology.	0.296	0.426	0.186
47	The performance of my friend in Biology motivated me to work hard in biology.	0.273	0.363	0.121
48	My friend encourages me to read hard in biology.	0.260	0.451	-0.167
49	The lucrative nature of friend in biology helps me to work harder	0.335	0.376	-0.203
50	My classmate discourages me to become biologist.	0.111	0.425	-0.103
51	My friend told me that biology is not important to learn	-0.022	0.513	0.213
52	My friend praises me for any good performance in Biology.	-0.096	0.384	0.040
53	I am desirous to become a biologist.	0.220	0.363	.0384
54	I am striving hard to become a medical doctor.	0.193	0.127	0.105
55	I am determined to become a researcher in Biology.	-0.022	0.492	-0.161
56	I am working hard to become a zoologist.	-0.147	0.152	0.128
57	I want to become a Biology teacher.	0.010	0.492	-0.190
58	I want to become a laboratory technician.	0.039	0.340	-0.009
59	I want to become a geneticist	-0.038	0.421	-0.107
60	I am working hard to become Biochemist.	-0.003	0.450	0.131
61	I want to become anatomist.	0.036	0.204	-0.077
62	I want to become an Agriculturist.	0.415	0.257	-0.082
63	I am working hard to become a parasitologist.	-0.203	0.072	0.192

In order to determine the construct validity of the instrument, the responses of the students to the questionnaire were subjected to Varimax rotating factor loading. A total of forty-three items were factorially pure, according to the rotated factor matrix shown in Table 1 of the results. The forty-three elements met Meredith's (1969) recommendation for a minimum loading of up to 0.35 as the cause. 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 and 63) did not attain the minimum loading of up to 0.35 on any of the three factors. These were considered to be factorially impure. In the same vein, one item (item 45) was loaded on more than one factor and were therefore considered factorially complex and discarded alongside the other items that did not attain the minimum loading

of 0.35 on any of the three factors. Therefore, a total of forty-three items were considered as valid and presented in table 1b.

Table 1B: Varimax rotated factor loadings of the pure items of SMLBS

S/N	Item Statement	Component factors		
		1	2	3
1	In order to get out of trouble with my teacher, I pay attention in biology class.	0.066	0.453	0.036
2	The teacher's strong biological understanding gives me hope.	0.422	0.142	0.187
3	I am able to learn more about biology since my biology teacher employs a variety of teaching methods.	0.436	0.329	0.121
4	My biology teacher clearly explains things to us.	-0.084	0.269	0.627
5	Active engagement in biology class is encouraged by my teacher.	-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 equipment 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
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32	My friend has passion for Biology.	0.296	0.426	0.186
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37	My friend told me that biology is not important to learn	-0.022	0.513	0.213
38	My friend praises me for any good performance in Biology.	-0.096	0.384	0.040
39	I am desirous to become a biologist.	0.220	0.363	.0384
40	I am determined to become a researcher in Biology.	-0.022	0.492	-0.161
41	I want to become a Biology teacher.	0.010	0.492	-0.190
42	I want to become a geneticist	-0.038	0.421	-0.107
43	I want to become an Agriculturist.	0.415	0.257	-0.082

What is the influence of class level on the students' motivation to learn Biology as measured by students' motivation learning biology scale (SMLBS)?

Table 2: Mean responses of SS1, SS2 and SS3 students on SMLBS

Class Level	N	Mean	SD
SS1	92	3.01	0.26
SS2	97	3.01	0.30
SS3	92	3.04	0.29

Table 2, shows the average score for SS1 biology students was 3.01, with a standard deviation of 0.26. In a similar vein, SS2 biology students' mean and standard deviation were 3.01 and 0.30, respectively,

while SS3 biology students' mean and standard deviation were 3.04 and 0.29, respectively. This indicates that there is no variation in the mean scores of biology students in grades SS1 through SS3.

Table 3: ANOVA of the significant difference in the mean ratings of students' motivation to learn Biology as measured by SMLBS with respect to class level.

	Sum of Squares	Df	Mean Square	F	P-value
Between Groups	0.041	2	0.020	0.252	0.777
Within Groups	19.091	278	0.081		
Total	19.132	280			

The SMLBS result for the significant difference in the mean ratings of students' motivation to learn biology with respect to class level is shown in Table 3. The outcome reveals that an F-ratio of 0.252 and a probability value of 0.777 were obtained. When this probability value was compared to the level of significance of 0.05, it was determined that it was not significant. The null hypothesis was approved as a result. The conclusion reached was that there is no discernible difference between class level and the mean ratings of students' motivation to learn biology as determined by SMLBS.

Discussions of Findings

The findings of the study are discussed in line with the research questions and hypothesis raised in the study. They are discussed with research findings in literature reviewed.

The items of the students' motivation learning biology scale (SMLBS) displayed adequate validity. From the result 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 based on Meredith (1969) recommendation that a loading of 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, and 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 items and these 43 items were found to be valid out of the initial 63 items.

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. 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 is consistent with (Chukwudolue, 2022; Ugochukwu, 2023), which indicated that, the instrument possesses good face, content validity and construct validity.

Again, the study revealed that the mean differences of SS1, SS2 and SS3 students and their standard deviations respectively were very insignificant. Pronounced differences were not observed in the responses of the SS1, SS2 and SS3 students. A further analysis of data using ANOVA on the F-ratio was employed and no significant result was observed. From the analysis, SS1, SS2 and SS3 does not derived more motivation than the other and this contradicted Osegbo's (2014) that, class level account for the highest variations in the classroom environment. However, the result is agree with Olagunju (2021) that, there is no significant differences among SS1, SS2 and SS3 students motivation towards the learning of biology. Therefore, every facet of the secondary school needs to be improved. Also, the session of this study was found to have an impact on students learning motivation.

Conclusion

As a result, this study used instrumentation that is only focused on the development and validation of measuring tools in education. According to the study's findings, the students' motivation to learn biology, as determined by the students' motivation to learn biology scale, was not significantly influenced by class level. Additionally, factor analysis was utilized in this work to examine the data for potential data reduction and to

determine the lowest number of hypothetical components that could explain observed co-variation. Finally, in order to increase student motivation, the government and other education stakeholders should establish sufficient motivational predators in secondary schools. These predators should encourage students to pursue their studies with a sense of purpose in order to maximize school production and efficiency.

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