The Psychometric Properties of Secondary School Biology Students Self-Reported Genetics Engagement Questionnaire (BSSRGEQ) in Kano State, Nigeria

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ABSTRACT

This study established the psychometric properties of secondary school Biology Students Self-Reported Genetics Engagement Questionnaire (BSSRGEQ). The instrument is to be used to examine Student Engagement towards Academic Achievement in Genetics among Senior Secondary School Students in Kano State, Nigeria. Two objectives with two research questions were raised for the pilot study. The instrument was subjected to face, content and construct validity, eight (8) experts in the field of Tests and Measurement, Educational Psychology, Biology, Microbiology and English Language from Bayero University Kano, Federal College of Education Kano, Kano State College of Education and Preliminary Studies and Kano State Senior Secondary Schools Management Board respectively validated the instruments. The pilot testing was conducted with a sample of (278) SS III students of GSS Dorayi Babba and GGSS Sani Managge in Gwale Zonal Education Directorate of Kano state. Construct validity was established through the use of Factor Analysis (FA), while content validity was established through the Content Validity Index (CVI). In the process of establishing the reliability index of the instruments, Cronbach's Alpha was used with aid of Statistical Package for the Social Sciences (SPSS) software. From the results of the analysis, it was found that: BSSRGEQ have adequate construct and content validity indices, where the (CVI) was found to be = 93.66% while Cronbach' alpha values for BSSRGEQ was α = .904. Based on the above findings, it can be concluded that the instrument was statistically valid and reliable for data collection.

Key Words: Psychometric Properties, Pilot Testing, Construct Validity, Face and Content Validity, Factor Analysis, Content Validity Index

Introduction

Ancestrally, progress in science have brought about healthier living and longevity, have led to wealthier and more productive lives, and have ensured that more advanced technologies, through the application of scientific knowledge, are developed for the betterment of mankind (Anaeto, Asiabaka,Nnadi,Ugwoke & Ihekeronye, 2016). One of the primary branches of science that has contributed this advancement is biology. Biology as a branch of science is central to many sciences related courses such as Medicine, Pharmacy, Nursing, Agriculture and Biochemistry. It is obvious that no students intending to study the above-mentioned disciplines can do without biology. As a natural science, biology is a unique branch of science, with many branches including genetics. In Nigerian secondary schools, biology is taught in senior secondary schools. Genetics is taught in Nigerian schools as a topic in biology in the terminal class (sixth year) of senior secondary school. İt is a topic that frequently intertwines with many other life sciences, and its knowledge is essential for biological and life scientists (Ajayi & Adelana, 2020).

Genetics studies is applicable to the identification, diagnoses and prognosis of heritable diseases, cancer and microbes, genetic recombination and mutation, drug discovery, production of vaccines, preservation of biodiversity, inheritance pattern, creating genetic reproduction, genetically modified organisms, genetic engineering, DNA fingerprinting and crime detection, breeding production, as well as disease resistance and improvement of crops and farm animal species (Choden & Kijkuakul, 2020). This points to the need to hype genetics literacy presently in secondary schools, especially among the science students of the 21st century (Boerwinkel et al, 2017). This is because, the more scientifically skilled and knowledgeable the citizens of a nation are, the higher the chances that such a nation will experience unprecedented scientific and technological development (Odufuwa et al, 2022).

Despite the basic importance of genetics for sustainability and socioeconomic development of the nation in all spheres of life in terms of medicine, agriculture, engineering, biotechnology and industries, the Chief Examiner's Reports 2002 to 2021 of the West African Examinations Council (WAEC), have shown that students find the concept of Genetics difficult and have issues with it every year (Chief Examiner Reports, 2022). Research studies revealed common genetics topics in which students encounter difficulties and hold misconceptions and also this makes students to show no interest in genetics and the situation lead to poor achievement of students in biology in general (Lawal, 2010, Etobro & Banjoko, 2017; Maigoro, Nansoh, Pam & Manji, 2017). Student's misconceptions and difficulties in grasping genetics terms attract the attention of many researchers, focusing on ways and strategies to follow for student success, several literatures reviewed such as (Angraini, Zubaidah, Susanto & Omar 2022; Oyelade & Oladiji, 2020; Shuaibu 2017; Abdullahi, 2015) makes investigation on teaching method and teacher's strategies for student's success which is concluded with inconsistent result and also failure in genetics concept are still detected.

In order to address students' misconceptions and difficulties in learning genetics concept, predictive variable such as student engagement is looked upon. In addition, student's engagement is a necessary pre-requisite to regulate student's learning. Therefore, learners need to be able to engage actively while carrying out their task of learning and achieve success as well.

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Numerous assessment tools exist to measure genetics concept and students engagement separately such as Students' genetics concepts test SGCT (Ojo, 2024) , Certainty response index scale CRI (Hasan et al.'s 1999), General Practitioner Genetics Questionnaire GPGeneQ (Flouris, Aitken, Metcalfe &Hawthorne, 2010), Questionnaire on perceived causes of students misconceptions in genetics concepts QPCSMGC (Ojo, 2024), Student Engagement Scale (Dogan, 2014), School Engagement Scale (Arastaman, 2006) etc. Therefore, gap remains. In Nigeria, there exists a deficiency of instrument used in measuring Genetics student's engagement in senior secondary school students at different levels. It is against this background that the present study sought to investigate the procedures and techniques employed in establishing the psychometric properties of Biology Students Self-Reported Genetics Engagement Questionnaire (BSSRGEQ).

Statement of the Problem

Students engagement in genetics plays a crucial role in enhancing learning outcomes, fostering critical thinking and improving academic achievement. However, measuring students' engagement in genetics accurately remains a challenge due to the lack of reliable and validated assessment tools. In Nigeria, there exists a deficiency of a valid, dependable and reliable assessment tool for measuring Genetics student's engagement of senior secondary school students at different levels. Existing inventories in literatures are for measuring either students' performance or perception in Genetics and also inventories in student engagement measures students' activities in school. Self-reported questionnaires are widely used to assess students' engagement, but their psychometric properties such as validity, reliability and factor structure must be rigorously examined to ensure their effectiveness in capturing students' true levels of engagement.

Despite the importance of genetics in biology, there is limited research on the development and validation of engagement measurement tools tailored specifically for biology students. Cognitive, emotional and behavioural dimensions of students' engagement in genetics learning. Without a well-validated tool, educators and researchers may struggle to accurately assess and enhance student engagement in this critical subject area. Therefore, this study sought to established the psychometric properties of secondary school Biology Students Self-Reported Genetics Engagement Questionnaire (BSSRGEQ). Specifically, it was sought the reliability, validity and factor structure of the instrument to determine its suitability for measuring genetics engagement among secondary school biology students.

Purpose of the Study

The main purpose of this study was to determine the psychometric properties of the Biology Students Self-Reported Genetics Engagement Questionnaire (BSSRGEQ). Specifically, the study:

1. Establish the face, content and construct validity of Biology Students Self-Reported Genetics Engagement Questionnaire (BSSRGEQ) adapted Reschly, Appleton, and Christenson (2007); Fin, Folger and Cox (1999).

2. Establish the internal consistency reliability of Biology Students Self-Reported Genetics Engagement Questionnaire (BSSRGEQ) adapted from Reschly, Appleton, and Christenson (2007); Fin, Folger and Cox (1999).

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Research Questions

Based on the above research objectives, the following research question were raised:

1. What is the face, content and construct validity of Biology Students Self-Reported Genetics Engagement Questionnaire (BSSRGEQ)?

2. What is the reliability coefficient of Biology Students Self-Reported Genetics Engagement Questionnaire (BSSRGEQ)?

Methodology

The sample size of the pilot testing covered 278 senior secondary three students selected using simple random sampling technique, the schools include GSS Dorayi Babba and GGSS Sani Mainagge in Gwale, Zonal Education Directorates of Kano State. The distribution of the sample by gender is 118 males (42.5%) and 156 (57.5%) females. The schools are within the target population for the study, but did not form part of the main study, thus they have similar characteristics with other schools proposed for the main study. The pilot study used SS III because they are already introduced to Genetics concepts and are still under treatment. The Biology Students Self-Reported Genetics Engagement Questionnaire (BSSRGEQ) was administered and last for 45 minutes' period. In the process of data collection, the researcher collects an introductory letter from the Department of Science and Technology Education, Bayero University, Kano and presented to the Principals of the sample schools for permission to conduct the pilot test of the instruments. After introduction by the subject teacher, the researcher briefed the students about the aims and importance of the study. Also, the researcher guided the respondents (students) on how to fill the instruments as the need may arise, and the completed copies of the instruments were retrieved on the spot from the respondents. This method ensures proper completion as well as high return rate of the instrument. The data collected were analyzed using the Statistical Package for the Social Science (SPSS) software version 20.

Data Collection Instrument

The instrument used in the conduct of the pilot testing, is titled: "Biology Students Self-Reported Genetics Engagement Questionnaire (BSSRGEQ)".

The Instruments Modification Processes

To ensure that the instrument have cross cultural validity, it has to be domesticated to the context of the intended study. The Biology Students Self-Reported Genetics Engagement Questionnaire (BSSRGEQ) was adapted from Students Engagement Instrument (SEI), developed by Reschly, Appleton, and Christenson (2007) and Students Engagement Observation Checklist (SEOC) developed by Finn, Folger and Cox (1991). The Students Engagement Instrument (SEI) is a self-reported tool designed to measure the emotional and cognitive engagement of students in school with 35 items. It assesses factors such as teacher-student relationships, peer support, future aspirations and intrinsic motivation. The SEI is widely used in educational research to examine how students connect with their learning environment. Also the students engagement instrument with 35 items after exposed to factor loadings shows good validity, the internal consistency estimates for SEI was found to be $\alpha = 0.88$ which indicate it has good reliability.

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The Engagement Observation Checklist by Finn, Folger and Cox (1991) is an observational tool used to assess students' behavioural engagement in classroom settings with 4 subscales (effort, initiative, disruptive behavior and inattentive behavior) and consist of 18 items. It focuses on indicators such as participation and interaction with peers and teachers. This SEOC is particularly useful for researchers and educators aiming to measure engagement through direct observation rather than self-reported tool. The SEOC 18 items after exposed to factor loadings based on the taxonomy of students' participation was found to be sufficiently adequate, the instrument yield reliable scales (effort, initiative and non-participatory behavior) of 0.94, 0.89 and 0.89 respectively.

As for scoring, the SEI is a 4 point Likert scale which was designed with an ordinal scale ranging from 1 (strongly disagree) to 4 (strongly agree). While the SEOC is a 5-point scale ranging from 1(never) through 3 (sometimes) to 5 (always) Based on these qualities, the developers showed that the inventories have high reliability and it can be used to measure students' engagement towards learning.

The two inventories were merged and exposed to factor analysis, where 10 items from SEI make up the cognitive and emotional part of BSSRGEQ while 5 items from the SEOC constitute the behavioral part of BSSRGEQ, so the Biology Students Self-Reported Genetics Engagement Questionnaire (BSSRGEQ) is made up of 15 items with 3 subscales.

For the purpose of adaptation, the inventory title 'Biology Students Self-Reported Genetics Engagement Questionnaire (BSSRGEQ)' was adapted from SEI and SEOC. It is a 15 items scale of three component/subscale of cognitive, emotional and behavioral engagement after exposed to factor loading. Each of the three subscales contained five items. As for the scoring procedures, BSSRGEQ used 4-point Likert scale ranging from 1 Strongly Disagree (SD), 2 Disagree (D), 3 Agree (A), 4 strongly Agree (SA). Also to ensure there is no language bias some of the items were modified to suit Genetic class. For example: item (cognitive engagement 1) Cognitive Engagement1 'after finishing my school work I check it over to see if its correct' was modified to "after finishing my Genetics assignment I check it over to see if its correct" item Cognitive Engagement3 "when I do school work I check to see whether I understand what I'm doing" was modified to " when I do my Genetics assignment I check to see whether I understand what I'm doing" Cognitive Engagement7 "when I do well in school it's because I work hard" was modified to "when I do well in Genetics task it's because I work hard" item Cognitive Engagement 12 "the grade in my classes do a good job of measuring what I'm able to do" was modified to "the test in my classes do a good job of measuring what I'm able to do" item (emotional engagement 19) Emotional Engagement19 "I feel safe at school" was modified to "I feel safe in Genetics class" item (behavioral engagement 2) Behavioural Engagement2 'work well with other children' was modified to 'I work well with other students in Genetics lesson'. Item Behavioural Engagement4 "Act restless, unable to sit still" was modified to "My colleagues and I acts, restlessly and unable to active in Genetics lesson" item Behavioural Engagement11 "Is withdrawn, uncommunicative" was modified to "I am always withdrawn and uncommunicative in Genetics lesson" item Behavioural Engagement13 "ask questions to get more information" was modified to "1 ask questions to get more information in a Genetics lesson". "Item Behavioural Engagement17 "raises his/her hand to answer a question or volunteer information" was modified to "I raise stood up to answer questions or volunteer information in Genetics class".

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Research Instrument

The Biology Student's Self-Reported Genetics Engagement Questionnaire (BSSRGEQ) has two parts, the first part consists of the demographic information of the respondents which covers information about the respondents' ID, name of the school, gender of the respondents and the second part which contains the main items of the instrument. This consists 15- items in a 4-point Likert-scale format. It is designed in three components of 5 items each. The responses option are "Strongly Agree (SA), Agree (A), Disagree (D), Strongly Disagree (SD)". The distribution of the items on the subscales are as follows; (cognitive, emotional and behavioral engagement). The maximum scores, were 60 (i.e, 4 x 15 = 60) and the minimum score were 15 (i.e, 1 x 15 = 15). Scores obtained for each respondents were summed up into percentage.

Validation of the Instrument (BSSRGEQ)

One of the first psychometric tests, an instrument should undergo is to determine its validity. Validity is the extent to which a measuring instrument measures what it is supposed to measure (Yusoff, 2019; Anggraini et al., 2023). Among all the types of validity that have been identified in literature, the face and content validity are the first forms of validity that an instrument must undergo. Face validity is the assessment of the level in measuring clarity and purpose of a construct used to evaluate (Masuwai et al., 2024). While content validity is the extent to which the questions (items) in a measuring instrument are appropriate, relevant and representative of the targeted construct for a particular assessment purpose (Almanasreh, Moles & Chen, 2018). To ascertain the face and content validity of the instruments, the modified version of the instrument was taken to the experts for vetting. The experts were from Bayero University Kano, Federal College of Education, Kano and Kano State College of Education and Preliminary Studies. As for the face validity, all the observations and the suggestions raised regarding the suitability of the language were effected before taking the adapted instruments to the sampled senior secondary three students in the pilot testing. The expert established the content validity using the following ratings;

[2] Means the content is suitable as it is.

[1] Means the content is suitable when little modification is applied.

[0] Means the content is not suitable at all.

Table1:
Content Validity Index (CVI) of BSSRGEQ

Instrument	Expert 1	Expert 2	Expert 3	Expert 4	Expert 5	Expert 6	Expert 7	Expert 8	Average %
BSSRGEQ	92	100	88	84	96.6	100	87	90.1	92.21%

Table 1 show that based on the expert rating the adapted instrument have very good content validity index; 92.21%. Also based on the recommendation and suggestion of the expert, the instruments were advice to be exposed to construct validity with factor analysis in order to reduce the number of items as they are too many for the learners to answer as secondary school students.

Construct Validity of the Instrument

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To determine the construct validity of BSSRGEQ, students' responses were collected using the instrument, and subjected to Factor Analysis using both Exploratory Factor Analysis (EFA) and Confirmatory Factor Analysis which are run by using SPSS version.20. Kaiser Meyer-Olkin Measure of Sampling Adequacy (KMO/MSA) was used to test the sampling adequacy, and Bartlett's Test of Sphericity was used to test the strength of the relationship between the items. The results were summarized in Table 2:

Table 2:
KMO Measure of Sampling Adequacy and Bartlett's Test Results for BSSRGEQ

Types of Test	Statistics	Value
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.	KMO/MSA	.771
Bartlett's Test of Sphericity	Approx. Chi-Square	372.125
	Df	275
	Sig.	.0001

From the result in table 2 above, it was clear that the sampling process for the pilot study was adequate and sufficient for factor analysis (KMO/MSA = 0.771). Also, the correlation among the items was strong based on the Bartlett's Test of Sphericity (X^2=372.125, *df* = 275, *p* = 0.001). Therefore, the values showed that the data collected from a sample of (278) students for pilot study is good for conducting factor analysis. Therefore, the factor analysis was run with all the 53 items from SEI and SEOC to makeup the adopted instrument BSSRGEQ, so as to confirm the existence of the three (3) components of BSSRGEQ in line with factor restrictions. It was found that the three factors explained about 86.734% of the total variance. The Table 3 below is the summary of the Oblimin-rotated component matrix of the Confirmatory Factor Analysis (CFA) conducted:

Table 3:
Oblimin-Rotated Component Matrix for Biology Students Self-Reported Genetics Engagement Questionnaire (BSSRGEQ)

	Component		
	1	2	3
CE1	.919		
CE12	.906		
CE3	.882		
CE9	.865		
CE5	.784		
EE6		.762	
EE2		.862	
EE14		.847	
EE8		.829	
EE19		.745	
BE11			.877
BE2			.930
BE13			.843
BE4			.801

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BE17			.786
BE6			

Extraction Method: Principal Component Analysis.
a. 3 components extracted

Three (3) factors were identified as the underlying structure of the Biology Students Self-Reported Genetics Engagement Questionnaire (BSSRGEQ) and their factor loadings. These factors loadings have correlation coefficients ranging from -1.00 to +1.00 and are interpreted accordingly. From Factor 1, it can be seen that 5 items converged with the high factor loadings to this factor. These include Cognitive Engagement1, Cognitive Engagement3, Cognitive Engagement5, Cognitive Engagement9 and Cognitive Engagement12. Their factor loading ranging from 0.919 to 0.745 which is above the criterion value of 0.30 set for the study.

Moreover, in Factor 2, the results showed that 5 items converging with high factor loadings to this factor. These include Emotional Engagement2, Emotional Engagement14, Emotional Engagement6, Emotional Engagement19 and Emotional Engagement8. When observed carefully these items have loaded well. Thus, it can be seen confirmed that the items have factor loadings ranging from 0.801 – 0.786 which is above the criterion value of 0.30 set for the study as suggested by (McCollum et al, 2001).

From Factor 3, it can be seen that 5 items converged with the high factor loadings to this factor and are well load. These include Behavioural Engagement2, Behavioural Engagement4, Behavioural Engagement11, Behavioural Engagement13 and Behavioural Engagement17. Their factor loading ranging from 0.930 – 0.762 which is above the criterion value of 0.30 set for the study.

In summary, the factor analysis showed that out of the 53 Items initially adopted from the original version of the instrument 15 Items indicated high factor loadings with Biology Students Self-Reported Genetics Engagement Questionnaire (BSSRGEQ). This clearly showed that in the process almost 38 items were discarded due to their low factor loadings (i.e., below 0.30). The items discarded are item;EE1,EE3,EE4,EE5,EE7,EE9,EE10,EE11,EE13,EE12, EE15,EE16,EE17 EE18,EE20,EE21,EE22,EE23,CE2,CE4CE6,CE7,CE8,CE10,CE11,BE1,BE3,BE5,BE6,BE7,BE 8,BE9,BE10,BE12,BE14,BE15,BE16 and BE18 respectively. Therefore, based on this analysis, it can be concluded that the Biology Students Self-Reported Genetics Engagement Questionnaire (BSSRGEQ) has demonstrated a very good indices of construct validity and its valid for measuring Biology student's cognitive, emotional and behavioral engagement in a Genetics lessons among Senior Secondary III students in Kano state, Nigeria.

Reliability of the Instrument (BSSRGEQ)
To establish the reliability of the instrument, the use of internal consistency reliability was adapted using Cronbach's Alpha statistic. It provides a coefficient of inter-items correlations, the correlations, that is, the correlation of each item with the sum of all the other relevant items, and is useful for multi-items scales. (Cohen, Manion & Moris, 2018). Cronbach's Alpha is considered suitable for determining the inter-items reliability of the instrument because they are all in polytomous responses options with subscales.

Table 4: Reliability Coefficient of BSSRGEQ

Instrument	Cronbach's Alpha	No. of Item
BSSRGEQ	0.904	15

Table 4 provides the reliability coefficients of BSSRGEQ from the analysis on the table, Biology Students Self-Reported Genetics Engagement Questionnaire of 15 items has α = 0.904. Based on the obtained Cronbach's alpha coefficient, the instrument was found to be reliable, because the obtained coefficient has exceeded the minimum value of greater than or equal to 0.7 as recommended by Paulsen and Brckalorenz (2017).

Discussions

The paper provides the explanation on the details procedure that was used in establishing the psychometric properties of Biology Students Self-Reported Genetics Engagement Questionnaire. To validate the instrument, a representative sample of 278 senior secondary students were used in the pilot testing survey. The figure consist of 118 male and 156 female that were randomly selected. The instrument was validated using face, content and construct validity. In establishing face and content validity, the instruments were given to expert whose compositions include Educational Psychology, Measurement and Evaluation, Science and technology and English Language to check and validate the language, and if the items could measure the domains in the context of the intended study.

To establish the construct validity of the instruments, the study adopted the use of exploratory and confirmatory factor analysis. The Biology Students Self-Reported Genetics Engagement Questionnaire (BSSRGEQ) (X^2=372.125, df = 45, p = 0.001) has a very good index of construct validity, all indicating that the instruments can measure the intended construct.

The adapted instrument also undergone reliability test to examine their level of internal consistency in measuring the construct in the context of the intended study. The use of Cronbach`s alpha reliability test was used. The result from the reliability analysis showed that the instrument was having strong internal consistency index. BSSRGEQ showed 0.904.

Conclusion

To end this, the result of the validity and reliability analysis obtained from the pilot test of the instrument was good enough. It was therefore concluded that Biology Students Self-Reported Genetics Engagement Questionnaire is reliable to measure the construct as intended in the main study.

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BIOLOGY STUDENTS SELF-REPORTED GENETICS ENGAGEMENT QUESTIONNAIRE (BSSRGEQ)

S/N	Item Statements	Response Patterns			
1. Cognitive Engagement		**SA**	**A**	**DA**	**SD**
1.	After finishing my schoolwork I check it over to see if it's correct.				
2.	When I do schoolwork I check to see whether I understand what I'm doing.				
3.	I'll learn, but only if the teacher gives me a reward.				
4.	When I do well in school it's because I work hard.				
5.	The tests in my classes do a good job of measuring what I'm able to do.				
2. Emotional Engagement		**SA**	**A**	**DA**	**SD**
6.	My teachers are there for me when I need them				
7.	Students at my school are there for me when I need them				
8.	The school rules are fair.				
9.	When I have problems at school my family/guardian(s) are willing to help me.				
10.	I feel safe at school				
3. Behavioral Engagement		**SA**	**A**	**DA**	**SD**
11.	I work well with other students in Genetics lesson				
12.	I stood up to answer questions or volunteer information in Genetics class.				
13.	My Colleagues and I act restlessly and unable to sit still in Genetics lesson.				
14.	I am always withdrawn, uncommunicative in Genetics lesson.				
15.	I ask questions to get more information in a Genetics lesson.				

Thank you for cooperation