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Research Article

Assessment of Nigerian Biology Teachers' Knowledge of Errors in Biological Drawing

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ABSTRACT

In this survey research, biology teachers' knowledge of errors in biological drawing was assessed with a focus on their qualifications and years of teaching experience. A total of 100 out of 235 biology teachers in public secondary schools in Kwara State Central Senatorial District, Nigeria took part in the study. The teachers were selected through stratified random sampling procedure. An assessment test titled "identification of errors in biological drawing test" (IEBDT) designed by the researcher was used to gather data in the study. The reliability coefficient of IEBDT was 0.83. Results of the study revealed that biology teachers had poor knowledge of errors in biological drawings and that a significant difference does not exist in their knowledge of errors in biological drawing based on their qualifications and years of teaching experience. It was recommended that biology teacher education programs should be re-jigged while biology teachers were admonished to regularly participate in teacher professional development programs. Further research studies to determine factors responsible for the teachers' poor knowledge of errors in biological drawing and lack of significant difference in their knowledge based on qualifications and teaching experience in contrast to logical expectations was also, recommended in the study.

Keywords: assessment, biological diagram, biological drawing errors, biology teachers, biology education

INTRODUCTION

Biology is a distinct broad interdisciplinary subject that is popular among students in Nigeria and around the world. It is the scientific study of living organisms and their interactions, as well as their evolution. According to biologists, each individual organism in a biological population is distinct from the others. As a result, in the discipline of biology, meticulous observation and exact description of each specimen's unique structure are required process skills.

Biologists often use drawings or diagrams to record the unique structures of each observed specimen. Essentially, drawing is a form of data collection in the field of biology. Indeed, the use of drawing to succinctly describe observed structures of specimens is a well-established tradition among biologists.

A higher level of accurate observation than a casual examination of objects is required when drawing a biological specimen as noted by Oxford Cambridge and RSA (2015). Biological drawing serves as a permanent record of what has been observed, while its educational value is aptly captured in the popular Chinese proverb credited to Confucius:

> "I hear and I forget I see and I remember I do and I understand" (Oxford Cambridge & RSA, 2015).

Poor mastery of biology drawing skills is a major weakness among Nigerian secondary school students as indicated annually in the West African senior school certificate examinations (WASSCE) chief examiner's reports (West African Examinations Council, 2021). There is no argument that teachers can only teach what they know, if teachers are not competent in biological drawing skills, they would most likely not teach it. Besides biology teachers' competency, literature is awash with impacts of teachers' qualifications, years of teaching experience and gender among other variables on teaching and learning of science. Hence, an attempt was made in this study to assess biology teachers' knowledge of errors in biological drawings with a focus on disparity in their knowledge of errors in biological drawings based on qualifications and years of teaching experience. Specifically, the following research questions were raised in the study:

1. What is the level of biology teachers' knowledge of errors in biological drawings?
2. What types of errors in biological drawings do biology teachers recognize?

3. Do biology teachers' levels of knowledge of errors in biological drawings differ significantly based on qualifications?
4. Is there a significant difference in the level of biology teachers' knowledge of errors in biological drawings based on years of teaching experience?

Furthermore, two research hypotheses were generated from the research questions.

The importance of this study lies in the fact that it provided useful insight into the quality of biology teachers, and thus the quality and implementation of biology teacher education programs in the country. It equally provided useful insight into why students are performing poorly in biological drawing at the WASSCE. It also served as a catalyst for reenergizing biology teacher education with special focus on improving biology teachers' disciplinary content knowledge.

THEORETICAL FRAMEWORK AND LITERATURE REVIEW

Drawing is an integral component of teaching, learning and evaluation in the field of biology education. It is a basic process skill for the visual representation of biological data. It promotes model-based reasoning, a basic requirement for problem-solving, and analysis of complex and abstract concepts as noted by Quillin and Thomas (2015). Visual modeling is a type of model-based reasoning that is closely linked to drawing. It is the use of graphical languages to graphically represent concepts, objects, and systems to make both novice and expert share a common understanding of the complex concepts, objects, and systems. Models are abstractions that represent the fundamentals of complex concepts, structures, and problems, through removal of non-essential features, to make the complex concepts, structures, and problems readily understandable to everyone (Nersessian, 1999; Terry, 2002). Drawing provides an avenue to integrate verbal and visual information as it serves as both external and internal mental representation. A combination of visual and verbal information often enhances more meaningful learning than verbal information alone (Shin et al., 2018). Biology teachers frequently make use of drawings as a visual representation to enhance the conceptualization of complex biology concepts. As reported in the work of Liu et al. (2014), biology teachers make use of drawings flexibly to introduce biology topics, explain content knowledge, evaluate students' learning, and integrate it with analogical structures. Emerging literature in science education suggest that students' mastery of biological drawing skills impact their performance in biology (Burns, 2020; Cromley et al., 2015; Ihejiamaizu et al., 2020; Wekesa, 2013).

Cromley et al. (2015) reported that students often encounter difficulties in learning from diagrams in their science textbooks and that they often avoid many diagrams in biology. While Dempsey and Betz (2001) stated that biology teachers spend little or no time to develop students' drawing skills. Furthermore, Quillin and Thomas (2015) reported that few biology teachers recognize drawing as a teachable science process skill despite the significant role of drawing in visual model-based learning. There is no doubt that teachers can teach only what they know, hence, the reluctance of biology teachers to explicitly teach students biological drawing skills casts doubt on their biological drawing competence. Indeed, previous studies such as Patrick and Tunnicliffe (2014), Petr and Rokos (2018), Soyibo (1997), and Topsakal and Oversby (2012) indicated that both the pre-service and in-service biology teachers were not competent in biological drawings.

Several studies investigated the impacts of teachers' qualifications, years of teaching experience and gender and so forth on teaching and learning of science. For example, Ukala (2018) revealed a significant difference in the utilization of innovative teaching strategies by biology teachers based on qualifications and teaching experience. Similarly, a significant difference in the level of utilization of innovative teaching strategies based on science teachers' experience and qualification was revealed in the work of Oyelekan et al. (2018). Furthermore, Abe and Owoeye (2012) reported a significant difference in the biology topics perceived as difficult to teach in secondary schools by experience and less experienced biology teachers. However, Adegboye et al. (2017) revealed that a significant difference did not exist in the number of misconceptions and informed conceptions of the nature of biology they held by biology teachers based on gender, qualifications, and experience. Furthermore, Egun (2016) observed no significant difference in the achievements of biology students taught by qualified and non-qualified teachers as well as experienced and less experienced biology teachers. It is obvious from the foregoing that reports from previous studies on the impacts of science teachers' qualifications and teaching experience were inconsistent thus needing further investigations.

METHODOLOGY

The study adopted survey research design to assess biology teachers' knowledge on errors in biological drawings and the influence of their qualifications and years of teaching experience on their knowledge of errors in biological drawings. The population of the study consisted of all the biology teachers in Kwara State Central Senatorial District, Nigeria. Available statistics at Kwara State Teaching Servicing Commission indicated that there were 235 public school biology teachers in the Central Senatorial District in the year 2020. The population was stratified into two groups based on, qualifications and years of teaching experience. The stratified sampling technique was therefore, used to select 100 out of 235 biology teachers in public senior secondary schools in Kwara State Central Senatorial District. The instrument used for data collection in the study was an achievement test titled 'identification of errors in biological drawing test' (IEBDT). The instrument was designed by the researcher based on types of errors reported in previous studies and errors in biological drawing identified in the WASSCE biology candidates' answer scripts reported by the West African Examinations Council (2021). IEBDT consisted of 10 biological drawings extracted from pages of selected Nigerian senor secondary school biology textbooks and Internet websites. The 10 biological drawings were purposefully selected to reflect 10 common

types of error documented in a recent study by Bello et al. (2021) and some previous studies. Each of the selected drawings contained one or multiple types of error. An experienced senior secondary school biology teacher, a senior lecturer in the field of biology education from a university, and one experienced biology WAEC examiner helped to establish the face and content validity of IEBDT. Thereafter, the instrument was subjected to the test-retest reliability procedure and the coefficient stability was found to be 0.83. Items in section A of IEBDT sought for the bio-data of the participants while section B consisted of 10 biological drawings used to assess the teachers' knowledge of errors in a biological drawing. The teachers were requested to carefully study each biological drawing, identify and make a circle around the error(s)in each drawing. Scoring was based on each type of error correctly identified. Each correctly identified type of error attracts one mark hence, the maximum obtainable score was 10 marks.

Data gathered in the study was analyzed using mean, percentage, t-test, and analysis of covariance statistical tools. Teachers' knowledge of errors in biological drawing was categorized into three levels based on their mean scores. Mean scores less than four was considered to be poor knowledge level, mean scores between four and six were regarded as average knowledge level and mean scores above six were considered to be high knowledge level.

RESULTS

Research Question 1

What is the level of biology teachers' knowledge of errors in biological drawings?

Table 1 showed the result of the analysis of teachers' scores on knowledge of error in biological drawing test (IEBDT). The scores ranged between two and seven with a mean of 3.54. The mean score was below four hence, the biology teachers' knowledge of errors in biological drawing was, adjudged to be at a poor level. This result provided the answer to the first research question in this study.

Table 1. Descriptive statistics of biology teachers' knowledge of errors in biological drawing

N	Score	Range	Mode	Mean	Standard deviation
100	354	6	4	3.5400	1.34405

Research Question 2

What types of errors in biological drawings do biology teachers recognize?

Table 2 showed that almost all (93%) of the biology teachers were able to recognize non-horizontal guideline (NHGL) in biological drawings as an error. While 52% of the teachers identified using plural instead of singular for a single structure (UPISS) as an error in biological drawings. This result suggested that NHGL and UPISS were the errors in biological drawings that biology teachers readily identified. The remaining eight types of errors in the biological drawing were identified by less than 50% of the teachers. All the biology teachers were unable to recognize drawing without magnification as an error in the biological drawings as revealed in **Table 2**.

Table 2. Type of errors, percentage of teachers that identified the errors and those that were unable to identified the errors

S/N	Types of errors	n_1 (%)	n_2 (%)
1.	Non-horizontal guideline (NHGL)	93 (93%)	7 (7%)
2.	Using plural instead of singular for a single structure (UPISS)	52 (52%)	48 (48%)
3.	Label without guideline (LWGL)	49 (49%)	51 (51%)
4.	Wrongly labelled structure (WLS)	41 (41%)	59 (59%)
5.	Arrowhead guideline (AHGL)	40 (40%)	60 (60%)
6.	Guideline not touching the labelled structure (GNTLS)	37 (37%)	63 (63%)
7.	Using singular instead of plural for multiple structures (USIPMS)	37 (37%)	63 (63%)
8.	Incorrect spelling of labeled structure (ISLS)	2 (2%)	98 (98%)
9.	Drawing without label (DWL)	1 (1%)	99 (99%)
10.	Drawing without magnification (DWM)	0 (0%)	100(100%)

Note. n_1 (%): Number of teachers that identified each error (percentage); n_2 (%): Number of teachers unable to identify each error (percentage)

Research Question 3

Do biology teachers' levels of knowledge of errors in biological drawings differ significantly based on their qualifications?

A corresponding hypothesis (research hypothesis 1-RH1) was generated in other to provide the answer to this question as stated below:

RH1: Significant difference does not exist in the levels of biology teachers' knowledge of errors in biological drawings based on qualifications.

The hypothesis was tested using the one-way ANOVA statistical technique as presented in **Table 3**. The calculated, $F(2, 97)=.121$, $p(.886)>0.05$ was greater than .05 hence, the hypothesis was not rejected. The result suggested that a statistically significant difference does not exist in biology teachers' knowledge of errors in biological drawings based on their qualifications.

Table 3. One-way ANOVA of biology teachers' scores on knowledge of errors in biological drawing based on qualifications

Score	Sum of squares	Df	Mean square	F	Sig.
Between groups	.445	2	.223	.121	.886
Within groups	178.395	97	1.839		
Total	**178.840**	**99**			

Research Question 4

Is there a difference in the level of biology teachers' knowledge of errors in biological drawings based on years of teaching experience?

The second hypothesis (research hypothesis 2-RH2) in this study was generated from this research question in other to answer the question:

RH2: Significant difference does not exist in the level of biology teachers' knowledge of errors in biological drawings based on teaching experience**.**

The hypothesis was tested using the one-way ANOVA statistical technique as presented in **Table 4**. The result revealed that the calculated F(2, 97)=1.783, p(.174)>0.05 was greater than .05, thus, the researcher failed to reject hypothesis 2. This result indicated that a statistically significant difference does not exist in biology teachers' knowledge of errors in biological drawings based on years of teaching experience.

Table 4. One-way ANOVA of biology teachers' scores on knowledge of errors in biological drawing based on teaching experiences

Score	Sum of squares	Df	Mean square	F	Sig.
Between groups	6.342	2	3.171	1.783	.174
Within groups	172.498	97	1.778		
Total	**178.840**	**99**			

DISCUSSION

This study set out with the aim of assessing biology teachers' knowledge of biological drawing. The result of this study indicated that biology teachers lack adequate knowledge of biological drawing. This means that the teachers' knowledge of the principles, technicalities, and skills required in the field of biology to record observed biological specimens using visual representation was inadequate. As stated earlier, biological drawing is a fundamental form of scientific process skill. It is also an inseparable part of the disciplinary content knowledge in the field of biology; hence, this study has revealed a deficiency in the biology teachers' disciplinary content knowledge. One of the possible explanations for this finding might be inadequate biology teacher education programs. Another possible explanation for this result might be inadequate implementation of biology teacher education programs in the nation's teacher education institutions. It seems that most of the biology teachers were not participating in the marking of the WASSCE biology candidates' answer scripts as examiners; otherwise, their knowledge of biological drawing would not be deficient. The finding also seems to indicate that the teachers were not making use of the annual recommendations of the WAEC chief examiners' reports, which could have updated their knowledge in biological drawing, among other content areas. Hence, the finding provides a plausible reason why biology teachers do not often teach students how to draw biological drawings, as reported by Dempsey and Betz (2001), National Research Council (2012), and Quillin and Thomas (2015).

This finding helped to explain a major possible cause of some of the repeated biological drawing errors found in biology candidates' WASSCE answer scripts, as reported by the West African Examinations Council (2021). The current finding appears to be in line with those of prior studies such as Patrick and Tunnicliffe (2014), and Petr and Rokos (2018), Soyibo (1997), Topsakal and Oversby (2012) that have discovered inadequacies in biology teachers' knowledge of biological drawing.

Another outcome of this study is that few teachers were aware of the majority of the ten types of biological drawing errors under focus. This finding further revealed the shockingly inadequate knowledge among biology teachers about biological drawing errors. Deficits in biology teachers' disciplinary content knowledge in basic areas such as biological drawing present a serious impediment to effective teaching and meaningful learning by teachers and students, respectively. This merits the attention of biology teacher educators in teacher education institutions across the country. Biology teachers who are unable to spot mistakes in biological drawings are unlikely to draw biological specimens accurately during class lessons.

Contrary to expectations, this study did not find a significant difference in biology teachers' knowledge of errors in biological drawings based on qualification. This meant that the biology teachers, regardless of the level of their academic and professional qualifications, had limited knowledge of biological drawing errors. This is a remarkable finding because graduate professional biology teachers are expected to have a good grasp of biology knowledge than non-graduate professional biology teachers since they have been exposed to a higher level of biology teacher education program.

This result raises further concern about the quality of biology teacher education programs in Nigerian universities. The reason for this finding is not clear, but it could be related to the quality of students admitted to biology teacher education programs, as good biology students should have had a strong grasp of biological drawing right from secondary school. This present finding seems to be consistent with other research (Adegboye et al., 2017; Egun, 2016), which found no significant difference in the attributes and competencies of biology teachers based on qualifications. The finding, on the other hand, contradicts earlier research reports by Oyelekan et al. (2018) and Ukala (2018) who observed significant differences in teachers' competencies based on qualification. The finding, on the other hand, contradicts earlier research reports by Oyelekan et al. (2018) and Ukala (2018) who observed significant difference in teachers' competencies based on qualification.

Unexpectedly, it was discovered that a statistically significant difference does not exist in biology teachers' knowledge of errors in biological drawings based on years of teaching experience. One possible explanation is that experienced biology teachers do not take advantage of existing teacher professional development opportunities, such as the bi-annual WAEC examiner training workshops and the Science Teachers Association of Nigeria (Biology Panel) workshops to keep their knowledge up to date. This result was consistent with some previous studies that investigated teaching experience as a variable such as Adegboye et al. (2017) and Egun (2016). However, the finding of the current study does not support the previous studies conducted by Oyelekan et al. (2018) and Ukala (2018).

CONCLUSION AND RECOMMENDATIONS

This study assessed biology teachers' knowledge of errors in biological drawings based on their qualifications and years of teaching experience. It was concluded that the teachers' knowledge of errors in biological drawings was poor. It was also concluded that a significant difference does not exist in the level of the teachers' knowledge of errors in biological drawings based on their qualification and teaching experience. Furthermore, it was concluded that this study provided additional empirical evidence on biology teachers' inadequate disciplinary content knowledge.

Thus, it was recommended that:

1. biology teacher education programs at all levels should be rejigged to equip pre-service and in-service biology teachers with adequate knowledge and skills in biological drawings;
2. biology teachers should endeavor to participate in the biannual WAEC training workshop for WASSCE Examiners. This will not only qualify them to participate in the marking of WASSCE candidates' biology answer scripts, it would update their knowledge in biological drawings and other content areas in the biology curriculum;
3. biology teachers should enroll in teacher professional development programs (TPD) at the local and national level to enhance their competencies especially in biological drawings;
4. school proprietors should provide enabling environment for biology teachers to embark on TPD regularly;
5. biology teachers should always read the annual WAEC chief examiner's report on candidates' weakness and strengths especially on biological drawings. They should pay attention to the WAEC chief examiner's recommendations particularly those on biological drawings. This will provide immediate opportunity to update their knowledge of errors in biological drawings among other areas in the biology curriculum; and
6. further research should be conducted to establish the underlying factors responsible for the
    a. biology teachers' poor knowledge of errors in biological drawing and
    b. lack of significant disparity in their knowledge of errors in biological drawings based on their qualifications and teaching experience contrary to logical expectations.

The only limitation of this study lies in the fact that the sample size was relatively small hence, results should be interpreted with caution.

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