Conceptions of the Nature of Biology Held by Senior Secondary School Biology Teachers in Ilorin, Kwara State, Nigeria

Adegboye, Motunrayo Catherine[1], Ganiyu Bello [2], Isaac, O. Abimbola[3]

[1] Department of Science Education, University of Ilorin, Ilorin, Nigeria
P.M.B. 1515 Ilorin, Nigeria
adegboyemotunrayo@gmail.com

[2] Department of Science Education, University of Ilorin, Ilorin, Nigeria
P.M.B. 1515 Ilorin, Nigeria
bllganiyu@yahoo.com

[3] Department of Science Education, University of Ilorin, Ilorin, Nigeria
P.M.B. 1515 Ilorin, Nigeria
abimbola@unilorin.edu.ng

ABSTRACT

There is a sustained public outcry against the persistent abysmal performance of students in biology and other science subjects at the Senior School Certificate Examinations conducted by the West African Examinations Council (WAEC) and the National Examinations Council (NECO). Biology is a unique science discipline with peculiar philosophical principles and methodology that are not applicable to other science disciplines. Understanding the unique structure of knowledge, principles and methodology for providing explanations in biology is sine qua-non for effective and efficiency teaching of biology by teachers, and meaningful learning by the students. This study, therefore, investigated the conceptions of the nature of biology held by biology teachers in Ilorin, Nigeria. The study adopted the descriptive research design of the survey type. A questionnaire entitled "Biology Teachers' Conceptions of the Nature of Biology Questionnaire"(BTCNBQ) was designed by the researchers and used as the instrument for data collection. The population for the study comprised all the biology teachers in Ilorin, Nigeria. Simple random sampling technique was used to select two hundred and sixty (260) biology teachers from Ilorin, Nigeria. Results of the study revealed that each biology teacher held admixture of informed conceptions and misconceptions about the nature of biology. The results of the study also revealed that biology teachers' gender, qualifications and experience did not have a significant influence on the number of misconceptions and informed conceptions of the nature of biology they held. The findings imply that biology teachers often misrepresent biology concepts, principles, and theories in their explanations during class lessons, consequently, impeding meaningful learning by the students. Based on the findings, it was recommended that Biology educators and curriculum experts should introduce courses on the unique nature and philosophy of biology into teacher education programmes, to enhance teachers' pedagogical content knowledge (PCK).

Keywords: *Nature of Biology, Biology teachers, Science education, Misconceptions, Alternative conceptions, informed conceptions*

INTRODUCTION

The role of science education in the socio-economic development of any nation hardly needs any arguments. Bello and Abimbola (2015) rightly noted that 'the socio-economic development of a country cannot rise above its level of scientific and technological development; it is obvious that science education is a potent tool for the security of the country' (p.146). It is because of this realization that science

education has come to stay in school curricula in almost every country around the world. Science curricula in various countries of the world do not solely focus on developing the understanding of science concepts among students, but also on the understanding of the basic nature of science (American Association for the Advancement of Science (AAAS), 1990; National Research Council (NRC), 1996). Abd-EL-Khalick, Bell, and Lederman (1998) opined that the nature of science has to do with the theory of scientific knowledge. Lederman (2007) pointed out that the main attributes of the nature of science includes: scientific knowledge is empirically based, scientific knowledge is reliable and tentative, scientific knowledge is liable to change over time as new discoveries are made, scientific knowledge is a product of creative thinking; scientific knowledge is subjective and affected by the cultural milieu.

Biology is a unique branch of natural sciences, however, like other natural sciences; it is concerned with the search for in-depth understanding of natural phenomena and events. It is composed of two major fields, functional biology and historical biology, which is also, known as evolutionary biology. (Frilov, 1984; Mayr, 2004). The functional processes of biology deal with physiological processes in living things and it can be explained with the natural laws of physical sciences, especially at the cellular-molecular level. The most frequent question asked in functional biology field is how? In the field of historical biology, a sound knowledge of history is needed for the explanation of all aspects of the living world that have to do with the dimension of historical time. Experiments are sometimes inappropriate to provide answers to the why and how questions that are frequently and occasionally asked respectively in this field of biology. The historical narrative is the methodology used in this field of biology to provide explanations. The forgoing led to the rejection of cosmic teleology and vitalism as conceptual frameworks for explanations in biology. Indeed, there are certain principles of the physical sciences that are not applicable to biology. Such principles include Essentialism / Typology, Determinism, Reductionism, and many physical sciences laws. The aforementioned principles are now replaced with principles that are unique to living things only, which are not applicable to non-living things. For instance, the holistic thinking principles are the appropriate framework adopted in biology instead of reductionism, while Population thinking is the new framework that replaced typology principle. The Nigerian Secondary School Biology Curriculum partially reflected these features of the discipline. The forgoing discussions highlight the uniqueness of biology as a branch of natural science as explained by Mayr (2004).

Evidence abound in the literature that students and teachers held misconceptions and alternative conceptions on a wide range of biology concepts, and the nature of science (Bello, Bello, and Abimbola 2016; Modell, Michael, & Wenderoth, 2005; Palmquist & Finley, 2007). It is, therefore, logical to assume that teachers too hold a range of misconceptions as noted by Kikas (2004). Indeed, studies have shown that many teachers, including experienced biology teachers, teach while holding misconceptions about various biological concepts. In fact, research studies indicated that biology teachers hold many of the same misconceptions of biological concepts as their students (Chinsamy & Plagány, 2007; Nehm & Schonfeld, 2007). Researchers such as; Galvin, Mooney, Simmie and O'Grady, (2015); Yate and Marek (2013); Oyeyemi (2004); Boo (2005); have extensively conducted research works into teachers' misconceptions and alternative conceptions of the biology concepts, in particular. Yate and Marek (2013) studied the prevalence of biological evolution-related misconceptions held by introductory biology teachers, seventy six (76) biology teachers served as the sample for the study, the result of the study revealed that biological evolution related misconceptions were prevalent among biology teachers. Kurt, Ekici, Aksu, and Aktas (2013) investigated pre-service biology teachers' cognitive structures related to reproduction through the free word-association test and the drawing-writing technique. The findings of the study showed that pre-service biology teachers held misconceptions and alternative conceptions related to the concept of reproduction. A study conducted by Oyeyemi (2004) was carried out on the misconceptions and alternative conceptions of biology concepts held by biology teachers in Kwara State, the study showed that secondary school Biology teachers also held misconceptions and alternative conceptions on basic biology concepts. As Nehm and Schonfeld (2007) concluded, "one cannot automatically assume that biology teachers with extensive backgrounds in biology have an accurate working knowledge of the nature of biology" (p.52).

There are indications in biology education literature that learning biology by Nigerian secondary school biology students seems to be a struggle as reflected in their persistent abysmal performances at the Senior School Certificate Examinations conducted by WAEC and NECO. (Abimbola,

2013; Auwalu, Mohd, and Muhammad,2014; Sakiyo, and Badau, 2015; WAEC Chief Examiner report, 2013). It has also, been well documented in biology education literature that misconceptions and alternative conceptions are major barriers to learning of biology concepts by the students (Abimbola, 2015; Boo,2006; Olorundare,2014). Biology teachers' mastery of the unique nature of biology is essential in providing explanations of biology concepts and theories to students; eliminate students' misconceptions and alternative conceptions, and enhance meaningful learning by the students. It is thus, imperative to find out if biology teachers hold appropriate conceptions of the unique nature of biology in their cognitive structures as part of efforts to determine and improve their pedagogical content knowledge (PCK). In view of the foregoing, this study was aimed at investigating the misconceptions and informed conceptions of the nature of biology held by biology teachers in Ilorin, Nigeria. Misconception refers to an idea that is in conflict with biologic knowledge. While, informed conception refers to an idea which is in congruent with the accepted biologic knowledge.

Research Objectives

This study sought to examine the conceptions of the unique nature of biology held by biology teachers in Ilorin, Kwara State, Nigeria. It specifically sought to identify misconceptions and informed conceptions of the unique nature of biology held by the teachers. It also, sought to determine the influence of teachers' gender, years of teaching experience, and qualifications on their conceptions of the unique nature of biology.

Research Questions

The study was guided by the following research questions;

1. What are the conceptions of the nature of biology held by biology teachers?
2. Is there a gender difference in the number of informed conceptions and misconceptions of the nature of biology held by biology teachers?
3. Is there any difference in the number of informed conceptions and misconceptions of the nature of biology held by qualified and unqualified biology teachers?
4. Do the number of informed conceptions and misconceptions of the nature of biology held by experienced and less experienced biology teachers differ significantly?

Research Hypotheses

Based on the preceding research questions, it was hypothesized that;

1. HO_1: There is no significant difference in the number of informed conceptions and misconceptions of the nature of biology held by male and female biology teachers.
2. HO_2: Significant difference does not exist in the number of informed conceptions and misconceptions of the nature of biology held by qualified and unqualified biology teachers.
3. HO_3: There is no significant difference in the number of informed conceptions and misconceptions of the nature of biology held by experienced and less experienced biology teachers.

METHODOLOGY

The study was a descriptive research of the survey type. The population for this study was all biology teachers in senior secondary schools in Ilorin metropolis, Kwara State. Nigeria. The simple random sampling technique was used to select two hundred and sixty (260) biology teachers as the representative sample of the population. A research questionnaire entitled, "Biology Teachers' Conceptions of the Nature of Biology Questionnaire" (BTCNBQ) was designed by the researchers to gather data in this study. The researchers adapted some of the items in the questionnaire from the works of Mayr (2004) and Narguizan (2015). The questionnaire contained three sections, namely, A, B and C. Section A of the questionnaire was for demographic information while items in Section B sought for the biology teachers' conceptions of the nature of biology. It consisted of forty items that were based on the main tenets of the nature of biology. Twenty of the items reflect the appropriate conceptions of the nature of biology, while the other twenty items were on misconceptions of the nature of biology. Respondents were required to indicate the statements that are compatible with their conceptions of the nature of biology by ticking the statements. There were three open-ended items that required short responses in section C. The researchers used the test-retest procedures and Pearson Product Moment Correlation statistics to determine the reliability

coefficient of the questionnaire, which was found to be 0.72. The researchers employed the service of Research Assistants to administer the questionnaire.

RESULTS

Research Question 1: What are the conceptions of the nature of biology held by biology teachers?

Analyses of the data gathered in the study clearly indicated that each biology teacher held admixture of informed conceptions and misconceptions of the nature of biology. Tables 1 shows the list of informed conceptions and misconceptions of the nature of biology held by the biology teachers. Table1 equally indicated the number and the corresponding percentage of teachers that held each conception. Only 8 out of 20 (40%) informed conceptions were held by between 69.62% and 50% of the teachers, whereas, 15 out of 20 (75%) misconceptions were held by between 83.08% and 53% of the teachers. This finding implies that most of the misconceptions are widely held by the teachers, whereas most of the informed conceptions were held by few teachers. The finding also, revealed that misconceptions and informed conceptions of the nature of biology coexisted in the cognitive structure of the biology teachers. This finding is in congruent with the results of similar studies on the nature of science, such as Bello (In press), Gulcan and Alev (2013), Hamza (2014), Mir (2009), and Vazquez, Antonia, Antonia, & Antonio, (2011).

Table 1 Conception of the Nature of Biology Held by Senior Secondary School Biology Teachers in Ilorin, Kwara State, Nigeria

S/N	Informed Conceptions	Frequency	Percentage
1	**Observation is a key factor in the establishment of biological knowledge.**	**181**	**69.62%**
2	Biologists have observed that nature apparently follows the same rules throughout the universe.	150	57.69%
3	There are two forms of biology; functional biology, which asks proximate questions, and; evolutionary biology, which asks ultimate questions.	140	53.85%
4	Comparative method is essential in biological science.	138	53.08%
5	The history of biology has been dominated by the establishment of concepts and by their maturation, modification, and - occasionally - their rejection.	138	53.08%
6	Historical narratives are strongholds of biological concepts.	135	51.92%
7	Biology specific concepts are non-reducible to the concepts and theories of the physical sciences	131	50.38%
8	Biological knowledge is tentative and thus, subject to change.	130	50.00%
9	Theories fit within certain paradigms, hence, if these are old or untrue these are still helpful to biologists.	128	49.23%
10	Biologists often try to test or disprove possible explanations about living organisms.	126	48.46%
11	Biological knowledge is characterized by a large degree of order or organization in hierarchically organized complex systems.	123	47.31%
12	Theories in biology are not strictly formalized unlike other physical sciences.	122	46.92%
13	A biologist should be curious about both the known and the unknown	122	46.92%
14	Chance is a major factor in the field of biology	114	43.85
15	Universal laws are not relatively important in the field of biology.	108	41.54%
16	Biology as a field of study is a pure science.	108	41.54%

17	A biologist should be able to suspend judgment in order to give room for review of phenomena.	103	39.62%
18	Biology is a product of the 19th century scientific enterprise.	101	38.85%
19	Researches in biology are less guided by theories as in other physical sciences.	87	33.46%
20	Biological knowledge is cumulative; it increases with observations.	75	28.85%
	Misconceptions		
21	Researches in biology are entirely guided by theories, just as in other physical sciences.	216	83.08%
22	Biological laws can be proven to be absolutely correct.	213	81.92%
23	A good biologist should recognise the important role of folk ideas and mysterious beliefs in the biological enterprise; hence, make judgement based on those beliefs.	184	70.77%
24	After a failed experiment, a biologist is justified if he abandons such an experiment	174	66.92%
25	Biology can use supernatural explanations, if necessary. For instance, humans were created by gods.	168	64.62%
26	Reductionism which is a theory used in reducing facts to the simplest forms is applicable in biology.	163	62.69%
27	Knowledge of biology as a subject can be used to solve any problem or answer any question.	161	61.92%
28	All theories in biology are based on natural facts and laws	157	60.39%
29	Biologists sometimes entertain biases depending on the situation at hand.	152	58.46%
30	A good biologist is right to reject the opinions of others when he is absolutely sure of his methods	147	56.54%
31	Theories in biology are strict and rigid as in other sciences.	143	55.00%
32	Biological rules depend on the locality of its application.	143	55.00%
33	Biology as a field of study entirely relies on laws and theories to explain concepts.	142	54.62%
34	Biology as a field of study is as old as science itself.	141	54.23%
35	Prediction is a major part of biology hence, it is a standard of the goodness of a test in biology.	138	53.0%
36	The cumulative nature of biological knowledge is a weakness of biology as a science subject	124	47.69%
37	Biological knowledge is formed through scientific and non-scientific means.	120	46.15%
38	The historical nature of organisms may not be fully considered in understanding biological concepts.	118	45.38%
39	Biology as a subject can be influenced by the race, gender, nationality, or religion of the scientists.	113	43.46%
40	Disagreement between biologists is one of the weaknesses of biology as a science subject.	102	39.23%

Research Question 2: Is there a gender difference in the number of informed conceptions and misconceptions of the nature of biology held by biology teachers? In order to provide the answer to this question, a corresponding research null hypothesis was generated from the question. The hypothesis was tested using the chi-square statistical technique at 0.05 alpha level as indicated below.

HO_1: There is no significant difference in the number of informed conceptions and misconceptions of the nature of biology held by male and female biology teachers.

Table 2 showed that there was no significant difference in the number of informed conceptions and misconceptions of nature of biology held by male and female biology teachers (χ^2 (1, 260)= 2.295, p = 0.130). The null hypothesis was, therefore, not rejected because the p-value (0.130) is greater than 0.05.

This result suggests that gender does not influence the magnitude of misconceptions and informed conceptions of nature of biology held by the biology teachers. This finding seems to be consistent with that reported by Bello (In press), and Suleyman and Hasret (2010).

Table 2: Chi square Analysis of Significant Difference in the Number of Informed Conceptions and Misconceptions Held by Male and Female Biology Teachers.

Gender	χ^2	Df	Sig
Pearson Chi-Square	2.295	1	.130
Likelihood Ratio	2.274	1	.132
Linear-by-Linear Association	2.286	1	.131
No of Valid Cases	260		

Not Significant at 0.05 alpha level of significance

Research Question 3: Is there any difference in the numbers of misconceptions and informed conceptions of the nature of biology held by qualified and unqualified biology teachers? The second null hypothesis (HO_2) in this study was generated from this research question. The hypothesis was tested at 0.05 alpha level using the chi-square statistical tool.

HO_2: Significant difference does not exist in the number of misconceptions and informed conceptions of the nature of biology held by qualified and unqualified biology teachers.

As shown in Table 3, the result of the chi-square analysis revealed that there was no significant difference in the number of misconceptions and informed conceptions of the nature of biology held by qualified and unqualified biology teachers ($\chi^2(1, 260) = 1.733$, $p = .188$) hence, the hypothesis was not rejected. This finding tends to indicate that the teachers' qualification does not influence the number of informed conceptions and misconceptions about the nature of biology in their cognitive structures.

Table 3: Chi square Analysis of Significant Difference in the Number of Informed conceptions and Misconceptions Held by Qualified and Unqualified Biology Teachers.

Qualification	χ^2	Df	Sig
Pearson Chi-Square	1.733	1	.188
Likelihood Ratio	1.718	1	.240
Linear-by-Linear Association	1.726	1	.189
No of Valid Cases	260		

Research Question 4: Do the numbers of informed conceptions and misconceptions of the nature of biology held by experienced and less experienced biology teachers differ? The third research hypothesis was generated from this question and also, tested using the chi-square statistical tool at 0.05 alpha level.

HO_3: There is no significant difference in the number of informed conceptions and misconceptions of the nature of biology held by experienced and less experienced biology teachers.

Table 4 presents the result of the chi-square analysis which showed that there was no significant difference in the number of informed conceptions and misconceptions about the nature of biology held by experienced and less experienced biology teachers (χ^2 (1, 260) = .001, p= .978). Since the p-value of .978 is greater than 0.05, the hypothesis was not rejected. This result suggests that both the experienced and less experienced biology teachers held a similar number of informed conceptions and misconceptions about the nature of biology.

Table 4: Chi square Analysis of Significant Difference in the Number of Informed conceptions and Misconceptions held by Experienced and Less Experienced Biology Teachers.

Experience	χ^2	Df	Sig
Pearson Chi-Square	.001	1	.978
Likelihood Ratio	.001	1	.978
Linear-by-Linear Association	.001	1	.978
No of Valid Cases	260		

Summary of the Major Findings

- Biology teachers hold admixture of informed conceptions and misconceptions about the nature of biology in their cognitive structures.
- There is no significant difference in the number of informed conceptions and misconceptions of the nature of biology held by male and female biology teachers.
- A significant difference does not exist between the number of misconceptions and informed conceptions about the nature of biology held by qualified and unqualified biology teachers.
- The number of informed conceptions and misconceptions about the nature of biology held by the experienced and less experience biology teachers is not significant.

DISCUSSION

Existing literature in the field of biology education revealed that biology teachers held misconceptions and alternative conceptions on a wide range of biology concepts and the nature of science (Buaraphan, 2009; Sangsa-arda, Thathongb, & Chapooc, 2014; Galvin, Mooney, Simmie & O'Grady, 2015; Yate and Marek, 2013). Findings of this study provided additional empirical evidence which indicated that biology teachers lack adequate knowledge of the unique nature of biology as a science discipline. Specifically, findings of this study indicated that there exists an admixture of informed conceptions and misconceptions about the nature of biology in the biology teachers' cognitive structures. This implies that the biology teachers held distorted conceptions of the nature of biology. The pedagogical implications of this finding could be enormous. For instance, biology teachers may erroneously employ certain principles and laws in the field of physical sciences that are not applicable to biology as a conceptual framework for explanation in biology. Such principles include essentialism / typology, determinism, and reductionism. Similarly, biology teachers may also, use an intuitive cognitive construct like, cosmic teleology, anthropocentric thinking, and vitalism in their explanations of biological phenomena and concepts thereby, introducing or reinforcing intuitive biological thinking in their students. Consequently, meaningful learning of biology concepts by the students would be impeded. Understanding the nature and structure of knowledge in a discipline is a crucial element in determining appropriate instructional strategies and material by the teacher. It is arguable, that the existence of misconceptions about the nature of biology in the cognitive structures of the biology teachers, could significantly contribute to the lack of meaningful understanding of biology concepts among biology students.

Findings of this study also, revealed that the disciplinary content knowledge and by extension the quality of the biology teachers cannot be said to be satisfactory. This has brought to light the need for biology curriculum experts to critically re-examine what should constitute disciplinary content knowledge in the biology teacher education curricular. The disciplinary content knowledge components of biology teacher education curricular in Nigeria are restricted to selected biology concepts and theories. It is imperative to consider the inclusion of the historical and philosophical foundations of biology in the curricular. This is to equip biology teachers with a holistic perspective of biology as a unique science discipline and thereby, improve their PCK and quality. High quality teachers often produce good students as noted by biology education scholars (Akinfe, Olofinniyi, and Fashiku,2012; Ferguson,1992; and Wenglinsky, 1992). Hence, improving the quality of Nigerian secondary school biology teachers could stem the abysmal students' performance in the biology.

This study revealed that significant difference did not exist between the number of misconceptions about the nature of biology held by male and female biology teachers. This result is in accord with that of Bello (In press), but it is at variance with that of Omoifo (2004).The fact that male and female biology teachers are not taught differently in teacher education institutions in the nation is a plausible explanation for this finding. Misconceptions in science are closely associated with the intuitive cognitive construct, which is not peculiar to neither male nor female biology teachers hence; they are likely to hold similar numbers of misconceptions and informed conceptions of the nature of biology.

Findings from this study also, indicated that there was no significant difference between the numbers of misconceptions and informed conceptions of the nature of biology held by qualified and unqualified biology teachers. The finding is contrary to report from the study conducted by Monther, and Abeer, (2013), but it is similar to that of Vazquez, Antonia, Antonia, and Antonio, (2011). This may be due to the non-inclusion of the nature of biology as a mandatory course in biology teacher education programmes, which could enhance the qualified teachers' informed conceptions about the nature of biology. In addition, results of this study revealed that biology teachers' years of teaching experience had no influence on the number of misconceptions and informed conceptions about the nature of biology in their cognitive structures. This finding could be partially attributed to the fact that in Nigeria, it is not mandatory for experienced in-service biology teachers to regularly undertake professional development programmes.

CONCLUSION

The study has established that biology teachers held an admixture of misconceptions, and informed conceptions about the nature of biology. Also, it has established that biology teachers' gender, qualifications, and years of teaching experience does not influence the number of misconceptions and informed conceptions about the nature of biology in their cognitive structures. The study concluded that biology teachers lack adequate knowledge of the unique nature of biology, and call to question the quality of the teachers. The teachers' inadequate conceptions of the nature of biology are arguably an indication that the biology teachers partially accounted for the persistent abysmal performance of students in biology. It is obvious that teachers can only teach what they already know hence, students' performance in biology cannot rise above the quality of their teachers.

The conclusion reached in this study brought to light the need to appraise biology teacher education curricular in the nation with the view of improving the quality of biology teachers. The disciplinary content knowledge of the biology teacher education curricular in the nation is limited to biology concepts and theories that are directly related to the contents of the secondary school biology curriculum. This seems to be insufficient to provide biology teachers with in-depth knowledge of the unique nature of biology. Teachers' mastery of the unique nature of biology is a pre-requisite for distinguishing between the functional and historical aspects of biology, and the development of appropriate PCK by the teachers. In view of the relative dearth of studies on biology teachers' conceptions of the unique nature of biology, it becomes necessary for other researchers to investigate the relationship between teachers' conceptions of the nature of biology, their PCK and students' performance.

RECOMMENDATIONS

Based on the findings of this study, the following recommendations were made to improve the teaching and learning of biology:

1. Biology teacher educators, biology teachers associations and proprietors of schools should provide an avenue for biology teachers to improve upon their disciplinary content knowledge through workshops and seminars.
2. Biology textbook authors should include the nature of biology in secondary school biology textbooks through regular reviews and update of their textbooks.
3. Biology teachers should regularly identify their students' misconceptions about the nature of biology and biological concepts and take appropriate instructional measures to remediate them.
4. Curriculum planners should include the nature of biology in the teacher education and secondary biology curricular so as to help biology teachers and students to develop an understanding of the unique nature of biology.

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