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Teachers and Students Understanding of the Nature of Science as Predictors of Students Achievement in Biology in Senior Secondary Schools of Oyo State, Nigeria

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Abstract
This study focuses on the teachers and students understanding of the nature of science as predictors of students' achievement in biology in senior secondary schools of Oyo State, Nigeria. To guide the study three research questions were raised. The study adopted an ex-post facto design. A sample of 400 students and 20 teachers were used for the study (420). The schools used were stratified into public and private and a purposive sample technique was used to select 20 schools. Simple random sampling was used to select 20 students from each class in senior secondary school (SS II) and 1 biology teacher was used per school. Three validated instruments were used in the study, these were; Teachers Understanding of Nature of Science Scale (TUNSS), Students Understanding of Nature of Science Scale (SUNSS) and a Biology Achievement Test (BAT). From the findings of this study, it is evident that there was a significant relationship between teachers understanding of nature of science and that of their students and their achievement in biology. Teacher's improper application of their understanding of nature of science will lead to poor performance of student. Therefore, we recommend that government should make efforts to provide adequate and necessary training, re-training, seminars and workshops focusing on teachers and students understanding of nature of science.
Keywords: Achievement in biology, Nature of science, Nigeria, students understanding, Teachers

1. Introduction
There is presently much dissatisfaction with the levels of both teachers and students understanding of the nature of science, which in recent time is contributing to the growing rate of failure in yearly performance of science students especially in Biology (Lederman, 1999; Butler, 2009). The teaching of science in the senior secondary school takes the form of Biology, Chemistry, Physics and Agricultural Science. Bilesanmi found out that too often, Science teaching generally and Biology teaching in particular, laid more emphasis upon verbalization than it did upon concept development, the major aim of science teaching is to promote the understanding of the concept being taught with a view of applying knowledge of such understanding to real life situations (Bilesanmi, 2001). According to Nwagbo (2001), the persistent poor performance of students in biology and their negative disposition towards science attest to the fact that science teaching has not been properly done. Hence the concepts being taught are not properly understood. This improper science teaching has led to a vigorous search for appropriate teaching methods that would best achieve the aim of science teaching, thus improving performance and enhancing student's positive attitude towards science subjects including Biology.

2. Concept of Nature of Science
Science educators have the common goal of helping students develop scientific literacy, which includes developing their foundational knowledge, critical thinking skills, ability to apply what has been learned, and understanding of the nature of science (Abd-El-Khalick & Lederman, 2000).

Nature of science is a complex concept which involves the process of science, the products of science, its ethics, attitude, regulative principles and the logico-mathematical system all defining and controlling its methodological inquiries (Ogunniyi, 1982). The phrase nature of science; is often used in referring to issues such as what science is, how it works, the epistemological and ontological foundations of science, how scientists operate as a social group and how society itself influences and reacts to scientists endeavors (Clough, 2006). A theoretical model of the nature of science was developed by Kimball (1968) out of extensive study of the literature on the nature and philosophy of science. The declarations forming this model are:

1. Curiosity is the fundamental driving force in science;
2. Science is a dynamic, ongoing activity;
3. Science aim at comprehensiveness and simplification;
4. There are many methods of science;
5. A basic characteristic of science is a faith in the susceptibility of their physical universe to human ordering and understanding;
6. Science has a unique attribute of openness, and

7. Tentativeness and uncertainty mark all of science.

The nature of science is designed to measure students understanding of the characteristics and methods of scientific inquiry and their ability to apply the processes of science to solve problems.

a. Concept of Biology and its Importance

Science is the study of natural things while Biology is the study of living things (Sarojini, 2002). Biology is the study of organisms, ranging from little microorganisms to larger ones, plants and animals and all entities that have a form of life. The study of biology also helps us to understand our environment. The study of terminal diseases, their origin, causative agent, symptoms, control and cure as well as right drug to be used can be attributed to the knowledge of biology, even the so called dreaded diseases can now be managed. With the help of biology, environmental pollution can now be taken care of, High yielding varieties of crop plants like Cassava, Wheat, Oil Palm and animals such as fishes can now be bred with the influence of biotechnology. The above highlighted importance of biology has made it one of the core science course or subject of importance which should be made compulsory at all levels of education.

b. Teachers Preparation

In any educational programme, a teacher is the motivator and facilitator of learning. In spite of the generally held notion that students learn without teachers guidance but experience do show that the teacher is a significant factor and may indeed constitute a major constraint to students learning. The important role of teacher is to interpret and translate complex science concepts to the level appropriate to the learning experiences of the target students. It is essential that they must first develop a personal understanding of the subject matter that they are expected to impact to their students. When teachers do not fully understand the content of science, they will not be able to impact knowledge (Abd-El-Khalick & Lederman, 2000) and even more damaging is the fact that they may cause students misconceptions. How well science is taught will depend on the teachers understanding of the continuity and connection of concepts in science and their ability to relate these concepts to everyday life (Ball, 2000; Borko & Putman, 1996).

c. Students Learning Outcome/Achievement in Biology

Achievement in teaching and learning process has to do with attainment of set objectives of instruction. Several research reports in Nigeria, indicate that students achieve poorly in secondary school science subjects especially biology (Duyilemi, Olagunju, & Olumide, 2014; Aghadinuno, 2005; Olarewaju, 1986). A number of factors have been identified as militating against students attainment of the objectives of science instruction but the commonest factor among researchers is the lack of students' knowledge of the nature of science which should be the basic fundamental principle of science and another factor is the inappropriate and uninspiring teaching methods adopted by teachers.

d. Statement of the problem

The performance of students in Senior Secondary Biology in Nigeria has remained consistently poor over the years (Sakiyo, 2015). This can be linked to the teachers and students improper understanding of nature of science.

e. Objective of the Study

The objective of this study is to investigate the relationship between teachers and students understanding of nature of science, as predictors of achievement in Biology of senior secondary schools in Oyo State, Nigeria.

f. Research Questions

To carry out this research, the following questions were raised:

1a. What are biology teachers understanding of the nature of science?

1b. What are biology students understanding of the nature of science?

2. What is the level of student's achievement in Biology?

3. Will teachers and students understanding of nature of science predict their achievement in Biology?

g. Research Hypotheses

There is no significant relationship between teachers understanding of nature of science and that of their students.

There is no significant relationship between teachers understanding of nature of science and student achievement in biology.

h. Significance of the Study

The outcome of this study may shed some light on the students understanding of the nature of science and it may influence their performance at the senior secondary level of education in Oyo State, Nigeria. Findings of this study may serve as part of the contributed efforts made by educators in Nigeria to equip students to live effectively in our modern age of science and technology and to develop positive attitude towards learning of biology.

i. Scope of the Study

The study focuses on teachers and students understanding of nature of science, as predictors of student achievement in biology in Ibadan North local government in Oyo State, Nigeria.

3. Methodology

3.1 Population of the Study

The population of the study comprises all Senior Secondary II (SS II) students in Ibadan North Local Government Area of Oyo State, with random selection of 400 students in 20 schools as well as 20 teachers.

3.2 Sample and Sampling Technique

The sample consists of twenty teachers and four hundred SS II biology students drawn from twenty intact classes randomly sampled from twenty secondary schools in Ibadan North Local Government Area of Oyo State. The twenty schools were all co-educational. Simple random sampling technique was employed in drawing the participating schools after schools comparability have been established using certain criteria such as; year of establishment; senior secondary certificate examination (SSCE) results, and quality of laboratory equipment.

3.3 Instrument for the study

Three instruments were used to collect data:

1. The teachers understanding of nature of science scale (TUNSS)
2. Students understanding of nature of science scale (SUNSS)
3. Biology Achievement Test (B A T*)*

3.4 Instrument Administration

The instruments was administered to randomly selected sampled senior secondary school students and teachers which was distributed and collected at the spot to ensure its reliability in the study.

3.5 Analytical Technique

Data collected were analyzed using descriptive statistics, percentage, frequency count, mean and multiple regression analysis.

4. Results

Research Question 1a: What are biology teachers' understanding of nature of science?

Presented on Table 1, is the response of teachers on items eliciting their understanding of nature of science. From the analysis in Table 1, it shows that teachers of biology disagreed with the assumption on item 41 that science is essentially theoretical (x = 1 .60). They however strongly agreed with the fact that scientist no matter how hard they try, observation methods and results are always fringed by their personal beliefs (item 42, x = 3 .05) and with item 43-45 which state that science is a process of creating theories and trying to prove them wrong (x = 2. 80). All other items viz: items 2, 3, 4, 6, 7, 8 and items 11 to 40 yielded high means scores of 3.65 and above. Scientific method is used by scientists in all fields of research. Above all, the weighted average of 6.12 which is very high portrays teachers as having high level of understanding of the nature of science. To answer research question 1a, biology teachers were requested to indicate their opinions of the nature of science. Table 1 shows the mean scores as well as the standard deviation of biology teachers that held correct views and misconceptions about various aspects of the nature of science respectively. However, biology teachers appeared to hold more correct views about the nature of science than misconception about it. This finding provides answer to research question 1a.

Table 1: Biology Teachers' Understanding of Nature of Science

Correct views about the nature of science held by Biology Teachers

S/N	Items	Mean	STD Deviation
1.	Science is an attempt to explain observations of nature events.	3.60	0.50
2.	Scientists assume that the natural world operates according to constant rules that can be observed.	3.35	0.75
3.	Scientists value methods of observation that produce unbiased, replicable data.	3.65	0.49
4.	Scientists curiosity about the natural world leads them to continually ask What if…????? And So what….? Questions.	3.70	0.47

5.	Scientists principles and; laws are always tentative and subject to change as new evidence is available.	3.45	0.51
6.	Successful scientists habitually question what others accept as established knowledge.	3.60	0.50
7.	Scientists form theories to link concepts, principles, hypotheses, and observations in a logical way.	3.60	0.5
8.	Scientists use established rules of evidence to evaluate their own research findings and the findings of other researchers.	3.55	0.51
9.	Scientists strive to develop theories and hypotheses that reflect the observable natural world.	3.45	0.51
10.	When two theories explain the same data equally well, scientists prefer the simpler explanation.	3.05	0.89
11.	Scientists generate research questions	3.00	0.97
12.	Scientists use existing theories and explanations as a starting point for new research.	3.35	0.75
13.	Scientists form theories to describe observations of the natural world.	3.15	0.88
14.	There are no limits to the types of questions that can be asked and answered by science.	3.65	0.59
15.	Scientists seek the simplest explanations of data with the greatest ability to make accurate predictions.	3.20	0.41
16.	Scientists present their findings as logical arguments.	3.60	0.50
17.	Productive scientists have to be creative and imaginative.	3.40	0.50
18.	Scientists reasoning often involves creative leaps of imagination.	3.60	0.50
19.	Interpretations of scientific evidence are presented as logical arguments in written reports; therefore, scientists strive to make the logic of their reasoning as clear as possible.	3.40	0.75
20.	Scientists strive to be unbiased when they analyze research results.	3.30	0.73
21.	Scientists research methods can be used to make valid judgments about moral issues.	3.20	0.89
22.	Scientists' value peer scrutiny before research is fully disclosed.	3.55	0.51
23.	Scientific methods focus on natural events which can be observed and/or measured.	3.40	0.59
24.	The process of developing scientific knowledge is a repeated cycle of asking questions collecting evidence, and forming conclusions.	3.55	0.51
25.	Scientists describe their methods with enough detail for others to repeat because they expect other scientists to duplicate their work.	3.30	0.86
26.	Conclusions drawn by previous scientists often form the foundation for new research.	3.25	0.55
27.	Scientists try to be unbiased when they report research findings.	3.05	0.94
28.	Scientists attempt to describe their findings with enough detail that other researchers can judge the adequacy of their procedures.	3.55	0.51
29.	Flaws in the arguments and explanations of previous research often lead scientists to plan and conduct new research.	3.30	0.47
30.	Scientists value honesty in reporting the methods and procedures they use in their research.	3.50	0.51
31.	Scientific hypotheses can be tested in an unbiased manner.	5.90	11.8
32.	A necessary part of science involves validating claims made by scientists by replicating research results many times.	3.15	0.75
33.	Scientists value openness and honesty in reporting their own research and expect other scientists to do the same.	3.40	0.50
34.	By critical analyzing previous research, scientists generate new questions and hypotheses to investigate.	3.30	0.57
35.	Scientists frequently argue with other scientists about the assumptions, methods, findings and conclusions of their work.	3.40	0.59
36.	The development of scientific knowledge is a cumulative process.	3.25	0.55
37.	Scientists rarely use findings from previous investigations as they plan new research.	3.30	0.94
38.	Scientists conclusions can never be completely proven because they are based on an inductive process.	3.05	0.83

39.	Scientists expect other scientists to generally accept research methods, evidence, and conclusion without question.	2.85	0.93
40.	The same step- by- step procedure commonly known as the scientific method is used by scientists in all fields of research.	3.45	0.75

Misconceptions about the Nature of Science held by Biology Teachers

S/N	Items	Mean	STD Deviation
41.	Science is essentially theoretical.	3. 35	0.78
42.	No matter how hard the scientist tries, observation methods and results are always fringe-d by their personal beliefs.	3.18	0.75
43.	Science is a process of creating theories and then trying to prove them wrong.	2.76	1.03
44.	Once a scientific theory has been established, scientists stop further investigation.	2.63	1.08
45.	Theories do not allow scientists to make predictions of new events.	2.83	0.95

Weighted average= 3.34

Research Question 1b: what are biology students understanding of nature of science?

Table 2 shows that the biology students believe that once a scientific theory has been established, scientists stop further investigations about it (item 41; X = 3.35). Also, they agreed with the fact that science is a process of creating theories and trying to prove them wrong (item 43; X = 2.76). From other items, means scores obtained vary from lowest (X = 2.63) to highest (X = 3. 65). The weighted average of 3.45 out of 6.00 shows that the student possess a slightly low level of understanding of the nature of science. To answer research question 1b, biology students were requested to indicate their opinions of the nature of science. Table 2 shows the mean scores as well as the standard deviation of biology students that held correct views and misconceptions about various aspects of the nature of science respectively. However, It could be inferred that teachers understanding of nature of science with the (weighted average of = 6.12) is higher than that of their students with the (weighted average =3.13). This finding provides answer to research question 1b.

Table 2: Biology Students understanding of nature of science

Correct views about the nature of science held by Biology Students'

S/N	Items	Mean	STD Deviation
1.	Science is an attempt to explain observations of nature events.	3.42	0.66
2.	Scientists assume that the natural world operates according to constant rules that can be observed.	3.25	0.71
3.	Scientists value methods of observation that produce unbiased, replicable data.	3.18	0.68
4.	Scientists curiosity about the natural world leads them to continually ask What if…????? And So what….? Questions.	3.18	0.75
5.	Scientists principles and; laws are always tentative and subject to change as new evidence is available.	3.27	0.75
6.	Successful scientists habitually question what others accept as established knowledge.	3.27	0.71
7.	Scientists form theories to link concepts, principles, hypotheses, and observations in a logical way.	3.27	0.71
8.	Scientists use established rules of evidence to evaluate their own research findings and the findings of other researchers.	3.25	0.82
9.	Scientists strive to develop theories and hypotheses that reflect the observable natural world.	3.74	0.67
10.	When two theories explain the same data equally well, scientists prefer the simpler explanation.	3.38	0.71
11.	Scientists generate research questions	3.24	0.84
12.	Scientists use existing theories and explanations as a starting point for new research.	2.63	1.08
13.	Scientists form theories to describe observations of the natural world.	3.09	0.87
14.	There are no limits to the types of questions that can be asked and answered by science.	3.25	0.81
15.	Scientists seek the simplest explanations of data with the greatest ability to make accurate predictions.	3.17	0.80

16.	Scientists present their findings as logical arguments.	3.16	0.92
17.	Productive scientists have to be creative and imaginative.	3.26	0.78
18.	Scientists reasoning often involves creative leaps of imagination.	3.35	0.73
19.	Interpretations of scientific evidence are presented as logical arguments in written reports; therefore, scientists strive to make the logic of their reasoning as clear as possible.	3.31	0.81
20.	Scientists strive to be unbiased when they analyze research results.	3.37	0.79
21.	Scientists research methods can be used to make valid judgments about moral issues.	3.25	0.80
22.	Scientists' value peer scrutiny before research is fully disclosed.	3.29	0.74
23.	Scientific methods focus on natural events which can be observed and/or measured.	3.12	0.77
24.	The process of developing scientific knowledge is a repeated cycle of asking questions collecting evidence, and forming conclusions.	3.12	0.86
25.	Scientists describe their methods with enough detail for others to repeat because they expect other scientists to duplicate their work.	3.06	0.86
26.	Conclusions drawn by previous scientists often form the foundation for new research.	3.25	0.80
27.	Scientists try to be unbiased when they report research findings.	3.28	0.94
28.	Scientists attempt to describe their findings with enough detail that other researchers can judge the adequacy of their procedures.	3.55	0.51
29.	Flaws in the arguments and explanations of previous research often lead scientists to plan and conduct new research.	3.30	0.47
30.	Scientists value honesty in reporting the methods and procedures they use in their research.	3.50	0.51
31.	Scientific hypotheses can be tested in an unbiased manner.	5.90	11.8
32.	A necessary part of science involves validating claims made by scientists by replicating research results many times.	3.15	0.75
33.	Scientists value openness and honesty in reporting their own research and expect other scientists to do the same.	3.40	0.50
34.	By critical analyzing previous research, scientists generate new questions and hypotheses to investigate.	3.30	0.57
35.	Scientists frequently argue with other scientists about the assumptions, methods, findings and conclusions of their work.	3.40	0.59
36.	The development of scientific knowledge is a cumulative process.	3.25	0.55
37.	Scientists rarely use findings from previous investigations as they plan new research.	3.30	0.94
38.	Scientists conclusions can never be completely proven because they are based on an inductive process.	3.05	0.83
39.	Scientists expect other scientists to generally accept research methods, evidence, and conclusion without question.	2.85	0.93
40.	The same step- by- step procedure commonly known as the scientific method is used by scientists in all fields of research.	3.45	0.75

Biology Students' Misconception about Nature of Science

S/N	Items	Mean	STD Deviation
41.	Science is essentially theoretical.	1.60	0.88
42.	No matter how hard the scientist tries, observation methods and results are always fringe-d by their personal beliefs.	3.05	0.94
43.	Science is a process of creating theories and then trying to prove them wrong.	2.80	1.01
44.	Once a scientific theory has been established, scientists stop further investigation.	2.55	1.09
45.	Theories do not allow scientists to make predictions of new events.	3.10	0.91

Weighted average = 3.13

From table 3, the lowest score obtained among the biology student is 0 while the highest score is 16 out of maximum score of 20. From the entire sample of 400 students the mean score in the achievement of Biology is 7.8. This shows that achievement in Biology is poor.

Research Question 2: What is the level of achievement of students in Biology?

Table 3: Students Achievement in Biology

	N	Minimum	Maximum	Mean	Std Deviation
ACHIEVT VALID N	400	0.00	16.00	7.8825	2.5953
(listwise)	400				

Table 4 shows that students and teachers understanding of nature of science have positive multiple correlation with students achievement in Biology (R =.060). They also accounted for 0.1% of the total variance in students achievement in Biology (adjusted R value = .001).

Research Question 3: Will teachers and students understanding of nature of science predict their achievement in Biology?

HO1; There is no significant relationship between teachers understanding of nature of science and that of their students.

HO2; There is no significant relationship between teachers understanding of nature of science and students achievement.

Table 4: Regression of students and teachers understanding of nature of science on achievement

R	R Square	Adjusted R Square	Std. Error of the Estimate
.060	.004	-.001	2.5971

From Table 5, the R value of the effect of students and teachers understanding of the nature of science on student achievement is not significant (F.716; p >.05). It therefore could be due to chance.

Table 5: ANOVA Table for Regression on Achievement

Model	Sum of Square	Df	Mean square	F	Sig
Regression	9.664	2	4.832	.716	.489
Residual	2677.813	397	6.745		
Total	2687.1478	399			

n.s = not significant at p < 0.5

Table 6 shows that there is a significant relationship between students understanding of the nature of science and teachers understanding of nature of science (r = -.117; df = 399; p < .05). This led to hypothesis 1 been rejected. This relationship is negative and weak, implying that teachers' vast understanding of the nature of science did not lead to an improvement in the students understanding of the nature of science.

Table 6: Relationship between students understanding of nature of science and teachers understanding of nature of science

Variable	Mean	Std. Deviation	N	R	df	Sig.	Remarks
STDUNDSTA	210.6475	31.1171	400	-.117	399	.019*	Significant
TRUNDSTA	223.9500	27.4743	400				

Significant at p < .05

Table 7 shows that there is no significant relationship between teachers understanding of the nature of science and students achievement in Biology (r = .054; df =399; p > .05). Hence, hypothesis 2 is not rejected.

Table 7: Relationship between teachers understanding of nature of science and students Achievement in Biology.

Factors	Mean	Std. Deviation	N	r	D f	Sig	Remarks
6 TRKNOWL	223.9500	27.4743	400	.054	399	.279	n.s
ACHIEVT	7.8825	2.5953	400				

n.s not significant at p < .05

5. Discussion

The study revealed that the Biology teachers have high level of understanding of the nature of science. This could be due to series of training and re-training they have undergone in the course of time. This agrees with the findings of Norman (1999), Clark and Peterson, (1986) that teachers possess what would be considered to be desired understanding of nature of science. It was evident from this study that the teachers understanding of nature of science made higher contributions than students understanding of nature of science to students achievement in biology. This could be as a result of teachers professional background in the field of teaching. This finding is in agreement with Lederman (1999). It is clear that such a relationship is far from being direct or simple. Reasonably, such a relationship is contingent upon teachers explicit attention to his/her views of the nature of science during instruction.

The study further found that the teachers vast understanding of nature of science did not lead to an

improvement in the students understanding of nature of science. This could be due to teachers poor presentation of instruction to students neglecting science process skills in the course of teaching. This finding is also consistent with prior research findings (Abd-El-Khalick et al., 1998; Duschl & Wright, 1989; Gess-Newsome & Leder, 1993) indicating that teachers rarely consider the nature of science when planning for instruction or making instructional decisions.

On the other hand, the students were found to possess a slightly high level of understanding of the nature of science. This could be because some of them have strong foundation from their junior secondary school which was being transferred to their senior secondary classes. This is in line with the finding of Wood (1972), Bilesanmi (2001) who found out that secondary education majors had a better understanding of the nature of science than the elementary education majors. The reason for this type of result could have been that the students who had more practical activities have over time acquired more process skills which have tendency to increase their understanding of the nature of science.

This study further reveals that achievement of students in biology is poor. Some of these students possess slight understanding of nature of science but could not translate it to their performance. This is also in line with Ajagun, (2000) that the performance of students in senior science has remained consistently poor. The study also reveals that the students and teachers understanding of nature of science have positive multiple correlation with student achievement in biology. They also accounted for 0.1 % of the total variance in students achievement in biology. This is in agreement with Bilesanmi (2001) that there was positive multiple correlation between students and teachers understanding of nature of science and their achievement in biology. Hence, for better performance in biology, the curriculum should emphasize learning of the processes of science rather than mere acquisition of knowledge.

On the whole, the summary of findings arising from this study is as follows: Biology teachers possess high level of understanding of the nature of science while Biology students possess slightly high level of understanding of the nature of science. The achievement of students in biology is poor. Interestingly, teachers and students understanding of nature of science have positive multiple correlation with student achievement in Biology. They also accounted for 0.1 % of the total variance in students achievement in Biology. The teachers understanding of nature of science made higher contributions than students understanding of nature of science to students achievement in Biology. Conversely, the teachers vast understanding of nature of science did not translate to an improvement in students achievement in Biology and there is no significant relationship between teachers understanding of the nature of science and students achievement in Biology. In the light of the findings of this study, we recommend that government should make efforts to provide adequate or necessary training, re-training, seminars and workshops focusing on teachers and students understanding of nature of science and teachers should motivate and help students to translate their understanding of nature of science to a better performance in biology. Additionally, teachers should bring to mind the nature of science when planning for classroom instruction.

6. Conclusion

The study revealed that teachers and students understanding of nature of science have influence on student's achievement in biology in senior secondary schools. However, the teachers understanding of the nature of science did not translate to an enhanced achievement in Biology test.

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