



Effect of Training Biology Teachers in Scientific Thinking Skills on Senior Secondary School Students' Achievement in Biology in Kano, Nigeria

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Abstract. The study investigated the effect of training biology teachers in scientific thinking skills on senior secondary school students' achievement in biology in Kano, Nigeria. Pre-test, post-test quasi experimental design was employed. The sample used comprised 975 senior secondary two students. Biology Achievement Test (BAT) was used to collect data from students. The BAT was content validated with its internal consistency established as .85 using Cronbach alpha method. The experimental group was taught biology concepts for eight weeks by teachers trained in scientific thinking skills while the control group was taught the same biology concepts for the same length of time by biology teachers not trained in scientific thinking skills. Data analysis was done using SPSS version 27.0. Research questions were answered using mean and standard deviation while hypotheses were tested using ANCOVA at .05 level of significance. Results showed that the experimental group achieved higher than the control group. Gender was found not to have any significant effect on biology achievement of students in the experimental group. It was concluded that training teachers in scientific skills improved students' achievement in biology. It was recommended that teachers should engage students in scientific thinking skills in biology classrooms for improved achievement outcome in biology.

Keywords: Achievement, Biology, Gender, Scientific thinking skills.

1. Introduction

Education has been widely acknowledged as a critical factor for the development of individuals, the society and the nation. For meaningful national development there is need to put in place a functional education for the youth, particularly in science which is the engine room for technological growth. There is an urgent need to inculcate science, technology, engineering and mathematics skills among students in line with

the global shift towards engaging students with 21st century skills to equip them for effective living in a technology drive era.

The Nigerian government, in her national policy on education (Federal Republic of Nigeria [FRN], 2014) stipulates that teaching and learning of science, which includes biology should be process-oriented and learner-centered to promote students' understanding of science concepts and application of knowledge to solve societal problems. The Policy furthermore prescribes hands-on and minds-on methods via process-oriented activities to enable students participate actively in science tasks and become critically-minded, scientific, reflective and socially responsible citizens. These objectives cannot be said to have been realized in biology classrooms as results of students in public examinations show high rate of poor achievement in biology examinations (West African Examinations Council [WAEC], 2010-2019).

Studies show that methods of teaching science which biology is part and parcel of, are predominantly lecture and discussion which are known to engage students in little or no thinking (Nworgu, 2012; Nbina, 2013; Adegboyi, Otuka & Uzoechi, 2015; Ozoji, 2020). Biology is concerned with the study of life and living organisms in the environment (Nwagbo, 2014); how life and natural systems evolved, are governed and respond to changing environments. Like other sciences, biology is both a body of knowledge and a process. It contains practical aspects which equip students with concepts and skills that are useful in solving day-to-day life challenges and meeting the scientific and technological demands of the society (Adewale, Nzewuihe & Ogunsola, 2016). Biology is the foundation of all sciences and environmental professions, like medicine, pharmacy, nursing, genetic engineering, and forensic science. These disciplines are essential for the nation's scientific,

technological and economic development. The biology teacher therefore, occupies a strategic position in the integration of scientific thinking skills into biology instructional delivery for improved achievement outcomes.

Despite the important roles biology education plays in national development and self-emancipation of individuals and the efforts by the government to improve the teaching and learning of the subject in schools, students' achievement in biology in public examinations has remained persistently poor (Achem, 2012; Ugbede & Agbo, 2014; WAEC, 2010-2019). If the spate of underachievement by students is not checked, the implication is that the 60:40 ratio mandate by the government for admissions into Nigerian universities for science-based courses cannot be achieved. This may in turn affect the realization of the National Policy on Education (2014) goals of production of a scientifically literate citizenry and skilled manpower to promote technological and scientific advancement of the country. The ripple effect is that Nigeria will continue to lag behind in the global scene as far as science and technology advancement is concerned. Furthermore, obtaining the required workforce to move the nation forward in science and technology development may not be realized.

Some of the factors identified by researchers responsible for poor achievement in biology by students in Nigeria and other developing countries include teaching methods, teachers' poor application of thinking skills in science classrooms (Nworgu, 2012; Nbina, 2013; Aina, 2017; & Ozoji, 2020), students' inability to interpret questions that required scientific thinking skills; failure to answer questions logically, systematically and convincingly (WAEC, 2017). Of all the fore-going factors, employing ineffective and poor teaching methods appear overbearing. Research reports revealed that teachers predominately use the lecture method of teaching, which to Ozoji, stifles meaningful learning and understanding of science concepts and does not engage students in activities that require scientific thinking but rather makes them prone to rote learning and regurgitation of facts.

Gender has also been implicated in biology achievement, with studies showing inconclusive results. For instance, Olashinde and Olatoye (2014) reported that females were deficient in science because they lacked analytical and other scientific thinking skills needed for abstract reasoning. Afuwape and Oludipe (2011); Agbaje and Alake (2014) in their separate researches, observed no

significant gender differences in students' achievement in science. This situation has necessitated the need for the use of innovative, activity-oriented and gender-friendly teaching methods and packages, such as scientific thinking skills package to address students' underachievement in biology.

Scientific thinking skills package is one of the innovative ways teachers can employ to effectively deliver biology in schools. Scientific thinking skills are often referred to as process skills, which are basically the ability to apply scientific method starting from identifying and formulating problems or questions, formulating hypotheses, designing experiments to collect data, making predictions to drawing conclusion among others (Asmitia & Crowley, 2011). Scientific thinking skills are problem-solving skills that enable students find out facts and make discoveries through asking the right questions, conducting investigations, collecting data, analyzing data, evaluating ill-defined problems, making informed decisions and providing a variety of solutions to a particular problem. As important as scientific thinking skills are in effective science instruction, studies revealed that students are not deliberately taught how to think in science classrooms (Chollom, 2017; Adegboyi, Otuka & Uzoechi, 2015; Fazzila, 2017; Ozoji, 2020). Moreover, there is paucity of studies on training biology teachers in scientific thinking for effective teaching and learning of biology in Nigerian senior secondary schools. This study therefore, investigated the effect of training biology teachers in scientific thinking skills on senior secondary school students' achievement in biology in Kano, Nigeria. Moreover, influence of gender on biology achievement of students taught by teachers exposed to scientific thinking skills training was investigated. The study was guided by the following research questions:

1.2 Research Questions

- What are the pre-test and post-test achievement mean scores of SS11 students in experimental and control groups?
- What are the post-test achievement mean scores of SS11 male and female students in experimental group?

1.3 Hypotheses

The following hypotheses were tested at 0.05 level of significance:

- There is no significant difference between the achievement mean scores of biology students taught by teachers exposed to scientific thinking skills training and those taught using the lecture method.
- There is no significant difference between the achievement mean scores of male and female biology students taught by teachers exposed to scientific thinking skills training.

skills taught the same concepts to the control group for eight weeks too. In teaching the experimental group, the students were actively engaged in scientific thinking skills including, experimenting on osmosis, plasmolysis and haemolysis; communicating ideas to one another, raising questions and answering higher order questions posed by the teachers, predicting outcomes of experiments in the concepts they were taught and making inferences. The control group was not engaged in scientific thinking as they were taught the same topics using the lecture method.

2. Research Method

2.1 Research Design

The study adopted the pre-test, post-test quasi experimental design.

2.2 Population and Sample

The population of the study comprised 4789 students in 48 senior secondary schools in Kano, Nigeria. The sample comprised 975 students (male=650, female=325) in intact classes from 30 randomly selected senior secondary schools in the area of the study. Fifteen schools were randomly assigned to the experimental group while the other 15 schools were assigned randomly to the control group.

2.3 Procedure

Fifteen teachers trained in scientific thinking skills by the researchers, taught the concepts of forms of cell, cell structure, cell theory, cell and its environment to the experimental group for eight weeks while 15 biology teachers not trained in scientific thinking

Instrument for collecting data from students was a Biology Achievement Test (BAT) consisting of sections A and B. Section A solicited students' demographic information, such as, school, gender. Section B comprised 40-item multiple choice Biology Achievement Test (BAT). Each BAT item had four options, A-D. The BAT was validated by two experts in Biology education in the University of Jos. The reliability index was established as .85 using Cronbach alpha method. Students in experimental and control groups were pre-tested before they were taught biology concepts with scientific skills package and lecture method, respectively. Experimental and control groups were post-tested after the period of teaching. Students' scripts were scored over 40 and converted to 100 by the research assistants. Data collected were analyzed using SPSS version 26.0. Research questions were answered using mean and standard deviation while hypotheses were tested using Analysis of Covariance (ANCOVA) at 0.05 level of significance.

3. Results

What are the pre-test and post-test mean achievement scores of SS11 students in experimental and control groups?

Table 1: Pre-test and post-test Biology Mean Scores of Students in the Experimental and Control Groups

Test	N	Before		After		Mean Gain	\bar{x} -difference
		Mean	SD	Mean	SD		
Experimental	515	42.30	10.78	71.80	12.79	29.5	27.98
Control	460	40.81	11.28	42.33	9.16	1.52	

Table 1 reveals the biology students' pre-test and post-test mean achievement scores in the experimental and control groups. The result shows a pre-test mean score of 42.30 for experimental group and a mean score of 71.80 for post-test. Also, the pre-test mean score for control group is 40.81 and a post-test mean score of 42.33, indicating that there was improvement in the achievement mean score of students after exposure of teachers to scientific thinking skills training. The experimental group had a higher mean score (71.80) than the control group (42.33) with a mean difference of 27.98.

Research Question Two: What are the post-test achievement mean scores of male and female Biology students in the experimental group?

Table 2: Result of Post-test Mean Score of Male and Female Students in Biology in the Experimental Group

Group	Gender	N	Mean	SD	\bar{x} Difference
Experimental	Male	340	70.20	13.35	4.70
	Female	175	74.90	11.04	

Table 2 shows the mean and standard deviation of post-test achievement mean scores of male and female Biology students in the experimental group. The mean score for male is 70.20 and a standard deviation of 13.35, while females had a mean score of 74.90 and a standard deviation of 11.04 with a mean difference of 4.70.

Ho1. There is no significant difference between achievement mean scores of biology students exposed to scientific thinking skills training and those exposed to the lecture method.

Table 3: ANCOVA Result on the Difference between the Post-test Mean Scores in Experimental and Control Groups

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	251786.773a	2	125893.387	1494.979	.000	.755
Intercept	68141.656	1	68141.656	809.179	.000	.454
Pre-test	40767.760	1	40767.760	484.115	.000	.332
Group	197728.585	1	197728.585	2348.019	.000	.707
Error	81852.919	972	84.211			
Total	3601371.000	975				
Corrected Total	333639.692	974				

a. R Squared = .755 (Adjusted R Squared = .754)

Table 3 reveals the ANCOVA result on the difference between the post-test mean scores of biology students taught by teachers exposed to scientific thinking skills training and those who were not exposed. From Table 1, $F(1,972) = 2348.01$, $P < 0.05$, $p < 0.05$, partial $\eta^2 = .707$, since the p value of 0.000 is less than 0.05 level of significance with an effect size of 71%, the null hypothesis was rejected, indicating that there was a significant effect of scientific thinking skills training on students' achievement. The result further reveals an adjusted R squared value of .754 which means that 75.4 percent of the variation in the dependent variable which is students' achievement is explained by variation in the treatment of scientific thinking skills training, while the remaining 24.6% is due to other factors not included in this study

Hypothesis Two: There is no significant difference between post-test achievement mean scores of male and female biology students in the experimental group.

Table 4: Post-test mean Achievement Scores of Male and Female Biology Students taught by Teachers exposed to Scientific Thinking Skills Training

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	23192.581 ^a	2	11596.290	97.430	.000	.276
Intercept	61503.535	1	61503.535	516.743	.000	.502
Pre-test	20643.537	1	20643.537	173.444	.000	.253
Gender	251.396	1	251.396	2.112	.147	.004
Error	60939.011	512	119.022			
Total	2738793.000	515				
Corrected Total	84131.592	514				

a. R Squared = .276 (Adjusted R Squared = .273)

Table 4 reveals the ANCOVA result on the difference between post-test mean scores of male and female biology students exposed to scientific thinking skills training and those not exposed. From Table 5, $F(1,512) = 2.11$, $P > 0.05$, partial $\eta^2 = .004$. Since the p -value of 0.147 is greater than 0.05 level of significance with an effect size of 0.4%, the null hypothesis was retained, indicating that there was no significant effect of scientific thinking skills training on students' achievement due to gender.

4. Discussion

Results on Table 3 show that there was a significant effect of scientific thinking skills training on students' achievement. The result further reveals an adjusted R squared value of .754 which means that 75.40 percent of the variation in the dependent variable which is students' achievement is explained by variation in the treatment of scientific thinking skills training, while the remaining 24.6% is due to other factors not included in this study. The finding agrees with that of Ozoji, Iliya, Sa'ad and Isuwa (2022). which showed that exposing students to metacognitive skills package improved their achievement in basic science and technology. However, improvement in students' achievement in biology must have been as a result of training teachers in scientific skills which impacted positively on students' creativity, communication skill, critical thinking and reflection, thereby, culminating in improved achievement in biology.

Data in Table 4 show no significant difference between biology mean achievement scores of male and female students in the experimental group. This means that gender had no significant effect on biology mean achievement scores of students taught by teachers exposed to scientific thinking skills training. This further means that male and female students in the experimental group enjoyed biology lessons to the same degree. This finding is in consonance with that of Umar, Ozoji, and Ikpechukwu (2018) that revealed no gender influence on students' achievement when exposed to computer-simulation.

5. Conclusion and Recommendations

From the findings of the study, it was concluded that training biology teachers in scientific thinking skills improved students' achievement in biology, as well as gender equality.

Based on the findings, the following recommendations were made:

- Secondary school teachers should incorporate scientific thinking skills package into their teaching strategies to improve students' understanding and achievement in biology through engaging them in hands-on and minds-on, problem-solving activities.
- Teacher educators should emphasize exposure of pre-service biology teachers to scientific thinking skills and other 21st century skills in their methods courses, in

the course of their study to equip them for effective teaching.

- Professional associations, such as, the Science Teachers Associations in Nigeria and other countries of the world should mount conferences and organize workshops for training and retraining of teachers in scientific skills package and other innovative and activity-based strategies/packages to improve their pedagogical skills.

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