



IMPACTS OF COLLATERAL AND ANALOGY TEACHING STRATEGIES ON PRECONCEPTIONS AND PERFORMANCE IN EVOLUTION CONCEPTS ON MALE AND FEMALE NCE III BIOLOGY STUDENTS NORTH CENTRAL, NIGERIA

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ABSTRACT

This study investigated the Impact of Collateral and Analogy Teaching Strategies on preconceptions and Performance in Evolution Concepts among male and female Nigeria Certificate in Education Students North Central, Nigeria. A pretest, posttest quasi-experimental control group research design was used. Two groups were involved. The target population for the study was 1211 NCE III Biology students. The study sample of 256 consisting of 151 males and 105 females was drawn from two colleges of education intact classes within North Central, Nigeria. A pretest was administered before treatment to establish the equivalence of the experimental groups. The male and female subjects in the experimental group¹ were taught evolution concepts using analogy teaching strategy, while the experimental group² students were taught the same concepts using collateral teaching strategy for the period of six weeks. The instruments used, Unscientific Preconception Test on Evolution (UPTE) and Evolution Performance Test (EPT) was adopted from Biology textbook questions and past moderated NCE III examination questions. The questions were validated for data collection and reliability index of 0.69 for UPTE and 0.76 for EPT. Two research questions and two null hypotheses were stated and tested. The data collected were subjected to statistical analysis at $p \leq 0.05$ level of significance. Descriptive statistics was used to answer the research questions, while t-test statistics was used to test the hypotheses stated. The results obtained showed that both male and female students taught using analogy teaching strategy performed significantly better than those taught using collateral teaching strategy. However male and female students did not differ significantly in their unscientific preconceptions in evolution concepts. Based on the findings it was concluded that both male and female NCE III Biology students did not differ significantly in the unscientific preconceptions. It was recommended that teacher-trainers like the Colleges of Education, Polytechnics and Universities should incorporate analogy strategy into their methodology curricular at all levels. This will ensure the development of its knowledge in the teachers on training.

INTRODUCTION

The impact of gender has on performance in science generally in Nigeria schools has remained an issue in the front burner of academic discourse. Scholars like Iman and Dada (2011) have become enthusiastic on addressing issues that have continued to create differences among people on the basis of gender which has continued to have adverse consequences on sustainable



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economic development of the nation. Obeka (2013) worked on gender differences and academic achievement in biological sciences in senior secondary school. He reported a significant difference in male and female academic performance. Science education researchers like Ogunleye (1999), Chew (2004) and Jiya (2011) reported that a number of concepts in Biology including evolution, genetics and ecology contain topics which pose difficulty for Biology students to understand. This has resulted to poor performance in the subject. Usman (2008) stated that many students are said to have wrong perceptions about evolution concepts on the basis of how they were taught Biology in schools. To further support Usman (2008), Kampourakis (2014) is of the view that one of the learner factors that affect meaningful learning in Biology generally is the wrong perception such as cultural and religious believe about how life originated of evolution concepts held by the students. Learners interpret the world, based on what they had, see or learnt from others and often if these they already know, do not reorganized in their minds. As a result, humans do not learn the true nature of scientific phenomena.

De Kock (2005) agrees and adds that the way the students view science are result of personal experiences, which can include watching television, reading books and oral language interactions in addition to interaction with adults. Thus, some students' everyday activities have enabled them to learn science even before entering school. Kambouri (2007) went further to say that the difference is that when starting kindergarten the child comes in contact with science as organized body of knowledge instead of unstructured and random activities that can happen outside the school. Henriques (2002) reported that science education community generally accepts the idea that students enter the classroom with their own understanding of the world and that some of this knowledge is incorrect and remarkably resistant to change. This prior knowledge is referred to as preconceptions. Preconception can be seen as the ideas students have before learning or experiencing the actual knowledge. Preconception can be categorized into scientific and unscientific ideas. The unscientific can be referred to as misconception. The Unscientific preconceptions are resistant to change persistent and difficult to extinguish even with instruction designed to address them. In fact, Brown and Clement (1987) and Kikas (2004) also confirmed that unscientific preconceptions are detrimental to



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learning as they constitute major block to students' understanding. Haider (1997) and Kwen (2005) opined that the unscientific preconceptions of learners may generally hinder their subsequent learning. So, learners' unscientific preconceptions should be taken into consideration in the developing of science curricula. Moreover, it seems that unscientific preconceptions related to biology are never completely over written, despite a deep understanding of biological processes or expert scientific knowledge. Besong (2002) noted that one factor that militates against science literacy is gender discriminatory barriers in African societies that operate against equitable participation of boys and girls in science education. Besong further observed that one out of four girls of school age is actually in school. Orji and Oladi (2010) asserted that in Africa, especially in a traditional setting female and male sex roles are seen as mutually exclusive. For instance, some professions like carpentry, engineering, woodwork, metalwork and automobile engineering technologies are still regarded in some quarters as no –go-areas for female while nursing and catering professions are seen as exclusive areas for the female.

Some researchers like Olorukooba, Lawal and Jiya (2012); Obeka (2013) found that male students have higher performance in biology than female students. Duyilemi and Bolajoko (2014) worked on gender differences and academic performance on constructivist learning strategies in Biology and confirmed that males had higher performance score than female counterparts. Similar findings were reported by Lagoke, Jegede and Oyebanji (1997) who observed that boys performed better than girls in those science learning situations where instructional methods are full of activities and manipulations and are found to be more oriented towards laboratory work. Also, they further reported that boys performed better than girls in processes of measuring and experimenting in the laboratory. Adesoji and Babatude (2008) confirmed that male subjects were superior over female counterparts in science performance and possessed less unscientific preconceptions as well. While Mustapha (2010) noted that female students exhibit more positive performance towards Biology and male towards Physics. Mari (1994), Bichi (2004) and Atadoga (2005) observed that female students performed better in understanding of science process skills than male students. Also Lawal (2009) explained that female subjects performed significantly better than male counterparts and in ability to solve



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quantitative problems. Yet other researchers Ifeyinwa (2014) and Awolaju, (2016) all reported no significant differences among boys and girls performances in science. Similarly, Olasehinde and Olatoye, (2014) compared gender differences among secondary school students learning outcomes in science. They reported that there were no significant difference between male and female students in overall science performance, and also Biology, Chemistry and Physics performance respectively. The study of Agboghoroma and Oyovwi (2015) identified difficult concepts among biology students in secondary school showed that gender and school location has no effect on difficult concepts in biology.

Bichi (2002) reported that there is no gender related difference in achievement in evolution concepts among secondary school students exposed to teaching and learning Biology concepts using problem solving teaching strategy. From these studies, there is no conclusive position yet on the gender related issues investigated by the researchers. However, some instructional strategies are gender bias while some are gender friendly, the degree of gender related differences in learning vary from one method of instruction to the other. As such this study compared the possible impact of collateral and analogy on unscientific preconceptions and performance of concepts in evolution among male and female NCE III Biology students in North Central, Nigeria. Analogy and collateral teaching strategies has been found to enhance students' performance because both the two strategies put into consideration the prior knowledge of learners which is able to bring about meaningful learning as a result of students' involvement in integrating new information with pre-existing knowledge. Use of analogy teaching strategy is another way of helping teachers and students to overcome difficulties associated with teaching and learning of difficult science concepts. This is because some of the difficulty experienced by students in these topics no doubt stem from lack of insight into the internal workings as well as inter and intra-particle/ phenomenal interactions that result in the observable outcomes.

Use of analogy as constructivist instructional strategy has shown much promise in its application in science teaching. Analogies are of various types depending on the nature of what analogy represent and the problem analogy are intended to solve in the teaching/ learning situation. In this study, Analogy Teaching Strategy of Glynn (2007) was adopted. Analogy



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Teaching Strategy (ATS) model was preferred to other Analogy models for this study because the model simplifies a difficult concept or idea, provides a variety of approach to link an unfamiliar idea with a familiar idea and visualizes a structure or process. Above all, it puts into consideration the prior knowledge of the learner, which according to Millar, (1989) constructivists' view that meaningful learning must necessarily involves students in integrating new information or knowledge with pre-existing knowledge.

Glynn (2007) model consists of six steps that the teacher carries out when drawing an analogy as teaching strategy. The steps are as follows

- Step I. Introduce the target concept
- Step II. Review the analogy concept.
- Step III. Identify the relevant features of target and analogy
- Step IV. Map the similarities
- Step V. Indicate where the analogy breaks down
- Step VI. Draw conclusions

This study adopted Glynn's model of analogy teaching strategy and all the six steps were followed accordingly. Another influential teaching strategy that may help students to correct unscientific preconception and improve performance in science learning is collateral teaching strategy. Spindler (1987) and Wolcott (1991) explained that teaching science is viewed as cultural transmission and learning science as culture acquisition. According to NB (2007), culture is the accumulated habits, attitudes and beliefs of a group of people that defines peoples' general behaviour and way of life. Looking critically at the influence of cultural background on learning science, it becomes important for science teachers and Biology in particular, to address learner's background issues like language, customs and experiences that students' from different communities bring to science classroom (Jiya, 2017). Thus, Biology teachers are faced with increasing complex problems of creating a suitable learning situation for Biology students with varied cultural backgrounds especially when teaching topics like evolution that has to do with beliefs on how life originated. Abonyi (2002) stated that the current approaches to science instruction in Nigeria have been criticized as being incapable of



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bridging the gap between the initial background of the learner and the new field of knowledge. Learning science involves negotiating meaning, comparing what is known to new experiences and resolving discrepancies between what is known and what seems to be implied by new experiences. The effectiveness with which students move between life-world culture and the culture of science or school science depends on the assistance students receive in making those transitions easier. Collateral teaching strategy is a strategy that helps in resolving problem of conflict between culture and science as it attempts to help students cope with science learning, without doing violence to student's particular cultural beliefs and experiences.

According to Jegede (1995) collateral teaching has an accommodative mechanism for the conceptual resolution of potentially conflicting tenets within a person cognitive structure. Collateral teaching is the cognitive explanation of border crossing (Jegede, 1997). Also Ogawa (1995) defined collateral teaching as a strategy that enables learners to understand science concepts while maintaining their world view. The task of science teaching is to help all children acquire scientific knowledge, interest, skills, attitudes and ways of thinking without violating students cultural believes and experiences. Shull (2013) suggested some advantages of collateral learning as a teaching strategy that improves learning and increases content taught without significant loss of class time, it helps students to have better understanding of concepts taught. Students in the science classroom will construct scientific concepts side by side and the strategy is active and experimental.

The following steps are involved when using Collateral Teaching Strategy Fakudze (2004) model

Step 1. Sensory Register (SR)

Introduction of the concept to be learnt through materials like pictures, diagrams, and questions related to the topic in the society.

Step 2. Working Memory (WM)

Presentation of the target concept is done in this place

Ideas gathered from the society are brought into science classroom and are related to the science concepts taught.



Step 3. Border Crossing and Transition between Working Memory and Collateral Learning.

Questions were asked by the researcher based on the topic taught from the answers given by the students the researcher was able to know the types of border crossing that has taken place in the students.

Step 4. Collateral Learning

From the information passed from WM to the collateral learning, there is permanent storing of what students have learned depending on the type of border crossing. The storage takes place in the form of collateral learning.

This study therefore, compared the impacts of collateral and analogy teaching strategies on preconceptions and performance in evolution concepts among NCE III male and female Biology students in North Central, Nigeria. However, according to Greg (2007) the teaching and learning of evolution has faced difficulties ranging from pedagogical obstacles to social controversies. These include two distinctive sets of problems: one arising from the fact that many evolutionary concepts may seem, at least initially, counterintuitive to students, and the other deriving from objections rooted in religion. According to Goldberg and Thompson-Schill (2009), Kampourakis (2014), evolution concepts are rather counter-intuitive ideas that generate unscientific preconceptions in students, make its theories difficult for students to understand, abstract in nature as well as having cultural and religious bias which has resulted in students performing poorly in evolution concepts at NCE level. Further research studies by Hokayem and Boujaoude (2008); Athanasious and Papadopoulou (2011) on undergraduate students from various countries and religious backgrounds have also revealed that students often perceive conflict between students worldviews and what evolution theory suggests. Therefore, students' poor performance may be as a result of teachers using ineffective teaching methods that cannot help overcome unscientific preconceptions and boost students' performance in evolution concept. In fact, Treagust (1993), Greg (2007), Jiya (2011) and Ogonnaya (2011) stated that unscientific preconceptions and poor performance of students in evolution concepts may be overcome if the teacher provides a bridge (link) between the unfamiliar concepts (evolution concepts in particular) and the knowledge which the students already possess. Specifically, this



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study seeks to investigate the impact of analogy and collateral teaching strategies on NCE III biology students' unscientific preconceptions and academic performance in evolution.

Objectives of the Study

The main aim of this study are to examine the impacts of analogy and collateral teaching strategies on preconceptions and performance in evolution concepts among NCE III Biology students in North central, Nigeria. The study has the following objectives to:

1. find out the impacts of collateral teaching strategy and analogy teaching strategy on preconceptions in evolution concepts among male and female NCE III Biology students; and determine the impacts of collateral teaching strategy and analogy teaching strategy on academic performance in evolution concepts among male and female NCE III Biology students.

Research Questions

The study seeks to answer the following research questions:-

1. What is the difference in the preconceptions mean scores in evolution concepts between male and female NCE III Biology students taught using collateral teaching strategy and those taught using analogy teaching strategy?
2. What is the difference in performance mean scores in evolution concepts between male and female NCE III Biology students taught using collateral teaching strategy and those taught using analogy teaching strategy?

Null Hypotheses

The following null hypotheses were tested in the course of this study at $p \leq 0.05$ levels of significance:

- H0₁: There is no significant difference in the mean preconception scores in evolution concepts between male and female NCE III biology students taught using collateral teaching strategy and those taught using analogy teaching strategy.
- H0₂: There is no significant difference in the mean performance scores in evolution concepts between male and female NCE III Biology students taught using collateral teaching strategy and those taught using analogy teaching strategy.



METHODOLOGY

The research design adopted for this study was quasi experimental groups design involving pretest and posttest. The male and female subjects in the experimental (1) and experimental group(2) were pretested to determine their equivalence in academic ability and preconceptions held on evolution concept before the exposure to collateral and analogy teaching strategies. The population for the study comprised all the NCE III Students of Department of Biology in Colleges of Education in North Central Zone, Nigeria. The target population was 1211 made up of 683 male and 528 females. A sample of 256 students made up 151 male and 105 females, intact classes are used after establishing their equivalence using pretest scores. The average age of the students was 21years. The instruments used for data collection were Unscientific Preconception Test on Evolution (UPTE) made up of 15 short structured questions and Evolution Performance Test (EPT) made up of 50 multiple choice questions. The UPTE and EPT were validated by two Chief Lecturers from college of education and two Senior Lecturers from Science Education Department ABU Zaria. The reliability coefficient of 0.69 for UPTE and 0.76 for EPT was calculated for the two instruments using test re-test method (Tuckman, 1975 and Sambo, 2005). The experimental GroupE1 was taught evolution concept using analogy teaching strategy, while the experimental group E2 was taught using collateral teaching strategy. Both the experimental groups were taught for a period of six weeks. After treatment EPT and UPTE were administered to the subjects of the two groups as posttest to determine the effectiveness or otherwise of the two strategies employed in the teaching of the concepts. Two research questions and two hypotheses were tested; descriptive statistics was used to answer the research questions and t-test was used to test the stated hypothesis at $p \leq 0.05$.

RESULTS

Research Question one: what is the difference in the mean preconceptions scores in evolution concepts between male and female NCE III Biology students after being taught using collateral and analogy teaching strategies

The scores collected were used to answer research question one, and were analyzed using descriptive statistics in form of mean scores and standard deviation as shown in Table 1.



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Table 1: Pretest-Posttest Mean Scores for Unscientific Preconceptions Test for Male and Female in Experimental Groups.

Group	N	Sex	Mean Pretest	Mean Posttest	SD	MD
Analogy	126	M	7.66	23.58	8.36	15.92
	90	F	6.03	23.99	7.65	17.96
Collateral	25	M	8.18	23.04	8.04	14.86
	15	F	6.87	23.20	8.10	16.33

Table: 1. shows that there was difference in pretest and posttest mean scores of male and female students in their unscientific preconceptions test. Before treatment the male and female subjects were given UPTE test in which they had mean scores of 7.66 and 6.03 for analogy group while they had mean scores of 8.18 and 6.87 for collateral group. After treatment they were given the same test and they scored 23.04 and 23.40 for collateral teaching strategy group with the mean difference of 14.86 and 16.33, for analogy teaching strategy group were 23.57 and 23.98 with the mean difference of 15.92 and 17.96 respectively. These suggest that treatment had positive effect on both male and female students in their unscientific preconceptions in evolution concepts at NCE level.

Null Hypothesis one: There is no significant difference in the mean preconceptions scores in evolution concepts between male and female NCE III Biology students taught using collateral teaching strategy and analogy teaching strategies

To test this null hypothesis one, the unscientific preconceptions mean scores of male and female students were subjected to t-test. The result is shown in Table 2.



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Table 2: Result of t-test Analysis for Posttest Unscientific Preconception Mean Scores between Male and Female in Analogy and Collateral Groups

Methods	Gender	N	\bar{X}	MD	SE	Tcal	Tcrit	P	R
Collateral Strategy	M	25	23.04	0.16	1.19	0.55	1.98	.86	NS
	F	15	23.20						
Analogy Strategy	M	126	23.58	0.41					
	F	90	23.99						

Not Significant level of $p \geq 0.05$

Result in Table 2 shows that there was no significant difference between male and female in the analogy and collateral strategies groups with p-value of .86 which is greater than the p-value of 0.05 as indicated. This shows that sex does not significantly influence the unscientific preconceptions in evolution concepts taught using analogy and collateral teaching strategies. The null hypothesis which stated that there is no significant difference in the unscientific preconceptions scores on evolution concepts held by male and female NCE III biology students taught using collateral and analogy teaching strategies is therefore accepted and retained. The treatments were gender friendly.

Research Question Two: What is the difference in academic performance mean scores in evolution concepts between male and female NCE III biology students taught using collateral and analogy teaching strategies?

The scores collected were used to answer research question two, and analyzed using descriptive statistics in form of mean scores and standard deviation as shown in Table 3.



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Table 3: Pretest-Posttest Mean Scores of Evolution Performance Test for Male and Female Students for Analogy and Collateral Groups.

Group	N	Sex	Mean Pretest	Mean Posttest	SD	MD
Analogy	126	M	7.66	25.50	4.82	17.84
	90	F	6.03	23.70	4.06	17.67
Collateral	25	M	8.18	21.36	5.60	13.18
	15	F	6.87	19.13	3.37	12.26

The result in Table 3 showed that there was difference in male and female students pretest and posttest mean scores among NCE III biology students. Before treatment male and female subjects were given EPT test. Their mean scores were 7.66 and 6.03 for analogy strategy group and 8.18 and 6.87 for collateral strategy group. After treatment when given EPT test their mean scores increased. The mean scores of collateral strategy were 21.36 and 19.13 for male and female students with the mean difference of 13.18 and 12.26; mean scores for analogy strategy were 25.50 and 23.70 for male and female students with the mean difference of 17.84 and 17.67 respectively. This showed that the treatments had effect on their performance. The difference in the mean scores could be attributed to exposure of male and female subjects to treatment which had positive effects on their performance.

Null Hypothesis Two: There is no significant differences in academic performance mean scores in evolution concepts between male and female NCE III biology students taught using collateral and analogy teaching strategies.

To test this hypothesis, the posttest means scores for EPT test for male and female students were subjected to t-test statistical analysis. The results are shown in Table 4.



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Table 4: Result of t-test for Posttest Performance Mean Scores Test between Male and Female in Analogy and Collateral Group.

Methods	Gender	N	X	MD	SE	Tcal	Tcit	P	R
Collateral Strategy	M	25	21.36	2.23	.72	5.28	1.98	.001	S
	F	15	19.13						
Analogy Strategy	M	126	25.50	1.8					
	F	90	23.70						

*Significant at $p \leq .05$ level

In Table 4 p values observed for collateral and analogy for male and female were 0.001 which is less than $p \leq 0.05$ level of significance. Result indicates that there is significant difference in the academic performance between male and female NCE III Biology students taught using collateral and analogy strategies. It also shows that male and female students taught using analogy strategy performed significantly better than those taught using collateral strategy. This shows that male students performed significantly better than female students when taught using analogy and collateral strategies. Therefore the null hypothesis which states that there is no significant difference in the academic performances in evolution concepts among male and female NCE III biology students is therefore rejected.

DISCUSSION

The objectives of this study were to find out the impact of collateral and analogy strategies on unscientific preconceptions and performance in evolution concepts among Nigeria Certificate in Education biology students. The study also aimed at finding out whether the unscientific preconceptions could be overcome using collateral and analogy strategies of Fakudze (2004) and Glynn (2007) to improve students' performance. Tables: 1 show that there is difference between male and female pretest and posttest mean scores which show that treatment was effective in addressing or correcting students unscientific preconceptions in evolution concepts, that has positively increase their mean unscientific preconceptions scores. Table: 2 shows that there is no significant difference in the unscientific preconceptions of male and female students taught using collateral and analogy teaching strategies. It was observed that male and female



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students do not differ significantly in their unscientific preconceptions. Thus the null hypothesis is therefore accepted and retained. The subjects were able to have equal level of understanding of the concepts learned because of using familiar experiences and ideas which acts as a motivating influence in studying unfamiliar concepts.

The results of this study is in agreement with the findings of Nussbaum (2000), Bichi (2002), Danmole and Adebayo (2004), Udousoro (2011) that gender does not have any significant effect on the unscientific preconceptions scores of students in science subjects. The finding is also in line with the findings of Danmole and Femi-Adeoye (2004). Abdu-raheem (2012), Kevin, Ushie and Okworo (2014) who reported that no significant difference existed between the academic performance of male and female maritime security trainees. The findings of no significant difference in performance of male and female taught using analogy and collateral teaching strategies is also supported by the findings of Oyedokun (1998), Lakpini (2006) and Lawal (2009). Yet other researchers found significant difference between male and females. Driver (1980) reported higher performance for girls in mathematics and physical science than boys.

Results in Table 3 show that there is difference in the performance mean scores of pretest and posttest of students as result of treatment administration that has significantly improved their mean performance sores. Table: 4. the research question two was answered by testing the corresponding hypothesis. Hypothesis which states that there is no significant difference in the mean scores of male and female students taught evolution concepts using collateral and analogy teaching strategies. The results showed that there is a significant difference in male and female students taught using collateral and analogy teaching strategies. The null hypothesis is therefore rejected. It was observed that male students performed significantly better than the female students when taught using analogy and collateral strategies, this might be due to change in mode of instructions that is from teacher-centre to students-centre thus male and female in analogy group performed significantly better than those in collateral group.

The finding is supported by Arbogast (1997), Usman (2000), Jiya (2011) who reported that boys performed significantly better than girls in SSCE physics examination, biology among others. Olorukooba, Lawal and Jiya (2012) also revealed that there is a significant difference in



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the performance of male and female students in favour of the male students at NCE level when taught using Analogy Teaching Strategy. Jegede and Inyang (1990) worked on gender differences and academic achievement in integrated science in junior secondary schools. They confirmed that males performed better than females. They affirmed that males demonstrated significantly more positive performance towards science than females, but disagree with the findings of Schibbeci (1984) who noted that female exhibit more positive performance towards biology and males towards physics.

CONCLUSION

Based on the findings from the study, the following conclusions were drawn:

Male students taught using analogy and collateral teaching strategies performed significantly higher in evolution concepts at NCE level than female students. Male and female NCE III biology students' unscientific preconceptions were not gender base.

The collateral and analogy teaching strategies have potentials of improving students' performance in evolution concepts and overcome their unscientific preconceptions because prior knowledge was used and familiar ideas were also used to link what the teacher wanted the students to learn and what the students already knew to explained difficult concepts.

RECOMMENDATIONS

1. College managements, STAN, MAN should organized seminars, workshops and conferences for training and re-training of biology teachers on the use of analogy and collateral teaching strategies for teaching.
2. Book writers should published books to give examples of how to use analogy and collateral in simplifying some difficult biology concept in biology textbooks in order to enhance better understanding and easier access.
3. It is recommended that teacher-trainers like the Colleges of Education, Polytechnics and Universities should incorporate analogy and collateral strategies into their curriculum.



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