Innovations

Effect of Four-Mode Application Technique and Lecture Method on Biology Students' Achievement in Secondary Schools in Delta State

[1]Chukwuka, Rita Ewere & [2]Professor. Ajaja Osawaru Patrick
Department of Science Education, Delta State University, Abraka, Delta State, Nigeria
Corresponding Author: **Chukwuka, Rita Ewere**,

Abstract
The study examined the effects of four-mode application technique and lecture method on achievement of Biology students in secondary schools in Delta State. Two hundred and twenty-five (225) Biology students from 6 selected schools were used as sample for the study. The study employed the pretest posttest planned variation quasi-experimental design. The Biology Achievement Test (BAT) was used as data collection instruments. Collected data were analysed utilising mean, independent sample t-test, and ANCOVA. The study results showed that there is significant statistically difference in the achievement of Biology students instructed with 4MAT and those instructed with lecture method in favour of 4MAT group; there is no significant statistical difference in the mean achievement score of male and female students instructed with 4MAT; there is no statistically significant interaction effect between methods and sex on students' achievement. The study concluded that Four-Mode Application Technique (4MAT) is a major variable which affects academic achievement of student in Delta State secondary schools. It was recommended that Government should organize seminars and workshops through the Ministry of Education to train teachers on how to use the Four Mode Application Technique (4MAT) to teach their students and as such, make the teaching learning process meaningful, improve students' achievement.

Keywords: *1.Four-Mode Application; 2.Four-Mode Application Technique; 3.Biology Students'; 4.Achievement; 5.Secondary Schools; 6.Delta State; 7.Lecture Method*

Introduction

Biology is a branch of science that deals with the study of life. The study of Biology is very important to any nation. This is why it is included in the Senior Secondary School Curriculum. The Biology curriculum was developed from the policy statement in the National Policy on Education (2013) with the following specific objectives; to enable the students to appreciate how their environment are related to them and how they are related to their environment; to prepare the students for higher education and to have interest in Biology career for example medicine; to enable the individuals understand their body, their functions for example circulation of blood, respiration, excretion and so on; to enable the students acquire scientific skills. These include field and laboratory skills, the ability to comprehend certain key biological concepts necessary for a successful life, the development of the habit of critical observation, the ability to question or challenge certain superstitions, the illumination of social issues such as food production for societal benefits, sex, population, reproduction, growth, disease control, pollution, health, the facilitation of technological development/innovation, and to increase the students' aesthetic appreciation of nature (Nigerian Educational Research and Development Council, 2013).Therefore, for these Biology curriculum objectives to be achieved, the process of teaching and learning should be organized and carried out to help students or learners develop their highest potentials (Protoontong, 2011).

Teachers should organize activities and learning experiences that will make the learners to be actively engaged in their academic works and also help them to construct their own knowledge and understanding. Nwagbo (2001) and Nwosu (2001) in their investigations, shown that biology instructors/teachers do not always use teaching methods that are efficient for biology teaching and learning. These instructional strategies do not bring about active engagement of students in the class and transfer of learning. There are many differences (physiological and psychological) among learners in the classroom. Every single learner is unique in his or her genetic make-up and preferences. This individual differences in students are the reason why students respond to the same teaching method in different ways and this is reflected in their learning styles.

Academic achievement is the amount of knowledge acquired, often after partly or completely finishing a course of study in a given grade and passing an achievement examination. Academic achievement, according to Guttman and Schoon (2013), is measured by how much a student benefits from instruction or teaching in a particular subject area; in other words, it is how much knowledge or skill has been imparted or transferred to him. Academic achievement is also seen as the degree student or instruction has accomplished either long- or short-term educational goals. Students' academic achievement is measures utilizing the grade points average (GPA) of students in examinations or continuous assessment. According to Guttman and Schoon (2013), there are two major factors affecting academic achievement which are; cognitive factors such as intelligence and non-cognitive skills or factors– these are sets of attitudes, behaviour and strategies that promote success academically and professionally.

Sex refers to a person's gender, which in a school setting means a boy or a girl. It's not clear how sex affects how well students perform in science class. Some researchers believe that sex affects students' achievement in science classes like Biology, Physics, and Chemistry (Ogunleye, 2002; Ezirim, 2006; Okwo, and Otuba, 2007), but others disagree (Nwosu, 2006). Therefore, it's clear that the issue of sex and students' achievement in Biology is inconclusive. Hence, more research is needed, especially when trying out new strategies.

RQ

1. What is the difference in the mean achievement score of Biology students instructedwith 4MAT and those instructed with lecture method?
2. What is the difference in the mean achievement score of male and female Biology students taught with 4MAT?
3. Is there any interaction effect of methods and sex on Biology students' achievement?

Hypotheses

1. There is no significant statistical difference in the mean achievement score of Biology students instructedwith 4MAT and those instructed with lecture method?
2. There is no significant statistical difference in the mean achievement score of male and female Biology students taught with 4MAT?
3. There is no significant interaction effect of methods and sex on Biology students' achievement?

Review of Literature

Concept of Four-Mode Application Technique (4MAT)

The four-mode application technique (4MAT) was developed and published by Bernice McCarthy in 1980, but she had the idea in the 1970s. This model is based on the premise that individuals perceive and process information in different way. Individuals perceive new information in two ways which vary from experience and conceptualisation. Learners experience ideas through sensations, physical memories, emotions, feeling the learning through experience.

The 4MAT framework or model is anoutlineor framework for teaching, understanding the way people learn and communicating. It is grounded on how people perceive (feel and think) and process (reflect and do) and thus learn.

Concept of Lecture Method

Lecture as a word is derived from the Latin word "lectus" meaning "to read". Lecture dates from the 14th century and means "action of reading that which is read". Since the16th century, it has come to denote a discourse or speech in front of an audience with the aim of instructing them on a specific subject. It is a teaching method used by teacher at all levels of education. The method is a teacher-centred method where the teacher does most of the talking while the students remain passive listeners, taking down notes (Alcorn, 2010). The lecture method is the oldest teaching method used by teachers. It is a one-way channel of communication and students' participation and contribution in the teaching-learning process is just to sit down, listen and take down notes during the lecture. The lecture method is the simplest teaching method for teachers. There is very little scope for learners' activity. It is the commonly used teaching method. According to Hafezimoghadam, Sahar, Darood & Zare, (2013), lecture method only focuses on memorisation rather than the comprehension and utilisation of information.

Empirical Studies on 4MAT and Academic Achievement

Khumwong and Singinuang (2013) aimed to find student's learning achievement after learning using 4MAT lesson plans, and student's satisfaction after learning using 4MAT lesson plans. The results revealed that the student's learning achievement after using 4MAT lesson plans was statistically very significant, which was higher than that before using 4MAT lesson plans at the level 0.05. The student's satisfactions towards the 4MAT learning activities were at the highest level. The results indicated that 4MAT learning activities could be effective in order to enhance student's Mathematics achievement on several topics. Uyangor (2012) examined the impact of the 4MAT teaching approach, which is based on the brain-learning relationship. The 4MAT way of teaching was discovered to be effective than the standard method. Silva, Sabino, Adina, Lanuza and Baluyot (2011) aimed to find out the influence of the 4MAT Cycle of Learning on the behaviour, attitude and academic performance of the students. The results revealed that student attitudes and performance were influenced by the 4MAT cycle of learning as evidenced by surveys, rating scale, observations and interviews. Pratoomtong (2011) carried out a study on science learning activities using 4MAT to promote multiple intelligences of students. The design of the study was quasi experimental, specifically pre testpost test control-group design. The data were analysed using mean values and standard deviation and MANOVA. The results demonstrated that students instructed using 4MAT did better in attitude and achievement than those instructed utilising the traditional/conventional teaching method.

Empirical Studies on Gender Differences in Science Achievement

Many studies have focused on gender differences in science achievement (Pajares, 2003; Britner and Pajares, 2006). Britner and Pajares (2006) examined the science performance among eighth grade students. They found that the average eighth grade science achievement scores significantly differ for with regards to gender. However, contemporary assessments show that gender differences or variances in performance in science have narrowed over time according to Britner and Pajares (2006). A study by Pajares (2003) concludes that grade nine female students obtained better writing scores, than male students.

Abu-Hola (2005) found that girls outperformed males in science. Kauru (2010) analysed students' performance in math and other scientific disciplines and found that female students did better in Biology than male students did in math, physics, and chemistry. Billings (2000) discovered that male students performed better in science. Okebukola (2002),Dibu-Ojerinde (2006), Bamidele, Odusola and Olorukooba, Lawal, & Jiya (2012) observed similar findings. Also, researchers like Christine (2004) and Amoo (2011) found that girls achieve higher in science. More so, researchers such as David and Stanley (2000), Freeman (2002), Sungur and Tekkaya (2003), Arigbabu and Mji (2004),Din, Ming and Esther (2004), Bilesanmi-Awoderu (2006), found that there are no longer distinctive differences in students' achievements based on gender. Other researchers like Atadoga (2005), Bichi (2004), and Lawal (2009) showed no gender disparities in students achievement in science. The study by Nwagbo& Obiekwe (2010) revealed that gender does not affect students' achievement and knowledge of ecological concepts. Olasehinde&Olatoye (2014) found no difference in male and female scientific performance. Due to this inconclusive argument, gender was deemed a moderating variable in this study.

Methodology

This study employed a pretest, posttest, planned variation quasi-experimental design. Quasi-experimental design was adopted for this study.

The target population for this study consisted of 31,512 Senior Secondary two (SS 2) Biology students.Two hundred and twenty-five (225) Biology students were used for this study. The techniques adopted for sampling of samples for this study was the stratified random sampling techniques. The study instrument is the Biology Achievement Test (BAT). This is a 40-item test used as pretest, and posttest. The questions were drawn from WAEC past questions on Biology. The BAT consisted of multiple-choice questions. These questions were based on the following topics; respiratory system, transport system in plants, transport system in animals.

Two days prior to the commencement of instruction, all the biology students in all the groups were pretested with the 40-item Biology Achievement Test (BAT). This was done to see if the groups were the same before treatment and to make sure that any changes that were seen after treatment were caused by the treatment. After treatment for six weeks, all the students in the various groups were given a posttest. Data were analysedutilising sing mean, independent Sample t-test and ANCOVA.

Results

Research Question 1: What is the difference in the mean scores of Biology students instructed with 4MAT and those instructed with lecture method?

Table 1: Descriptive Statistics of Mean Comparing the Posttest Scores of Biology Students Instructed with 4MAT and those Instructed with Lecture Method

Groups	**N**	$\underline{X}$	$\underline{X}$**diff**	**SD**	$\underline{X}$	$\underline{X}$**diff**	**SD**
		Pretest			**Posttest**		
4MAT	112	18.08	1.36	4.41	54.79	1.36	13.50
Lecture	113	16.72		4.54	34.44		10.11

The results from the table 1 shows that at pretest, the 4MAT group had a higher mean of 18.08 and lecture method students orgroup had a mean of 16.72. At posttest, the 4MAT students or group had a higher mean of 54.79 compared to the lecture method group that had a mean of 34.44. This indicates that there is a mean difference of Biology students instructed with 4MAT and those instructed with lecture method.

Hypothesis 1: There is no significant statistical difference in the achievement scores of Biology students instructed with 4MAT and those instructed with lecture method.

Table 2: Independent Sample t-test Comparing the Mean Achievement of Biology Students instructed with 4MAT and those instructed with Lecture Method at Pretest

Groups	**N**	$\underline{X}$	$\underline{X}$**diff**	**SD**	**df**	**Tcal**	**Sig. (2-tailed)**
4MAT	112	18.08	1.36	4.41	223	2.29	0.230
Lecture	113	16.72		4.54			

P>0.05

Table 2exposed that the difference at pre-test was not significant since the calculated sig. value of 0.230 is higher than 0.05 significance level (P > 0.05). Therefore, the independent sample t-test was the appropriate statistics to test hypothesis 1. The result of which is shown in table 3.

Table 3: Independent Sample t-test Comparing the Mean Achievement of Biology Students instructed with 4MAT and those instructed with Lecture Method

Groups	N	$\underline{X}$	$\underline{X}$diff	SD	df	tcal	Sig. (2-tailed)	Decision
4MAT	112	54.79	20.35	13.50	223	12.80	.000	H_{03} Rejected
Lecture	113	34.44		10.11				

P< 0.05

Table 3 shows that the calculated sig. value of 0.000 is less than 0.05 alpha level of significance (P < 0.05). This implies that there is a significant statistical difference in the achievement scores of Biology students instructed with 4MAT and those instructed with lecture method, in favour of those instructed with 4MAT. Therefore, the null hypothesis of no statisticalsignificant mean difference in achievement scores of Biology students instructed with 4MAT and those instructed with lecture method is rejected.

Research Question 2: What is the difference in the achievement score of male and female Biology students taught with 4MAT?

Table 4: Descriptive Statistics of Mean Comparing the Posttest Achievement Score of Male and Female Biology Students instructed with 4MAT

Groups	N	$\underline{X}$ Pretest	$\underline{X}$diff	SD	$\underline{X}$ Posttest	$\underline{X}$diff	SD
Male	52	17.98	0.19	4.54	53.95	1.57	13.99
Female	60	18.17		4.33	55.52		13.14

Table 4 above shows the pretest and posttest of male and female Biology students taught with 4MAT. The male Biology students had a pretest mean score of 17.98, while the female Biology students had a pretest mean score of 18.17. The male Biology students had a posttest achievement mean of 53.95, while the female Biology students had a posttest mean of 55.52. This points that there is a difference in the mean of male and female Biology students instructed with 4MAT in favour of female Biology students. To ascertain if the difference is significant, H_{02} was tested using independent sample t-test.

Hypothesis 2: There is no significant statistical difference in the achievement score of male and female Biology students taught with 4MAT.

Table 5: Independent Sample t-test of Achievement Score of Male and Female Biology Students taught with 4MAT at Pretest

Groups	N	$\underline{X}$	$\underline{X}$diff	SD	df	tcal	Sig. (2-tailed)
Male	52	17.98	0.19	4.54	110	0.221	.825
Female	60	18.17		4.33			

p>0.05

Table 5 Shows no significant statistical difference in the achievement score of male and female Biology students taught with 4MAT at the pre-test. This is because the calculated sig. value of 0.825 is greater in comparison with the critical sig. value of 0.05 (p > 0.05). Therefore, independent sample t-test becomes the appropriate statistics for testing H_{02}.

Table 6: Independent Sample t-test Comparing the Posttest Achievement of Male and Female Biology Students taught with 4MAT

Groups	N	$\underline{X}$	$\underline{X}$diff	SD	df	tcal	Sig. (2-tailed)	Decision
Male	52	53.95	0.32	13.99	110	.610	.543	H_{O7} not Rejected
Female	60	55.52		13.14				

p>0.05

Table 6 presents the results of independent sample t-test showing the posttest achievement score of male and female biology students taught with 4MAT. From the result showed in table 6, the calculated sig. value of 0.543 is larger or greater than the value of 0.05 ($p > 0.05$). This indicates a no significant statistical difference in the achievement score of male and female Biology students taught with 4MAT. Therefore, the null hypothesis is accepted.

Research Question 3: Is there any interaction effect of methods and sex on Biology students' achievement?

Table 7: Descriptive statistics showing the Interaction Effect of Methods and Sex on Biology Students' Achievement

Groups	Sex	N	$\underline{X}$	SD
4MAT	Male	52	53.96	13.99
	Female	60	55.52	13.14
		112		
Lecture	Male	58	35.16	8.84
	Female	55	33.69	11.34
		113		

The result from table 7 shows that the male Biology students instructed with 4MAT had achievement mean of 53.96, while the female Biology students instructed with 4MAT had a mean of 55.52. The male Biology students instructed with lecture method had achievement mean of 35.16,while the female Biology students instructed with lecture method had achievement mean of 33.69. From the mean scores, it can be seen that female Biology students taught with 4MAT had the highest mean score followed by their male counterpart. While those in the lecture method group had lesser mean scores. This demonstrates an interaction effect. To established if the interaction effect is significant, ANCOVA statistics was utilised to test H_{03}.

Hypothesis 3: There is no significant statistical interaction effect of methods and sex on Biology students' achievement.

Table 8: ANCOVA Summary of Interaction Effect of Methods and Sex on Biology Students' Achievement

Dependent Variable: Posttest					
Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	50078.637[a]	4	12519.659	562.311	.000
Intercept	46.188	1	46.188	2.074	.151
Pretest	26661.237	1	26661.237	1197.469	.000
Methods	15697.322	1	15697.322	705.033	.000
Sex	132.120	1	132.120	5.934	.016
Methods * Sex	10.321	1	10.321	.464	.497
Error	4898.225	220	22.265		
Total	501958.250	225			
Corrected Total	54976.862	224			
a. R Squared = .911 (Adjusted R Squared = .909)					

The result in table 8 shows the interaction effect of methods and sex on Biology students' achievement. The table indicates that the calculated sig. value of 0.497 is greater than the critical sig. value of 0.05 ($p > 0.05$). Therefore, there is no significant statistical interaction effect of methods and sex on Biology students' achievement. As such, H_{03} which state that there is no significant statistical interaction effect of methods and sex on Biology students' achievement is not rejected.

Discussion of Results

Results of hypotheses 1 showed a mean difference in achievement of students exposed to 4MAT and those instructed with lecture method. The students in the 4MAT group had higher mean achievement score than Biology students in the lecture method group. This finding is corroborated with that of KhumwongandSingmuang (2013), Silver et al (2011), Dounghathai (2001), Lee and Hang (2009), Pratoomtong (2011), Phatchariya-Phetctong (2005) and Ergin (2011)who established that instructions based on 4MAT significantly improved students' achievement.

Results from hypotheses 2 exhibited a no significant Biology students'difference in the achievement mean of Biology students instructed with 4MAT based on gender/sex. This is an indication that the male and female students in the 4MAT group benefited equally from the teaching. This is because of students' active participation. This result is consistent withwith that of Arigbabu and Mji (2004), Bilesanmi-Awoderu (2006), Freeman (2002), Nwagbo and Obiekwe (2010), Lawal (2009) and Olasehinde and Olatoye (2014) who reported no significant statistical difference in male and female students' achievement.

Results from hypotheses 3 showed no significant statistical interaction effect of method and sex on Biology students' achievement. From the results, although the male Biology students had slightly higher achievement, the difference was not significantstatistically. This demonstrates that the combined effects of method and sex did not influence the achievement of Biology students. Rather the variables (methods and sex) acted independently in affecting Biology studentsachievement. This finding is in conformity with the studies of Ajaja (2013), Adeyemi (2012), Ezedinma and Nwosu (2018) and Okotcha (2018) who in their different studies found no interaction effect between teaching method and sex on achievement.

Conclusion

The study established the effects of four-mode application technique and lecture method on Biology Students' achievement. The following conclusions are taken from the study's findings is that four-mode application technique significantly influenced the achievement of Biology students. Sex had no significant effect on achievements of students in secondary schools in Delta State. Methods and sex did not interact to influence Biology achievement and of students.

Recommendation

1. The government should organize seminars and workshops through theEducation Ministry to train teachers on how to use the Four-Mode Application Technique (4MAT) to teach. This will help the teachers to teach efficiently and enhance the scholarly achievement of students.
2. Biology teachers should teach using the four-mode application technique (4MAT). This will help to improve the academic achievement of students.

References

1. *Abu-Hola, I. (2005). Uncovering gender differences in science achievement and attitude towards science for Jordanian primary pupils. Damascus University Journal, 21(1), 19- 40.*
2. *Adeyemi, A. B. (2012). Effects of computer aided instruction (CAI) on students' achievement in social studies in Osun State, Nigeria. Journal of Social Sciences, 3(2), 269 – 277.*
3. *Ajaja, P.O. (2013). Which strategy best suit biology teaching? Lecturing, Concept mapping, Cooperative learning or Learning cycle? Electronic Journal of Science Education. 17(1): 1-37*
4. *Alcorn, M. D. (2010). Better teaching in secondary schools. Holt Rinechart and Winston, New York.*
5. *Amoo, E. D. (2011), Gender and academic performance in Nigerian universities: economic implications. International Journal and Research in Education 8(1),159-172.*
6. *Arigbabu, A. A. &Mji, A. (2004). Is gender a factor in mathematics performance among Nigerian pre-service teachers? Sex Role, 51(11 & 12), 749. Britner, S. L. and Pajares. F(2006). Sources of science self-efficacy beliefs of middle school students. Journal of Research in Science Teaching 43(5), 485.*
7. *Atadoga, M. M. (2005), Gender related problem solving strategies and senior secondary students achievement in physics. Nigeria Journal of Science and Educational Research 1, 69-73.*
8. *Bamidele, A. F., Odusola, O. &DibuOjerinde (2006). A review of the enrolment and performance of male and female students in education/economics programme of Obafemi Awolowo University, Ile-Ife, Nigeria. Journal of Social Science, 12(2), 143-146.*
9. *Bichi, S.S. (2004). The effect of gender on academic achievement in evaluation concepts among secondary school students using problem solving instruction strategy. ZariaJournal of Studies in Education 3 (1), 123-138.*
10. *Bilesanmi-Awoderu, J. B. (2006). Effect of computer-assisted instruction and simulation/games on the academic achievement of secondary school students' in Biology. Sokoto Educational Review, 8 (1), 49-60.*
11. *Billings, D. (2000). Women's way of knowing and the digital divide. Presented in an interactive paper presentation.*
12. *Christine, P. (2004), Gender proves large factor in academic performance. The Pendulum online, March 11, Edition.*
13. *Coffield, F., Moseley, D., Hall, E. & Ecclestone, K. (2004). Learning styles and pedagogy in post-16 learning: A systematic and critical review. London: Learning and Skills Research Centre.*
14. *David, K.D. & Stanley, H.L. (2000). Effect of gender on computer-based chemistry problem-solving. Electronic Journal of Science, 97(6), 325-334.*
15. *Din Yan Yip, Ming M. C. & Esther SR. (2004). Hong Kong students achievement in OECDPISA study: Gender differences in science content, literary skills, and test item formats. International Journal of Science and Mathematics Education, 2(1), 91-106.*
16. *Dounghathai, S. (2001). The effects of using the 4MAT lesson plan on learning achievement responsibility and learning attitude in the education population unit and the occupations unit Prathomsuksa V. Master project, M.ES Bangkok: Srinakharinwirot University.*
17. *Ergin, S. (2011). Effects of 4MAT instruction method on the achievement of high school students with different learning styles on the subject of work, power and energy in physics education [unpublished dissertation], Gazi University, Department of Physics Education, Ankara.*
18. *Ezedinma, F. O. & Nwosu, A. (2018). Effects of three steps achievement in Basic Science. Journal of the Department of Science Education, Univeristy of Nigerial, Nsukka, 4(1).*
19. *Federal Ministry of Education (2013). National Policy on Education (revised). Federal Republic of Nigeria, Lagos: NERDC*
20. *Freedman, M.P. (2002). The influence of laboratory instruction on science achievement and attitude towards science across gender differences. Journal of Women and Minorities in Science and Engineering, 8 (2), 50.*
21. *Gutman, L. & Schoon, I. (2013). The impact of non-cognitive skills on outcomes for young people. Education Endowment Foundation: 59*

22. *Hafezimoghadam, P., Sahar, F., Darood, F. & Zare, M. (2013). A comparative study of lecture and discussion methods in education of basic life3 support and advanced cardiovascular life support for medical students. Turkish Journal of Emergency Medicine, 13(2), 59-63.*
23. *Kauru, A. (2010) Gender performance difference in mathematics and other science subjects at polytechnics. Journal of Educational Research and Development, 5(1), 51-55.*
24. *Khumwong, N. &Singmuang (2013). The development of 4MAT lesson plan on addition,substraction, multiplication and division combined for prathomsuska 3 students. The Asian conference on the social science: official conference proceedings. Osaka, Japan. 131-142*
25. *Lawal, F. K. (2009). Acquisition of entrepreneurial skills through Biology education and the role of the Biology teacher. STAN proceeding of 50th Annual Conference 2009.*
26. *Lee, L. T. & Hung, J. C. (2009). Effects of teaching using whole brain instruction on accounting learning. Retrieved online on 26th November 2021.*
27. *McCarthy, B. (2006). Teaching around the 4MAT Cycle: Designing Instruction for Diverse Learners with Diverse Learning Styles. Thousand Oaks, CA: Corwin Press*
28. *Nigerian Educational Research and Development Council (NERDC) (2007). 9-Year Basic Education Curriculum - Physical and Health Education for Primary 4-6. Abuja: NERDC.*
29. *Nwagbo, C. R. (2001). The relative efficacy of guided inquiry and expository methods on achievement in biology students of different levels of scientific literacy. Journal of Science. Teacher Association of Nigeria 36 (l&2), 43-51.*
30. *Nwagbo, C., & Obiekwe, C. (2010). Effect of constructivist instructional approach on students' achievement in basic ecological concepts in Biology. Journal of Science Teachers Association of Nigeria, 45(1&2), 26-35.*
31. *Nwosu, A. A. (2001). Gender and acquisition of science process skills among secondary school students: implications for science teaching. 42nd Annual conference proceedings of STAN. Women in science, technology and mathematics education in Nigeria, 206-209.*
32. *Okebukola, P.O. (2002). Beyond the stereotype to new trajectories in science teaching. Ibadan. Science Teachers Association of Nigeria.*
33. *Okotcha, E. N. (2018). Effects of a constructivist based instructional model on students' conceptual change in Chemistry. Journal of the Department of Science Education, University of Nigeria, Nsukka. 4(1).*
34. *Olasehinde, K. J., &Olatoye, R.A. (2014) Comparison of male and female senior secondary school students' learning outcomes in science in Katsina State, Nigeria. Mediterranean Journal of Social Sciences, 5(2), 517-523.*
35. *Olorukooba, Lawal and Jiya (2012), Effects of teaching with analogy on academic achievement and retention of evolution concepts among male and female NCE Biology students. Journal of Studies in Science and Mathematics Education 2(1), 81- 91.*
36. *Pajares, F. (2003). Self-efficacy beliefs, motivation and achievement in writing: A review of the literature. Reading and Writing Quarterly, 19(2), 139-158.*
37. *Phatchariya, P. (2005). The outcome activity learning and teaching of science for prathomsuksa v on sound by the 4MAT model. M.Ed project (Science Education). Khon Kaen: Khon Kaen University.*
38. *Pratoomtong, W. (2011). A development of science learning activities based on 4mat system and learning styles to promote multiple intelligences of sixth grade students. Unpublished PhD thesis submitted to the Science Education at Srinakharinwirot University*
39. *Silva, D. I., Sabino, L. D., Adna, E. M., Lanuza, D. M. and Baluyot, O. C. (2011). Transforming diverse learners through a brain-based 4MAT cycle of learning. Proceedings of the world congress on engineering and computer science, 1, 234-239. October 19 – 21. San Francisco, USA*
40. *Sungur, S. &Tekkaya, C. (2003). Students' achievement in human circulatory system unit: the effect of reasoning ability and gender. Journal of Science Education and Teaching, 12(1), 59-64.*

Corresponding Email: rechukwuka@delsu.edu.ng