EFFECTS OF COLLABORATIVE LEARNING STRATEGY ON STUDENTS' ACHIEVEMENT AND RETENTION IN CHEMISTRY

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Abstract
This study investigated the effects of Collaborative learning strategy on students' academic achievement and retention in balancing Redox equations in Chemistry in Ogoja Education Zone, Cross River State, Nigeria, Quasi-experimental research design involving pretest, post-test, delayed post-test, non-equivalent control group was adopted. The sample comprised 292 SSII students drawn from population of 6,643 using purposive sampling technique. Redox Equation Achievement Test (REAT) with reliability coefficient of 0.72, using Kuder-Richardson formula - (Kr) 21, was adopted instrument for obtaining data. Four research questions, using mean and standard deviation were addressed, while four hypotheses were formulated and tested at 0.05 levels of significance, using analysis of covariance (ANCOVA). Results showed that: (i) there was significant difference between the mean achievement scores of students taught Electrochemistry concept using Collaborative learning strategy and those taught using conventional instructions, (ii) there was significant difference between the mean retention scores of students taught using Collaborative learning strategy and those taught using the conventional instructions, (iii) there was no significant difference between the mean achievement scores of male and female students taught using Collaborative learning strategy, (iv) there was no significant difference between the mean retention scores of male and female students taught using Collaborative learning strategy. Based on these findings, conclusion was drawn and recommendations were made to include among others that government and stakeholders in STEM education should regularly organize workshops, seminars and conferences to update teachers' pedagogical knowledge in chemistry.

Keywords: Collaborative strategy, Conventional instructions, balanced Redox-equations, STEM education.

Introduction and Literature review

The spate of human quest for knowledge and survival in today modern society is premised regularly on the products of Science, Technology, Engineering and Mathematics (STEM) Education. Therefore, a sound knowledge of Chemistry, undoubtedly presents panacea for competing adequately and globally with comity of nations. Studies (Njoku, 2007; Nbina & Wagbara, 2012; Emendu, 2014; Akpan,2015; Ekem Obi & Mumuni, 2015; Idiege, Nja & Ugwu, 2017; Prescott, 2017;

Nja, Idiege & Obi, 2017) have acknowledged chemistry in diverse areas towards making life easier, safer, faster and more efficient than ever imagined before. Evidence abound in improved conditions of human life, health care services and food production, provisions of clothing and textiles, drugs, housing, beauty confectionaries and relaxations (Emendu, 2014). This suggests that Chemistry occupies not only prominent but pivotal position for turning around matter and environmental events into a globalized world of chemical operations in the annals of science education history.

Recognizing this impetus, the Federal Ministry of Education (FME, 2014) through Nigerian Educational Research and Development Council (NERDC) was poised to review the National Chemistry Curriculum for Senior Secondary Schools in Nigeria, in order to scale up the core areas in Chemistry with links to industries for students to properly grasp concepts taught at school. The objective, probably, was to improve on students' academic achievement, retention and understanding of those reviewed concepts in chemistry. Redox reactions are among the electro chemistry concepts reviewed that have gained not only popularity but acceptance in recent chemistry education history and times. Sadly, many students have always expressed difficulty instating clearly, practically and objectively electrochemistry terms, at external examinations such as, West African Senior Secondary Certificate Examinations (WASSCE) and National Examinations Council (NECO) over the years (Ojokuku & Amadi, 2010).This may, perhaps, be due to students' lack or inability of proper grasp to understand electrochemistry concepts taught at school. The Chief Examiner's Reports (WAEC&NECO, 2005-2020) have repeatedly expressed sad views about students' inability to express themselves clearly in this regards. Consequently, students' performances in chemistry at ordinary level external examinations have on the average, persistently remained poor over these years.

Apparently, everyday life and activities of mankind involves the production of energy from chemical reactions and its operations. This suggests that chemical operations, involving Redox reactions in electrochemistry do often yield products with chemical values that have been and still useful for mankind till date. Electrochemistry is that branch of chemistry which deals with chemical changes that generate energy for consumption in our environment (Ekem Obi & Mumuni, 2015). Truly, our environment and its chemicals activities are sacrosanct. This also suggests that the production of chemical energy from chemical reactions could be converted from one form to another form of energy for human use. Clearly, it is the platform upon which electrochemistry predominantly stands. The quantity of energy dissipated from many Redox reactions are determined from the moles of electrons calculated from each balanced Redox equation and measured in Faradays (F), expressed in Coulombs (C) per mole. Unfortunately, relating these links during balancing of Redox equation mechanism becomes relatively difficult for students to fathom out. Students' inability to establish this connection at their level of study in the classrooms may, probably, be due to inappropriate teaching strategy adopted by teachers. Undoubtedly, students' approach to the study of electrochemistry, particularly, balancing Redox equations with dread and fear may indeed be surmountable through the use of appropriate teaching strategies (Ojokuku & Amadi, 2010; Ekemobi & Mumuni, 2015). This would avoid repeated consequences of poor performance in chemistry at both internal and external examinations. Should this poor performance be allowed to persist, it may portend danger to our nation's educational system, dampens students' self-confidence level, instill low-spirited morale and ludicrous feelings of lassitude towards global competitiveness in chemistry.

Researchers have shown that regular application of conventional lecture method of instructions by teachers seemed to have not yielded the expected results from students at both internal and external examinations over the years (Lazakidou & Retalis, 2010; Barber, Rajaram & Fox, 2012; Idiege, Nja & Ugwu, 2017; Eze & Onyenwe, 2018).Consequently,

there is need to seek alternative or appropriate teaching strategy that may guarantee students' positive feelings about chemistry and perhaps, enhance their achievement and retention of knowledge in the context of balancing Redox equations using collaborative strategy in this study. This is because there is commonly held belief among educators and research scholars that learning in collaboration with others guarantee better understanding than learning alone (Barber, Rajaman & Fox, 2012). This belief is manifested in instructional activities across all levels of education and across subject disciplines from Language, Arts to Mathematics; and more prevalent in Science, Technology and Engineering (Emendu, 2014; Akpan, 2015; Njoku & Akwali, 2016; Idiege & Nja, 2018; Zakariyya & Bello, 2018).

The application of collaborative strategy requires teams of small group of students to work together on assigned task(s),for purposes of increasing their levels of understanding the concepts taught individually, collectively or group-wisely as members. Collaborative strategy is aimed at organizing classroom activities into a separate academic learning activity that allows for free flow of learning concepts to be dependent on socially structured exchange of vital information between students in each and within group.

Each member of a team is responsible for not learning only what is being taught within or outside the group; but for helping team-mates learn as well. Hence, creating an atmosphere of enhancing understanding, achievement and retention of concepts taught. Each team is assigned to learn a given task(s) as it were. Students within each team works collaboratively through series of the assignments until members successfully understand and complete the task(s) allotted to them by the teacher. This strategy focuses on le arners of different ability levels, using a variety of learning activities to improve on their understanding of the task(s)/or subject under discussion. The strategy, deemed as most appropriate for balancing Redox equations in chemistry, ensures the coordination of synchronous activities that are basically aimed at constructing and maintaining a shared conception of each problem under discussion. Collaborative learning approach is apparently designed for small interactive groups to learn effectively together and achieve team-success, promote individual or collective students' responsibilities for their own learning and the learning of others. Consequently, active learning is most likely guaranteed, as each group is glossed as student-centered learning group. Students' discovery learning is observed, as studying together and using available information provided to them within and outside the group are done in a collaborative manner as against the lecture method where the teacher simply dolls or reels out information to students and expect them to passively take down notes.

When students are encouraged to participate actively in group activities and/or discussions, their analysis may clearly remain focused on concept interpretations, remembering, evaluations, comparing notes for understanding, creative application of thoughts and knowledge-sharing (Njoku,2007; Duman, 2010; Lazakidou & Retalis, 2010; Barber, Rajaman & Fox, 2012; Idiege & Nja, 2018). These are the frameworks of Blooms taxonomy of education that make students to socialize, interacts with each other, divide up task(s) amongst themselves, provide feedbacks and debate on different conclusions from each group in order to encourage themselves in problem–solving skills, understand complex relationships and decision-making in open-ended academic scenarios. The students in each group would assist themselves through peer–coaching/tutoring, as the higher achieving member helps their less-achieving group members to understand the complexity of that problem and as well offer each other with possible solutions.

Therefore, the problem of this study is: how would the use of collaborative strategy improve students' academic achievement and retention in balancing Redox equations in Ogoja Education Zone of Cross River State, Nigeria?

Theoretical Background

This study is anchored on Albert Bandura's (1977) Social Learning Theory, which holds that learning takes place through observation of an individual making skilled responses, by trying to imitate a model in similar context. This theory refuted the trial and error approach to learning; and proposed a process of learning where learners acquire new knowledge by:

i. Observing the behavior of others in a social context,
ii. Committing into memory the actions and inactions observed and,
iii. Reproducing or imitating such actions in similar context when required.

The theory established four processes associated with observational learning which includes: Attention, motivation, retention and (re)production. By implications, the theory suggests that observational learning through collaboration eases:

i) learning and removes the flaws associated with attempts to perfect actions,
ii) abstractness and complex behaviors that would not have ordinarily been learned to be learnt
(iii) The Teachers efforts to teach learners without much stress or tears.

Through collaborative strategy, students may learn meaningfully and grasp the concepts taught by paying adequate attention to their own fellow's teachings and thereafter, become more motivated to learn with understanding either individually or collectively. While also, retaining a greater chunk of information learnt and oftentimes, reproduces them more clearly when required at examinations or tests. This forms the hallmark of learning towards enhancing students' academic achievement and retention of concepts taught at school without rote memorization.

Purpose of the Study

The purpose was to determine the effects of collaborative learning strategy on students' academic achievement and retention ability in chemistry. Specifically, it sought to investigate the:

1. Effects of collaborative learning strategy and conventional lecture method on students' mean achievement and retention scores in balancing Redox equations in chemistry.
2. Mean achievement and retention scores of male and female students in balancing Redox equations when taught using collaborative strategy.

Research Questions

1. What is the mean achievement scores of student' in balancing Redox equations when taught using collaborative strategy and those taught using conventional lecture method?
2. How does the mean retention scores in balancing Redox equations of students' using collaborative strategy differ from those taught using conventional lecture method?
3. What is the mean achievement scores of male and female students taught balancing of Redox equations using collaborative strategy?
4. To what extent do male and female students differ in mean retention scores when taught balancing of Redox equations using collaborative strategy?

Hypotheses

(1) There is no significant difference between the mean achievement scores of students taught balancing of Redox equations using collaborative strategy and those taught using conventional lecture method.
(2) There is no significant difference between the mean retention scores of students taught balancing of Redox equations using collaborative strategy and those taught using conventional lecture method.
(3) There is no significant difference between male and female students' mean achievement scores in balancing Redox equations when taught using collaborative strategy.

(4) There is no significant difference between male and female students' mean retention scores in balancing Redox equations when taught using collaborative strategy.

Method

The study was conducted in Ogoja Education Zone of Cross River State, Nigeria. A quasi-experimental research design involving pretest, post-test, non-equivalent control groups was adopted. Sample of the study comprised 292 SSII chemistry students drawn from the population of 6, 643 students in the zone using purposive sampling technique. Redox-Equation Balancing Achievement Test (REBAT) validated by three experts from University of Calabar was used for data collection using Kuder-Richardson's formula (KR-21) with a reliability coefficient of 0.72. The instrument contained 50 objective test-items structured with four response options, lettered A-D. These questions were adopted from past WASSCE, NECO and UTME chemistry papers that specifically addressed Redox equations.

This served as pre-test, post-test and delayed post-test or retention test. The delayed Post-test was a re-ordered post-test in terms of numbering. The post-test was reshuffled to have different numbering order but with the same content to ensure equivalence of the three tests. This was to give partial impression that the tests were all different. The instrument was administered to respondents in eight intact-classes that were grouped into experimental (EXG); n = 132 and control (COG); n = 160, by the researchers, assisted by research assistants. These assistants were the chemistry teachers in the sampled schools trained through sensitization briefs to teach their intact-classes. Two evaluators observed the research assistants in classroom actions recorded intra-observer consistency of 0.79 and 0.85. This suggests adequate instructional skills mastery and consistency for their various classroom situations. Subsequent monitoring of the research assistants by the researchers indicated their strict adherence to instruction as contained in the lesson notes throughout treatment duration. Treatment lasted for 10 weeks. Experimental (EXG) comprised 70 males and 62 females was exposed to teaching using collaborative strategy, while the Control (COG) comprising 84 males and 76 females was taught using the conventional lecture method. Two weeks after administering the post-tests, delayed post-test was administered and scored accordingly. The data obtained were analyzed using mean and standard deviation to answer the research questions, while analysis of covariance (ANCOVA) was used to test the hypotheses at 0.05 levels of significance.

Results

Research Question1

What is the students' mean achievement scores in balancing Redox equations when taught using collaborative strategy and those taught using conventional lecture method?

Table 1: Mean achievement gain and standard deviation of students in EXG and COG.

Groups	Pretest Mean	SD	Posttest Mean	SD	Mean Achievement gain	SD	N
Control group	24.18	1.76	48.36	2.12	24.18	2.14	132
Experimental group	29.44	1.89	68.88	2.24	39.44	4.98	160
Total							292

The result in Table 1 shows that the mean achievement gain of students taught using collaborative strategy is 39.44, while those taught using the conventional lecture method is 24.18. This means that the mean gain score of EXG is greater than COG.

Research Question 2

How does the students' mean retention scores in balancing of Redox equations using collaborative strategy differ from those taught using conventional lecture method?

Table 2: Mean retention gain scores and standard deviation of students in EXG and COG.

The results in Table 2 shows that the mean retention gain score of students taught using collaborative strategy is 38.48, while those taught using conventional lecture method is 22.70. This means that the mean gain score of students in EXG is greater than COG.

Research Question 3

What is the mean achievement scores of male and female students taught balancing of Redox equations using collaborative strategy?

Table 3: Mean and standard deviation of male and female students' achievement gain scores.

The results in table 3 shows that the mean achievement gain score of male students is 32.54, which is the same as the mean achievement gain score of the females that is 32.54. This means that both male and female students' achievement gain score is the same when exposed to treatment.

Gender	Pretest Mean	SD	Posttest Mean	SD	Mean achievement gain	SD	N
Male	2.95	1.123	35.50	2.26	32.54	8.74	70
Female	2.95	1.23	35.50	2.26	32.54	8.40	62
Total							132

Research Question 4

To what extent do the mean retention scores of male and female students differ when taught balancing of redox equation using collaborative strategy?

Table 4: Mean and standard deviation of male and female students' retention gain scores.

Gender	Posttest Mean	SD	Post-posttest Mean	SD	Mean retention gain	SD	N
Male	35.50	2.26	67.10	2.74	31.60	8.69	70
Female	35.50	2.26	66.54	2.64	31.05	8.67	62
Total							132

The results on Table 4 above showed that the mean retention gain score of male students is 31.60, while that of females is 31.05. Apparently, it implies that both male and female students appears to possess the same retentive ability for grasping the balancing of Redox equations concept taught when exposed to treatment even though their mean difference is 0.55.

Hypothesis 1

There is no significant difference between the mean achievement scores of students taught balancing of Redox equation using collaborative strategy and those taught using conventional lecture method.

Table 5: Analysis of covariance (ANCOVA) for EXG and COG students' mean achievement scores.

Source	Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	16849.537[a]	2	8424.769	535.950	.000
Intercept	4683.120	1	4683.120	297.921	.000
PRETEST	2.246	1	2.246	.143	.706
GROUPS	16849.245	1	16849.245	1071.881	.000
Error	4542.884	289	15.719		
Total	330663.000	292			
Corrected Total	21392.421	291			

a. R Squared = .788 (Adjusted R Squared = .786)

When mean scores were further compared using ANCOVA with the pre-test as covariate, the results showed that F-ratio obtained is 1071.88 at $p < 0.05$. Since the p-value of 0.000 is less than the critical p-value of 0.05 earlier set for the hypothesis, it implies that the null hypothesis is rejected. This means that there is a significant difference between the mean achievement scores of students taught balancing of Redox equation using collaborative strategy and those taught using conventional lecture method. The difference is in favor of EXG that received treatment.

Hypothesis 2

There is no significant difference between the mean retention scores of students taught balancing of Redox equations using collaborative strategy and those taught using conventional lecture method.

Table 6: ANCOVA for EXG and COG of students' mean retention scores.

Source	Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	18003.418[a]	2	9001.709	672.403	.000
Intercept	4232.635	1	4232.635	316.166	.000
POST-TEST	.469	1	.469	.035	.852
GROUPS	18001.393	1	18001.393	1344.654	.000
Error	3868.952	289	13.387		
Total	308844.000	292			
Corrected Total	21872.370	291			

a. R Squared = .823 (Adjusted R Squared = .822)

The above Table 6 analysis (ANCOVA) with post-test scores as covariate showed that F-value obtained is 1344.65 at $p < 0.05$. Since the p-value (0.000) is less than the critical p-value of 0.05 set for the hypothesis, it implies that the null hypothesis is rejected. This means that there is a significant difference between the mean retention scores of students taught balancing of Redox equations using collaborative strategy and those taught using conventional lecture method. The difference is in favor of those taught using collaborative strategy.

Hypothesis 3

There is no significant difference between male and female students' mean achievement scores in balancing Redox equations when taught using collaborative strategy.

Table 7: ANCOVA analysis of male and female students' mean achievement scores using collaborative strategy.

Source	Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	.307[a]	2	.153	.002	.998
Intercept	4584.643	1	4584.643	61.937	.000
PRETEST	.302	1	.302	.004	.949
GENDER	.014	1	.014	.000	.989
Error	21392.115	289	74.021		
Total	330663.000	132			
Corrected Total	21392.421	291			

a. R Squared = .000 (Adjusted R Squared = -.007)

The results in Table 7 above showed that (F = 0.000; p > 0.05). Since the p-value of 0.989 is greater than the critical p-value of 0.05 set for the hypothesis, it implies that the null hypothesis is not rejected. This means that there is no significant difference between male and female students' mean achievement scores in balancing Redox equations when taught using collaborative strategy. This implied that male and female students achieve academically the same when taught balancing of Redox equations using collaborative strategy.

Hypothesis 4

There is no significant difference between male and female students' mean retention scores in balancing Redox equations when taught using collaborative strategy.

Table 8: ANCOVA of male and female students' mean retention scores when taught using collaborative strategy.

Source	Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	23.566[a]	2	11.783	.156	.856
Intercept	4188.919	1	4188.919	55.408	.000
Post-test	.963	1	.963	.013	.910
Gender	21.540	1	21.540	.285	.594
Error	21848.804	289	75.601		
Total	308844.000	132			
Corrected Total	21872.370	291			

a. R Squared = .001 (Adjusted R Squared = -.006)

The results in Table 8 above showed that calculated F-value of 0.285 is significant at p-value of 0.594. Since the p-value of 0.594 is greater than the critical value of 0.05 set for the hypothesis, it implies that the null hypothesis is accepted. This means that there is no significant difference between male and female students' mean retention scores when exposed to treatment. Consequently, both male and female students retain equal concepts of balancing Redox equations when taught using collaborative strategy.

Discussions

There was a significant difference between mean achievements scores of students taught balancing of Redox equation using collaborative strategy and those taught using conventional lecture method. This means that students taught using collaborative strategy

performed academically better than those taught using conventional lecture method. Clearly, it agrees with the findings of Ekemobi and Mumuni, 2015; Idiege, Nja and Ugwu, 2017;Njoku and Akwali, 2016, who submitted that appropriate teaching method adopted by the teacher make students to learn meaningfully and grasp concepts taught with understanding, pay adequate attention with dexterity to the teachings, become more interested and motivated to learn with ease, retain quite a greater chunk of information learned than ever imagined and reproduce them when required at tests or examinations. The use of collaborative strategy in balancing Redox equations in this study have removed the abstractness and complexities associated with concept than when conventional lecture method was adopted.

Also, there was a significant difference between mean retention scores of students taught using collaborative strategy and those taught using conventional lecture method, which was in favor of those taught using collaborative strategy. Apparently, students taught using collaborative strategy were actively engaged in their learning tasks and participated effectively in group discussions, socialized, divided up learning tasks among themselves, provided feedbacks and debated different conclusions from each group in order to encourage problem-solving skills which enabled them to grasp and retain knowledge of balancing Redox equations longer than ever anticipated. The frequency of recall, recognition and relearn sequence accorded their learning activities gave impetus to strong retentive-memory of balancing Redox equations' knowledge as retention is clearly indispensable. The findings give credence to those of Oloyede, 2011; Ezeudu and Obi, 2013; Nja, Kalu and Neji, 2015; Idiege and Nja, 2018; Anamezie, 2018, whose reports attest to retention and remembrance of critical ideas when understanding is acquired through appropriate practice without any form of tip-of-tongue syndrome or confabulation.

Similarly, there was no significant difference between mean achievement and retention scores of male and female students when taught balancing of Redox equations using collaborative strategy. The findings contradicted those of Shihusa and Keraro, 2009; Oludipe, 2012 who found female students performing and retaining academically better than the males in the sciences, while Yusuf and Adigun, 2010; Udousoro, 2011; Njoku and Akwali, 2016 found that male students performed and retained better academically than females in science related subjects taught at school. However, the findings of Nja, Kalu and Neji, 2015; Anamezie, 2018 agrees with the findings of this study, which suggests that unlike some strategies that are prone to gender stereotype, collaborative strategy can be used to student's advantage without bias in co-educational schools.

Conclusion

Since teaching involves the fact that something is being taught to someone, its activity brings about learning. So, the skill of the teacher in designing learning activities that express the particular content for learning is essential to teaching, as demonstrated in collaborative teaching strategy. The strategy enhanced students' academic achievement and retention in balancing Redox equations without bias to gender. Therefore, it is an effective teaching strategy in chemistry for global competitiveness in STEM education.

Recommendations

1. Government, professional bodies and concerned education stakeholders should regularly organize workshops, seminars and conferences for science teachers to showcase their findings on application of teaching strategies, such as collaborative strategy, in order to enhance students' learning achievement and retention of chemistry concepts in school, especially, electrochemistry.
2. Curriculum planners should encourage teachers on the use of strategies such as collaborative strategy, in school based teacher-activity of the National Curriculum for Senior Secondary Schools in Nigeria, with the view to updating the teachers'

knowledge on the strategy in teaching chemistry concepts and other science-related subjects as may be specified.

3. Examination bodies like WAEC, NECO and NABTE should cooperate with relevant agencies of education to emphasize the need for inclusion of strategies, such as collaborative strategy, in order to enhance students understanding of relevant science concepts in their syllabuses.

References

Akpan, B. B. (2015). The place of science education in Nigeria for global competiveness. *Journal of Science Teachers Association of Nigeria (JSTAN), 50*(1), 1 – 23.

Anamezie, R. C. (2018). Effect of computer game instructional strategy on Secondary School Students' retention in Physics in Agbani Education Zone, Enugu State. *59th STAN Annual Conference Proceedings*, 220 – 225.

Aniodoh, H.C.& Egbo, J. J. (2014). Effect of gender on students' achievement in chemistry using inquiry-role instructional model. *International Journal of Social Science Education*, *4* (2), 185-191.

Bandura, A. (1977). *Social learning theory*. Eaglewood Cliff; New Jersey, Prentice Hall

Barber, S. J., Rajaman, S. & Fox, E. B. (2012). Learning and remembering with others: the key role of retrieval in shaping group recall and collective memory. *Social Cognition, 30*(1),121 – 122.

Duman, B. (2010). The effects of brain-based learning on academic achievement of students with different learning styles. *ERIC Journal of Education Science,10*(4), 2077-2103.

Ebbinghaus, H. (1913). *Memory: A Contribution to Experimental Psychology*. New York: Teachers College Press.

Ekemobi, T. N. & Mumuni, A. A. O. (2015). Efficacy of advance organizers strategies on chemistry students' cognitive achievements in Redox reaction concepts. *British Journal of Psychology Research, 3*(5), 16 – 27.

Emendu, N. B. (2014). The role of chemistry education in national development. *International Journal of Engineering and Science, 3*(3), 12 – 17.

Eze, G. N. & Onyenwe, G. E. (2018). Effect of concept mapping on academic achievement of secondary school students in chemistry in Umunneochi L.G.A., Abia State.*59th Annual STAN conference proceedings,* 200 – 2006.

Ezeudu, F. O. & Obi, T. N. (2013). Effects of gender and school location on students' achievement in chemistry in secondary schools in Nsukka L.G.A of Enugu State. The International Institute for Science, Technology and Education (IISTE). *Journal Research on Humanities and Social Sciences,3*(15), 50-55.

Federal Ministry of Education (2014). *National Policy on Education.* Abuja: NERDC Press.

Federal Ministry of Education (2014). *Senior Secondary Education Chemistry Curriculum for SS1-3*. Abuja: NERDC Press.

Idiege, K. J., Nja, C. O. & Ugwu, A. N. (2017). Enhancing secondary school chemistry students' academic achievement using K.W.L. instructional strategy. *Advances in Multidisciplinary and Scientific Research Journal(AIMSJ), 3*(1), 51- 62.

Idiege, K. J. S. & Nja, C. O. (2018). Relative efficacy of PQ4R meta-cognitive learning strategy on students' academic achievement in electrochemistry in Calabar Education Zone, Cross River State, Nigeria. *International Journal of Advanced Academic and Educational Research, 13*(3), 50 – 61.

Jegede, S. A. (2007). Students' anxiety towards the learning of Chemistry in some Nigerian secondary schools. *Educational Research and Review, 2*(7), 193 -197.

Lazakidou, G. & Retalis, S. (2010). Using computer supported collaborative

learning strategies for helping students acquire self-regulated problem-solving skills in mathematics. *Computers & Education,* 54, 3 – 13.

Kissan, S. (2006). Gender differences in motivation to learning French. *Canadian Modern Language Review,61*(3), 65-75.

Nbina, J. B. & Wagbara, O. S. (2012). Relationships between some factors and students' performance in secondary school Chemistry in Rivers State, Nigeria. *Journal of Africa Contemporary Research, 7*(1), 19-24.

Nja, C. O. (2012). Kitchen resources, Classroom interactions, Reasoning ability levels, Academic performance and retention of SS2 chemistry students in thermo chemistry in Calabar Education Zone, Nigeria. *Unpublished PhD Thesis.* University of Calabar, Calabar.

Nja, C. O., Idiege, K. J. & Obi, J. O. (2017).Effect of the use of ICT on chemistry performance. *Education for Today, 13* (1), 148 – 153.

Nja, C., Kalu, I. & Neji, H. (2015). Gender, kitchen resources and students' academic performance and retention in thermo chemistry in Cross River State, Nigeria. *Global Journal of Educational Research, 14*, 25-29.

Nja, C. O. & Idiege, K. J. (2019). Scientific attitudes and corruption tendencies among chemistry education students. *Education for Today, 15*(1), 54 – 59.

Njoku, Z. C. & Akwali, C. P. (2016). Gender and school location as factors of students' motivation to learn chemistry in Nigeria secondary schools. *Journal of Science Teachers Association of Nigeria (JSTAN),51*(1), 53-57.

Njoku, Z. C. (2007). Comparison of students' achievement in three categories of questions SSCE practical chemistry examinations. *JSTAN , 42* (1&2),67 – 71.

Ojokuku, G. O. & Amadi, E. O. (2010). *Teaching electrochemistry: A handbook for Chemistry teachers. Chemistry panel series 6.* Zaria: Mac Chin Multimedia Designers, pp.13-20.

Oloyede, O. I. (2011). A meta-analysis of the effect of advance organizers on achievement and retention of senior secondary school chemistry students. *International Journal of Education Science,* 3(2), 129 - 135.

Oludipe, D. (2012). Gender differences on Nigerian junior secondary school students' academic achievement in Basic Science. *Journal of Educational and Social Research, 2*(1), 25-30.

Prescott, T. (2017). The importance of Chemistry. Available at *www.lifepersona.com/electrochemistryencyclopedia.....*Retrieved on 20/07/2018.

Shihusa, H. & Keraro, F. N. (2009). Using advance organizers to enhance students' motivation in learning Biology. *Eurasia Journal of Mathematics, Science and Technology Education, 5*(4), 413-420.

Udousoro, U. J. (2011). The effect of gender and mathematics ability on academic performance of students in Chemistry. *African Research Review, 5*(4), 201-213.

Ukpong, E. M. (2020). Robots from our schools: A call for effective education. *91st Inaugural Lecture, University of Calabar,* Calabar.

West African Examination Council (2005-2020). *Chief Examiner's Reports*. Lagos: WAEC Press.

Yusuf, M. A. & Adigun, J. T. (2010). The influence of school location and Sex-type on students' academic performance. *International Journal of Education Science, 2*(2), 81-85.

Zakariyya, A. A. &Bello, A. S. (2018). Strengthening science, technology, engineering and mathematics (STEM) education through met cognitive teaching strategy on students' achievement in calculus. *56th STAN Annual Conference Proceedings,*82 – 90.