



Effect of Concept Mapping and Guided-Inquiry Instructional Strategies on Students' Academic Achievement in Chemistry

Jack Gladys Uzezi, Suleiman Zainab
Department of Science Education,
Taraba State University, P.M.B. 1167, Jalingo, Nigeria

ABSTRACT

This study investigated the effect of Concept Mapping and Guided-Inquiry instructional strategies on students' academic achievement in Chemistry. The study used a test-retest quasi-experimental design. The population for the study is 659 Secondary School One (SS I) Chemistry students of 2017/2018 academic session in Jalingo metropolis, Taraba state. The Sample size consisted of 113 students drawn from two schools which use intact classes with equivalent mean scores of 10.22 and 9.76 in their pretest. Chemistry Achievement Test (CAT) was used for data collection. The reliability coefficient of the CAT was found to be $r=0.84$. Data collected was analyzed using means, standard deviation and analysis of covariance (ANCOVA). The result showed that the experimental group which was taught chemistry using Guided-Inquiry instructional strategy performed significantly better than the Concept Mapping group. The results also showed that there is no significant interaction effect of method of teaching and gender on students' achievement in chemistry. The conclusions drawn revealed that students taught chemistry using Guided-Inquiry strategy performed better than their counterparts that used Concept Mapping strategy, and both methods were gender-unbiased. The study recommends, amongst others that, Chemistry teachers should incorporate both instructional strategies mostly Guided-Inquiry since it has improved students' achievement better and is gender-friendly.

ARTICLE INFO

Article History

Received: June, 2020

Received in revised form: August, 2020

Accepted: August, 2020

Published online: October, 2020

KEYWORDS

Concept Mapping, Guided-Inquiry, Academic achievement.

INTRODUCTION

Effective delivery of chemistry curriculum is no doubt a sine-qua-non to sustainable technological development. Chemistry is one of the fundamental ingredients of technology. There is the need for proper delivery of chemistry curriculum in Senior Secondary Schools. Research findings have shown that several topics in chemistry contain some concepts which pose unique and formidable challenges to the students. According to Jack (2013), it is

clear that when concepts are not meaningfully understood by students, they are discouraged in answering questions set on them during Senior Secondary Certificate Examination (SSCE). Invariably, this may lead to the poor performance of students in these areas and their overall performance in chemistry at SSCE. If learning strategies and students' achievement have to improve then students have to be introduced to more effective and appropriate learning strategies



through the use of appropriate instructional strategies.

The chemistry curriculum is intended to provide the learner with modern Chemistry course as well as to meet the needs of the society through relevance and functionality of contents, methods, processes and applications. To achieve these laudable objectives, there is the need to present the learning experiences to the learner with an approach that will entail the use of various senses that will guarantee an in-depth knowledge of the curriculum content Federal Republic of Nigeria (FRN, 2014). The inclusion of Concept Mapping and Guided-Inquiry as a strategy of teaching Chemistry is aimed at making students comprehend, analyze and proffer solutions to given Chemistry problems.

Results of students' achievement in chemistry for the past few years in Nigeria obtained from the West African Examination Council (WAEC) Chief Examiner's report also revealed a decline and high failure rate. About 38.17% of students passed at credit level in 2012, 40.36% passed in 2013 while less than 26% passed in 2014. The WAEC and National Examination Council (NECO) results released for chemistry in 2015 was also very poor with less than 22% passes at credit level in both examination and nose-divided to below 20% in the recent years. For instance, the WAEC Chief Examiners' report (2016 & 2017) noted that chemistry students find it difficult to answer questions on organic chemistry, carbon and its compound, gases and gas laws; most candidates could not identify simple apparatus during practical; poor performance was also noticed in questions involving calculations and poor knowledge in industrial chemistry. Fatokun and Eniayeju, (2014) revealed that most concepts in chemistry are difficult to learn by most students. Most of the students could not identify chemical symbols, many exhibited poor description of chemical

structure, and the relationship between organic and inorganic chemistry.

There were quite radical changes in emphasis in school chemistry education, with subsequent changes in many university courses. Considerable research was undertaken to explore the learning problems that students were experiencing. The common underlying trend became apparent as it relates to the way humans process new information. The secondary school knowledge of chemistry is often characterized by a lack of coherence. Instead of having a well-structured and integrated domain-specific knowledge structures, students do not possess a well-founded basic framework in which the newly acquired concept can be integrated (Fatokun, 2012). This lack of integration is suspected to be the basis of students' difficulties concerning concept formation and application of acquired knowledge in exercise and practical work (Fatokun & Eniayeju, 2014). Salahuddin (2010) expressed the view that the issues of the poor performance of students in secondary schools' chemistry in examinations are a source of worry to teachers as well as examination bodies. In this regard, Bulama (2012) asserts that there is various kind of teaching strategies from which a science teacher can select the most effective and appropriate teaching strategy, keeping in view the need of the learner, relevance to the science content and improved students' performance. Some instructional strategies and methods used in teaching science subjects especially chemistry are excursion, field trip, discovery, experimental, project, problem-solving and concept mapping etc. For this study, only two instructional strategies Concept Mapping (CMP) and Guided-Inquiry (GI) would be used in teaching some specific concepts in chemistry.



Concept Mapping is an instructional tool that is currently gaining popularity in the field of science education. Concept Mapping is a pedagogical/Metacognitive tool designed to help students learn how to learn. A concept map is a diagram showing the relationships among concepts. It is a graphical tool for organizing and representing knowledge. These are instruments that help with organizing and structuring knowledge (Jack, 2013). Concept Mapping has been adequately advocated in literature as strategies for meaningful learning of abstract concepts and assists learners in learning about conceptual changes. The use of this tool as a technique in teaching abstract concepts in chemistry may be observed as a paradigm shift. One big advantage of using concept maps is that during its formulation process, it consolidates a concrete and precise understanding of the meanings and inter-relations of concepts. Thus, it makes learning an active process, not a passive one (Jack, 2013). Several studies have found the use of Concept Mapping very effective in science teaching and learning difficult concepts in the sciences, though very few in chemistry (Okafor & Okeke, 2006; Ezekannagha, 2007; BouJaoude & Attieh, 2008; Fechner & Sumfleth, 2008, & Karakuyu, 2010)). Conceptual maps are very effective; they allow students to represent their understanding of domain knowledge in a well-organized format. In Concept Mapping, users construct a two-dimensional, Visually-based representation of concepts and their relationships. Concept maps were designed to support the learner's effort by externalizing concepts and propositions known to the student, making them visually apparent to facilitate their connection with newly acquired concepts.

Guided-Inquiry instructional strategy is a style of teaching where the teacher assists the learner in seeking to discover and create

answers to recognized problems through the procedure of making the diligent search, sometimes with minimum guidance from the teacher. Guided-Inquiry is also a term used in science teaching that refers to a way of questioning, seeking knowledge or information or finding out about phenomena, it involves investigating data and arriving at a conclusion (Suleiman, 2011). Yagger and Ackay (2010) defined Guided-Inquiry as an approach to teaching, the acts the scientist use in doing science and it can be highly effective teaching method that helps students to understand concepts and use of process skills. A guided-Inquiry strategy is an instructional strategy which enables students to find answers by themselves. It is also a strategy of teaching that involves probing, finding out, investigating, analyzing, synthesizing, discovering, evaluating, questioning and thinking (Sylvanus & Eke, 2017). It is a learner-centred approach hence it is called a heuristic method. It is also a term used in science teaching that refers to a way of questioning, seeking knowledge, information or finding out about a phenomenon. The Guided-Inquiry strategy often used in a science classroom in form of laboratory exercise where the teacher provides fairly structured procedures to enable learners to carry out an investigation (Adejo, 2015). Guided-Inquiry instructional strategy has been described as problem-solving, critical thinking, reflective inquiry, deductive thinking and not a mere personal assumption.

The present study, therefore, intends to use these innovative instructional strategies (Guided-Inquiry and Concept mapping) in the teaching of chemistry and ascertain their effect on students' academic achievement. The purpose of this study is to determine: the effectiveness of both strategies considering the mean achievement scores of students taught



chemistry using Concept Mapping and Guided-Inquiry instructional strategies, and also determine if there is any significant interaction effect of instructional strategy and gender on students' achievement in chemistry.

Hypotheses:

The following null hypotheses were formulated for testing at; 0.05 level of significance.

Ho₁: There is no significant difference between the mean achievement scores of students taught chemistry using Guided-Inquiry strategy and that taught using Concept Mapping strategy.

Ho₂: There is no significant interaction effect of strategy and gender on students' achievement in chemistry.

Methodology

The design for this study is quasi-experimental that employed pretest-posttest nonequivalent control group design. This study consists of two instructional strategies Concept Mapping (CMP) and Guided-Inquiry (GI) instructional strategies which form the independent variables and students' academic achievement which is the dependent variable. Diagrammatic representation of the study design.

Group	Pre-test	Independent variable	Post-test
E1	Yb	X1	Ya
E2	Yb	X2	Ya

Where: E=Experimental group1, E=Experimental group2, Y_b=pre-test, Y_a=Post-test, X₁=GI, X₂=CMP

The study was conducted in Jalingo metropolis which is in Jalingo Education Zone of Taraba State, Nigeria. The area of the study is selected because of low achievement of students in chemistry in secondary schools, low enrolment of students in chemistry and chemistry-related courses in a tertiary institution and lack of technicians in the field of chemistry. The Population of the study comprised all (10) Secondary School I (SSI) that offers chemistry which was located in Jalingo metropolis in 2017/2018 academic session. Two senior secondary schools were randomly selected using the balloting method, thereby giving each school an equal opportunity to be selected. In each school selected intact class of Secondary School II chemistry students was used. And the schools selected were assigned into two experimental groups (GI & CMP). The sample size used was 113 Chemistry students (GI=59, CMP=54) which are made up of 66

males (GI= 32, CMP=34) and 47 females (GI=27, CMP=20) from the sampled schools.

A (30) multiple-choice question Chemistry Achievement Test (CAT) derived by the researcher was employed for data collection in this study. The CAT was used in collecting data from the sampled schools. A table of the specification was drawn to cover the topics during the period of investigation which is designed to test the cognitive ability of the students. Each item in the test has options lettered A to E. Each correct answer carries one (1) mark; the CAT was scored over a total of thirty (30) marks using the marking scheme.

This was a set of instructional guides designed only for the experimental group-1. There were six-lesson guides on the selected topics for the study which was taught for six consecutive weeks. The experimental group used Guided-Inquiry instructional strategy with a set of questions outlined to be



answered and some activities to be carried out at different stages of each topic.

This comprises of six lesson plans on the selected topics for the study. It was to be used for teaching the control group using Concept Mapping instructional strategy where students were actively involved in the teaching and learning process for six consecutive weeks. The lesson plans were prepared based on chemistry syllables for SS I. The topics are contained in the recent senior secondary school education curriculum approved for use in secondary schools in Nigeria by NERDC. These topics are Separation Techniques, Acid, Base and Salt, Chemical Combination, Gaseous State and Gas Laws concept. The lesson plans were used by the research assistants after being trained on how to teach the students using a training manual.

The instrument, CAT was validated by three experts in the field of science education from Taraba State University for face, content and constructs validity. The experts were asked to assess the instrument in terms of clarity of expression and suitability of the items and content coverage of items. To ensure content and construct validity, each of the experts was provided with a copy of CAT, the topic of the research, lesson plans, and the extract of the curriculum on the content to be covered in the table of specification, research questions and purposes. Based on the comments and suggestions of the experts, corrections and modifications were made on the instrument. The CAT was subjected to psychometric analysis; items were reduced from 50 to 30.

A trial test was conducted; the aim was to estimate the reliability of the research instrument and the workability of the research design. The CAT was administered to the students and the result was used to calculate the reliability coefficient of the instruments. For CAT, the Kuder-Richardson formula (KR-20) was used

and the reliability coefficient of 0.84 was obtained. The result of the trial test shows that the instrument proposed as reliable for use in the main study.

A pretest was administered on the two groups to determine the initial knowledge of the students from the sampled schools and to determine the equivalence of the groups which participated in the study. The experimental group received instruction on the selected topics using Guided-Inquiry instructional strategy and the control group received instruction on the same topics using Concept Mapping strategy for six weeks, thereafter, a post-test was conducted immediately after the teaching and was used to determine the effectiveness of the two instructional strategies but particularly the effect of the treatment on the experimental group. Six weeks is long enough for the students to forget the pretest question. The CAT was administered within 60 minutes. The essential information of the respondents in section A should be filled before answering the questions. This was to ensure easy identification of the respondents with their performance in the test. In addition to the instruction written on the test, the students were given verbal instructions where necessary.

The teachers who assisted in conducting the treatment in the sampled schools were met separately to solicit for their cooperation. A training session was organizing which lasted for four days, the research assistants were taught exactly what they need to do during the treatment and the researcher made sure that they can carry out the task given to them without any problem.

The students in the experimental group-1 were provided with the materials needed to teach separation technique, Acid, Base and Salt, gases and gas laws as well as chemical combination concepts which make Guided-Inquiry instructional strategy a



success, these materials include; different types of apparatus, acid (strong and weak), base, a different type of salts and litmus paper.

The students in the Experimental group-2 were exposed to Concept Mapping instructional strategy, during the lesson, the students' carried out different activities and investigations under the supervision of the research assistant, the most important characteristics of the lesson was that the lesson is 'student-centred'. Activities were designed to encourage students to become more adapted to using science process skills by forming maps on concepts such as Acids, Bases, Salts, neutralization reaction, gas laws and chemical combination. The objectives of treatment were for the students to be able to achieve the stated objectives of the lesson by the end of the treatment by writing test and to observe whether there is a change in performance in the experimental groups.

The scores obtained from the pretest and posttest were analyzed using descriptive

statistics of the mean and standard deviation to answer the research questions, this is because the experiment involved pretesting of the subjects and an inferential statistics of Analysis of Co-variance (ANCOVA) was used to test the null hypotheses at 0.05 level of significance, for homogeneity or equality variance known as homoscedasticity i.e. the variance of data in groups should be the same. Also, Levene's test for homogeneity of variance was used to confirm homoscedasticity.

RESULTS AND DISCUSSIONS

Results

The data collected using the instruments developed for the study were presented and analyzed using mean and standard deviation to determine the mean gain while analysis of covariance (ANCOVA) was used to test the hypotheses of the study at .05 level of significance.

Table 1: Mean Achievement Scores and Standard Deviations of Subjects in Guided-Inquiry and Concept Mapping Groups

Group	N	Pre-test		Post-test		Mean Gain
		\bar{X}	δ	\bar{X}	δ	
Guided-Inquiry	59	10.22	2.26	21.14	2.79	10.92
Concept Mapping	54	9.76	2.38	14.93	3.37	5.17
Mean difference		0.46		6.21		

Key: \bar{X} = mean scores, δ = standard deviation scores

Results of Table 1 show that the post-test mean achievement scores of the Guided-Inquiry students are 21.14 with a standard deviation of 2.79, while that of Concept Mapping is 14.93 with a standard deviation of 3.37. The difference between the pre-test and post-test mean achievement scores (mean gains) of the Guided-Inquiry and Concept Mapping group is 10.92 and 5.17 respectively. The pre-test and post-test mean scores difference for the two groups show that that of the Guided-

Inquiry group is higher (10.92>5.17). There is also a difference of 6.21 between the post-test mean scores of the two groups in favour of the Guided-Inquiry group. This suggests that students taught using Guided-Inquiry strategy achieved higher than their counterparts in the Concept Mapping group. To verify this difference between the two means in the posttest was statistically significant, Analysis of Covariance (ANCOVA) was used and Table 4 showed the results of the covariance analysis.



Table 2: Mean and Standard Deviations of Achievement Scores of Subjects per Sex in the Guided-Inquiry and Concept mapping group

Sex	N	Pre-test		Post-test		Mean
		\bar{X}	δ	\bar{X}	δ	
Difference						
Guided-Inquiry group						
Female	27	10.04	2.23	21.26	2.74	11.22
Male	32	10.38	2.31	21.03	2.87	10.65
Mean Difference		0.34		0.23		
Concept mapping Group						
Female	20	10.20	2.91	15.05	3.73	4.85
Male	34	9.50	2.00	14.85	3.19	5.35
Mean Difference		0.7		0.2		

Key: \bar{X} = mean scores δ = standard deviation scores

Table 2 shows that the posttest means achievement scores of female students was 21.26 with a standard deviation 2.74 which is higher than the mean score of male students of 21.03 and a standard deviation of 2.87. The difference between pre-test and post-test mean scores of male students is 10.65 and that of the female is 11.22. The difference between the pre-test and post-test of the two sexes suggest that female students gained more than male students. The differences between the post-test mean scores of the two sexes are 0.23 in favour of female students. The implication is that there is no significant difference between the achievement scores of male and female students in Guided-Inquiry class.

Table 2 also shows that the posttest means achievement scores of female students taught using Concept Mapping is 15.05 with a standard deviation 3.73 which is higher than the mean score of males which

is 14.85 and a standard deviation of 3.19. The difference between the pre-test and post-test mean scores of the male students is 5.35 and that of the female students is 4.85. The differences between the two sexes suggest that male students gained more than female students. The difference between post-test mean scores of the two sexes is 0.20 in favour of female. This indicates that there is no much difference between the achievement scores of the male-female student in Concept Mapping class. To ascertain whether the observed difference had a significant interaction effect of method and gender on student's achievement, hypothesis 2 was tested as shown also in Table 4.

Two major assumptions of analysis of covariance (ANCOVA) are linearity of the relationship between the dependent variable and covariate, as well as homogeneity of regression slopes. Table 3 tests the assumptions of ANCOVA.

Table 3 Test for Assumption of Linearity and Homogeneity of Regression Slopes

Source of Variation	Type III Sum of squares	df	Mean Square	F	Sig
Corrected Model	1205.869 ^a	3	401.956	46.912	.000*
Intercept	1086.125	1	1086.125	126.762	.000*
Group	110.674	1	110.674	12.917	.000*
Pre-test	106.331	1	106.331	12.410	.001*

Corresponding author: Jack, G. U ✉ jack.gladys@tsuniversity.edu.ng ✉ Department of Science Education, Taraba State University, Jalingo. © 2020, Faculty of Technology Education, ATBU Bauchi. All rights reserved



Group * Pre-test	11.901	1	11.901	1.389	.241**
Error	933.937		109	8.568	
Total	39439.000		113		
Corrected Total	2139.805		112		

Key: * Significant, ** not significant

Results of Table 2 shows that there is no significant interaction between the covariate (pre-test) and the treatment manipulations ($F_{(1,109)} = 1.389$) at $P = .241$. This means that the assumptions of linearity and homogeneity of regression slope, which guarantees the use of ANCOVA for testing all

the hypotheses at .05 significant level have not been violated.

H0₁: There is no significant difference between the mean achievement scores of students taught chemistry using Guided-Inquiry strategy and that taught using Concept Mapping strategy.

Table 4: Results of Two-Way Analysis of Covariance of Methods of Teaching and Gender on Students' Achievement in Chemistry.

Sources of Variation	Sum of Squares	df	Mean Square	F	Sig
Corrected Model	1196.121 ^a	4	299.030	34.223	.000*
Intercept	1050.297	1	1050.297	120.201	.000*
Pretest	107.684	1	107.684	12.324	.001*
Method	982.739	1	982.739	112.470	.000*
Gender	.493	1	.493	.053	.813**
Method * Gender	1.509	1	1.509	.173	.679**
Error	943.685		108	8.738	
Total	39439.000		113		
Corrected Total	2139.805		112		

Key: * Significant, ** not significant

From Table 4, the results of the main effects on the Guided-Inquiry and Concept Mapping strategies indicated by $F(1, 108) = 112.470$ is significant at $P = .000$. This result affirms that there is a significant difference between the mean achievement scores of the students taught using Guided-Inquiry and those taught using Concept Mapping. Thus, the hypothesis of no significant difference is not retained. The results of the analysis revealed that the treatment (Guided-Inquiry) used in the experimental group was significant positively on students' academic achievement. The results revealed that the methods of teaching produced a significant difference in the posttest achievement

scores of students when the covariate effect (pretest) was controlled. The result indicated that the treatment, using Guided-Inquiry settings accounted for the difference in the post-test achievement scores of the students. This implies that a significant difference existed between the two groups of Concept Mapping and Guided-Inquiry instructional strategies; in favour of Guided-Inquiry.

H0₂: There is no significant interaction effect of method and gender on students' achievement in chemistry.

Also, from Table 4 the interaction effects on achievement due to methods and gender is $F(1,108) = .173$ is not significant with $p = .679$. These values as shown in Table

Corresponding author: Jack, G. U ✉ jack.gladys@tsuniversity.edu.ng ✉ Department of Science Education, Taraba State University, Jalingo. © 2020, Faculty of Technology Education, ATBU Bauchi. All rights reserved



3 suggest that gender and method of teaching do not jointly influence students' achievement, especially when Guided-Inquiry is used. Thus, the hypothesis of no significant interaction effects is not rejected. The results of the analysis revealed that the mode of instruction (Concept Mapping and Guided-Inquiry) and gender (male and female) had no interaction effect on students' academic achievement. The results revealed that the methods of teaching and gender produced no significant interaction effect on the post-test achievement scores of students when the covariate effect (pretest) was controlled.

The findings from the study are summarized as follows:

- i. There was a significant difference between the mean achievement scores of students taught chemistry using Guided-Inquiry strategy and that taught using Concept Mapping strategy in favour of Guided-Inquiry.
- ii. There is no significant interaction effect of method and gender on students' achievement in chemistry.

DISCUSSION OF FINDINGS

The mean achievement scores of students taught chemistry using Guided-Inquiry strategy compared to that taught using Concept Mapping strategy. It was discovered that students taught using Guided-Inquiry instructional strategy had significantly higher academic achievement than their counterparts taught using Concept Mapping strategy. This result is not entirely surprising, as in fact, confirms the assumption that students taught using Guided-Inquiry instructional strategy (experimental) performed significantly better than those taught using Concept Mapping strategy. This was confirmed from Table 1 by their calculated mean academic performance in chemistry which was 21.14 and 14.93 by experimental and control

group students respectively. Hypothesis One states that; there is no significant difference between the mean achievement scores of students taught chemistry using Guided-Inquiry strategy and that taught using Concept Mapping strategy. From Table 4, the result of the main effect on the Guided-Inquiry and Concept Mapping strategies indicated by $F(1,108) = 112.470$ is significant at $p = .000$. The result affirms that there is a significant difference between the mean achievement scores of students taught using Guided-Inquiry strategy and that taught using Concept Mapping strategy. Thus, the hypothesis of no significant difference is not retained.

The results had revealed that the methods of teaching produced a significant difference in the posttest achievement scores of students when the covariate effect (pretest) was controlled. The result indicated that the treatment, using Guided-Inquiry settings accounted for the difference in the post-test achievement scores of the students. This implies that a significant difference existed between the two groups of Concept Mapping and Guided-Inquiry instructional strategies; in favour of Guided-Inquiry. This finding supports works by Jack, (2013, 2017), Suleiman, (2011), Adejo, (2015) and Sylvanus and Eke, (2017). The guided-Inquiry strategy used involves problem-solving, critical thinking, reflective inquiry, deductive thinking and not mere personal assumptions. It is a method of teaching that involves probing, finding out, investigating, analyzing, synthesizing, discovering, evaluating, questioning and thinking. The findings also support Blanchard, Southerland, Osborne, Sampson, Annetta and Granger (2010) whose results showed that students who participated in an inquiry strategy; tend to have better outcomes than those who learned through traditional methods. The findings also support another science educationist whose



result showed a significant increase in students' academic achievement when Guided-Inquiry laboratory experiment was applied as an instructional approach Evrim (2016).

The findings from this study also revealed that there was no significant interaction effect between the instructional strategies (Guided-Inquiry and Concept Mapping) and gender on students' academic achievement in Chemistry. This finding implies that Guided-Inquiry strategy is an effective strategy for learning chemistry concepts/topics. Chemistry content is better retained when this strategy is employed because it adopts problem base learning (an integral part Guided-Inquiry strategy) that enhances cognitive restructuring and linkage of ideas to existing knowledge structure (Fatokun & Fatokun, 2013). This result indicates that gender and method of teaching do not jointly influence students' achievement when the right instructional strategies like Concept Mapping and Guided-Inquiry are used since they are gender-friendly.

CONCLUSION

From the result obtained from the study on the effect of Concept Mapping and Guided-Inquiry instructional strategies on chemistry students' academic achievement, the following conclusions were drawn;

- i. Students taught chemistry using both strategies had mean gains of 10.92 and 5.17 respectively; though Guided-Inquiry group performed better than their counterparts taught chemistry using Concept Mapping group.
- ii. There was no significant interaction between the mode of instruction and gender on students' achievement in chemistry.

RECOMMENDATIONS

Based on the findings of the study, the following recommendations were made:

- i. Because the use of Guided-Inquiry strategy was more effective and enhanced students' achievement in chemistry, the Ministries of Education should therefore ensure that textbook authors incorporate Guided-Inquiry instructional strategy for secondary schools and also ensure that teachers are trained regularly on the usage.
- ii. The Government should utilize the services of various bodies such as Science Teacher Association of Nigeria (STAN), All Nigeria Conference of Principals of Secondary School (ANCOPSS) and National Union of Teachers (NUT) to organize Seminar, workshop, conference and in-service training for chemistry teachers on the use of innovative teaching strategies (Concept Mapping and Guided-Inquiry) especially Guided-Inquiry since it has proved more effective.
- iii. Curriculum planners, developers and science educators should take cognizance of Guided-Inquiry strategy which is an innovative and effective pedagogical strategy in chemistry classrooms to promote students' achievement.
- iv. Chemistry teachers should incorporate both instructional strategies mostly Guided-Inquiry since they improved students' achievement better and is gender-friendly.

REFERENCES

- Achor, E.E., & Ejigbo, M.A. (2006). *A guide to writing a research report*. Kano: Sam Art trade Limited.



- Adejo, L.O. (2015). *Effect of inquiry method on the academic performance of chemistry students in senior secondary schools in Kaduna state, Nigeria*. An unpublished M.Ed. Thesis, Department of Educational Foundation and curriculum, Ahmadu Bello University, Zaria, Nigeria.
- Blanchard, M., Southerland, S.A., Osborne, J.W., Sampson, V.D., Annetta, L.A., & Granger, E.M. (2010). Is Inquiry Possible in light accountability? A quantitative comparison of the Relative Effectiveness of guided inquiry and verification laboratory instruction. *Science Education*, 94(4):577-616.
- BouJaoude, S. & Attieh, M. (2008). The effect of using concept maps as study tools on Achievement in Chemistry. *Eurasia Journal of Mathematics Science and Technology Education* 4(3): 233-246.
- Bulama, G. (2012). *Effect of teachers' qualification on senior secondary school students' academic achievement in chemistry*, Unpublished B.Sc. Ed project.
- Emaikwu, S.O. (2013). *Fundamentals of research methods and statistics*. Makurdi: Academic Press Limited.
- Evrin, U. (2016). The effect of Guided-Inquiry Laboratory Experiments on Science Education Students' Chemistry Laboratory Attitude, Anxiety and Achievement. *Journal of Education and Training Studies*, 4 (4):217-218
- Ezekannagha, G.N. (2007). *Effects of Concept Mapping and cognitive styles on achievements of students in integrated science*. Unpublished PhD Thesis, University of Nigeria Nsukka.
- Fatokun, V.K.F (2012). *The effect of Concept Mapping-guided discovery integrated teaching approach on chemistry students' learning style, achievement and retention*. Unpublished PhD. Thesis Nasarawa State University, Keffi.
- Fatokun, J.O. & Fatokun K.V.F. (2013). Problem-Base Learning (PBL): An approach for integrating acquired knowledge in Mathematics and Chemistry for effective classroom delivery. *Academic Journal of Education Research Review* 8(11):663-667
- Fatokun, K.V.F. & Eniayeju P.A. (2014). The effect of Concept Mapping-guided discovery integrated teaching approach on chemistry students' achievement and retention. *Academic Journal of Educational Research and Reviews*, 9(22), 1218-1223.
- Fechner, S. & Sumfleth, E. (2008). *Collaborative Concept Mapping in context-oriented chemistry learning*. Concept Mapping: Connecting Educators Process of the Third International Conference on Concept Mapping. The Federal Republic of Nigeria, (2014). *National policy on Education*. NERDC press, Yaba, Lagos-Nigeria.
- Jack, G.U. (2013). Concept Mapping and Guided-Inquiry as an effective technique for teaching difficult concepts in chemistry. Effect on students' academic achievement. *Journal of Education and practice*, 4, (5), 2013.
- Jack, G.U. & Suleiman Z. (2017). Effectiveness of Guided-Inquiry Laboratory Experiments on Senior Secondary School Students



- Academic Achievement in Volumetric Analysis. *American Journal of Educational Research*, 5(7):717-724.
DOI:10.12691/education-5-74.
- Karakuyu, Y. (2010). The Effect of Concept Mapping on attitude and achievement in Physics course. *International Journal of Physical Science*, 5 (6): 724-737.
- Okafor, E.N. & Okeke, S.O.C. (2006). Concept Mapping as an effective technique for teaching difficult concepts in biology. *Journal of Science Teachers Association of Nigeria*, 122-127.
- Salahuddin, J. (2010). *Students' Achievement in geography. A study of the senior secondary in Nigeria*: Ibadan: University Press.
- Suleiman, A.M. (2011). *Effect of inquiry method on Academic Achievement, Retention & Attitude towards Chemistry among Diploma in Kano State Polytechnic*. Unpublished Masters Dissertation.
- Sylvanus, T. & Eke, S. (2017). Effect of inquiry teaching strategy on academic achievement of senior secondary school chemistry students in Okrika Local Government Area. *International Journal of Education and Evaluation*, 3, 12.
- West African Examination Council (WAEC), (2016). *Chief examiners reports, Nigeria*.
- West African Examination Council (WAEC), (2017). *Chief examiners reports, Nigeria*.
- Yagger, R.E & Ackay, H. (2010). The advantages of an inquiry approach for science instruction in middle grades school science and mathematics, *School Science and Mathematics*: 110 (1): 5-12.