Chemistry by Guided Inquiry and Students' Academic Achievement in Tertiary Institutions in Rivers State, Nigeria

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Abstract: **The study was designed to determine the effect of guided inquiry teaching strategy on students' academic achievement in Chemistry. To this end three research questions which were transformed into three hypotheses guided the study. The study adopted the quasi experimental design of the pre-test post-test nonequivalent control group design. One hundred year two undergraduate students of Ignatius Ajuru University of Education and Rivers State University were randomly selected and assigned into two groups; fifty students for the experimental group (guided inquiry group) and the other fifty students for the control group (discussion group). After four weeks of the teaching of the twelve principles of Green Chemistry such as waste preventions, atom economic, less hazardous chemical synthesis, designing safer chemicals, safe solvent and auxiliaries design for energy efficiency, use of renewable feed stocks, reduce derivatives. catalysis, design for degradation, real-time pollution prevention and safer chemistry for accident prevention, a 36 multiple choice objective questions which was well validated and had a reliability co-efficient of 0.92 were administered to the students in the two groups before and after the application of the teaching strategies on the two groups. Mean, standard deviation and ANCOVA were the statistical tools used for data analysis. The result of the study reveals that students in the experimental group i.e. guided inquiry group did significantly better than their counter part in the control group i.e. discussion method group. It was also found out that student achievement do not significantly differ on the basis of university type. In addition, degree types (B.Sc./B.Sc.Ed) has significant influence on student achievement in favour of the B.Sc. students. Consequently, it was recommended among others that guided inquiry as a teaching strategy should be adopted by university lectures in delivery their lesson especially in the teaching of concept such as Green Chemistry.**

Keywords: **Chemistry; Guided inquiry; Academic achievement and Green Chemistry**

I. INTRODUCTION

The teacher is the key man in the educational sector; the quality of the teacher makes or mars the educational sector. Every teacher has a great responsibility to train responsible citizens by moulding the character of youths. According to Ajienka (2019), a teacher is T - Talented, E - Elegant, A - Awesome, C - Charming, H - Helpful, E - Efficient and R - Receptive. All these characteristics of the teacher make the teacher to use his talent to device methods that will help the helpless at a point and suitable for a particular subject. The teacher must teach in line with educational goals of the nation. Various nations of the world and their educational goals are tending towards science and technology. The science teacher has the duty to find new and better ways or modification of old methods with a view of improving student's learning outcome.

With the emergence of much technological advancement the science teacher especially the Chemistry teacher at the undergraduate level has to adjust to the student learning styles, adopt teaching methods and strategies that are all in line with the trend. Teague (2016) asserts that Chemistry is a content driven subject and is an accepted body of knowledge. Students of Chemistry are expected to master it. The mastery of the body of knowledge students are required to discover the material themselves through talking, listening, questioning, use of science process skills and collaborate as they work in group activities.

Guided inquiry is also known as inductive approach. It is a technique where a teacher provides language item and helps the learner to find the rules themselves. It encourages independence and makes learning more memorable if analysis is done in group, it is a meaningful communicative task. Dienye and Gbamanja (1990) in Nwanekezi and Arokoyu (2014) defines guided inquiry as a teaching strategy whereby the teacher asks the students to formulate the problem, state the purpose, predict result, identify procedures and to perform the investigation as well as study to learn from the activities.

Guided inquiry is a learner centered strategy where the teacher helps the learner to develop the 3Hs, the head, heart and the hand. In another development, Aduhullah (1982) in Chinda (2012) asserts that guided inquiry consist of instructional mode which can be inductive or deductive in nature. When the general principle is given and a student is required to use the principle in order to discover the solution to specific problem. Guided inquiry is employed through deduction method. On the other hand, when the student is required to discover the general principle on which the solution is based, it is guided inquiry adopted through inductive method. Karaliato and Vlassi (2013) sees guided inquiry method as a constructivism that uses student centered activities. It involves activities of

students in learning process instead of allowing the student to passively gather information.

Cornel (2014) studied the effects of inquiry based laboratory activities in the enhancement of student performance in practical Chemistry in Australian high school and found out that the performance of the students were better in the self-directed learning experience. Similarly, Nwafor and Nwanekezi (2018) investigated the effects of guided inquiry and task hierarchy analysis mode in cooperative learning strategy on Chemistry student's performance in Imo State. The result of the study revealed that guided inquiry learning strategy (GILs) and Task Hierarchy analysis model (THAM) in understanding Acid-Base reaction which were the two strategies used showed that guided inquiry has significant effect on the students' academic performance.

Furthermore, Karaliota and Vlassi (2013) compared guided inquiry and traditional teaching method: A case study for the teaching the structure of matter to 8th grade Greek student and found that guided inquiry is significantly supreme to traditional teaching method for the teaching of the structure of matter. Similarly, Okoth, Keener, Lanier and Rosado-Flores (2019) studied guided inquiry experiment; separation of active-component mixture by liquid-Liquid extraction and column chromatograph the result showed that the approach challenged the student to apply fundamental knowledge gained before and come up with new separation protocol. The students were delighted because they were able to achieve the separation irrespective of any extraction solvent they choose to start the separation protocol.

In the same vein, Bromfield-Lee (2019) investigated recasting traditional organic experiments in green guided inquiry based experiments and students' perception. He found out that the students were interested in the discovery of more style of experiments. The students developed and adapted experiments that are related. The green-principles were employed even when carrying out experiment. This has made the student to implement greener method in their experiment which is a major revolutionary in the area of Chemistry. Ugwu (2015) studied the impact of guided inquiry instructional strategy on Chemistry student performance in Abia state, Nigeria. The result revealed that Chemistry student taught using guided instructional strategy performed better than those taught with the conventional method.

In drawing attention to the importance of guided inquiry, Jerome Bruner who is a major proponent of this strategy agrees that if organized and constructed in a unique way by each individual, guided inquiry method could benefit the students and the teacher in the following ways;

1. The student gains knowledge though their active participation and develops their mind by using it to solve problems.
2. It encourages students to think creatively, critically and constructively.
3. It results in students learning skills and valuing activities thus enabling them to work on their own pace without relying on direction and feedback from other people and increasing their ability to deal effectively with unstructured situations in and outside school.
4. It motivates the learner as joy of discovery provides the student with intrinsic motivation thereby helping the learner to purse career related to the discovery.
5. Guided inquiry free the teacher from been a talkative to a facilitator of discovery and exploration.
6. Evaluation of the student is done both formative and summative as it reduces the evaluation done with final examination.
7. The spirit of team work and sportsmanship is instilling in the learner since no member of the team will claim sole responsibility of the discovery.
8. It leads to the development of scientific process skills and attitudes.

The other teaching strategy this investigation concerns itself with was Discussion method of teaching. Discussion method is a free and unrestricted consideration of a problem or problems by a cooperative group of persons talking together under the direction of the teacher. Ogbeba and Adagba (2013) defines discussion method of teaching as the method that involves group of students who interact to exchange ideas, facts, opinions and verbal expression about a topic of interest or outmost concern under the guidance of a teacher. Discussion method gives every member of the class or group the freehand to freely express his or her views. Chinda (2011) asserts that discussion method enables learners to acquire critical and evaluative thinking and listening skill and affords them some confidence through active participation. Achuonye and Ajoku (2013) define discussion method as teaching based upon active participation of every member of the class in a collective, exploration and public evaluation of ideas. There is no restriction to self-expression as members' pool ideas in a cooperative task of understanding an issue and learning from each other.

Nwanekezi and Arokoyu (2014) see discussion method as an interactive process involving a multiple flow of communication between teachers and students and from one student to the other. Discussion method encourages a healthy learning situation if properly moderated by the teacher. It allows for a rich contribution of idea and effective learning occurs when the ideas are intelligently coordinated and harmonized by the teacher. Alamina (2001) suggested that discussion should start with thought provoking questions and elicit students' ideas, their reasoning, their feeling etc. Discussion method is a democratic, permissive and collaborative skill. Ogbeba and Adagba assert that discussion method helps learners to be independent and aid discovery of knowledge and also sees the relationship that exists between concepts. Discussion method is used to promote inquiry learning as it equips the students with means of gaining

knowledge through active participation and develops their minds by using it to solve problems. Nevertheless, Jegede (2012) opines that apart from the fact that the method consumes time, it increases communicating skills, critical and reflective thinking. Achuonye and Ajoku (2013) asserts that when the teacher is weak, the discussion may get out of control and drag for too long and get off the topic of discussion and the bright students outshine the weak ones. For this method to be effective, the teacher should create an enabling environment that is friendly, devoid of threats and humiliation. The teacher should pull the ideas together for the final summary.

Examining one of the independent variables considered in this investigation, Edomwonyi and Avaa (2011) carried out a work on the challenges of effective teaching of Chemistry and concluded stated that the type of institution has an active role to play in the performance of undergraduate Chemistry students. Edomwonyi and Avaa were able to illustrate that the attitudes and professionalism of the teachers in Chemistry are factors that should also be considered. Furthermore, most universities do not have enough lecturers in physical, organic and inorganic Chemistry. Chemistry workshop and laboratory adequacy was also pointed out by them. In a similar venture, Abraham (2011) also reported that the attitudes and professionalism of the teachers plays an active role in teaching and learning Chemistry.

Chinda and Ikiroma (2020) studied undergraduate students mastery and use of standard nomenclature in Rivers State and found out that students in Rivers State University and University of Port Harcourt exhibited moderate mastery in the use of conventional nomenclature and units in Chemistry while students in Ignatius Ajuru University of Education exhibited poor mastery in the use of conventional nomenclature in Chemistry. University type was not a significant factor influencing undergraduate Chemistry education students' mastery and use of conventional nomenclature in Chemistry. These works were cited to lay credence to the role of university types in the present study, since; university type was one of the independent variable investigated in this study.

At this juncture a brief discourse on the concept of Green Chemistry will suffice since it is the major idea upon which the respondents of this investigation were examined.

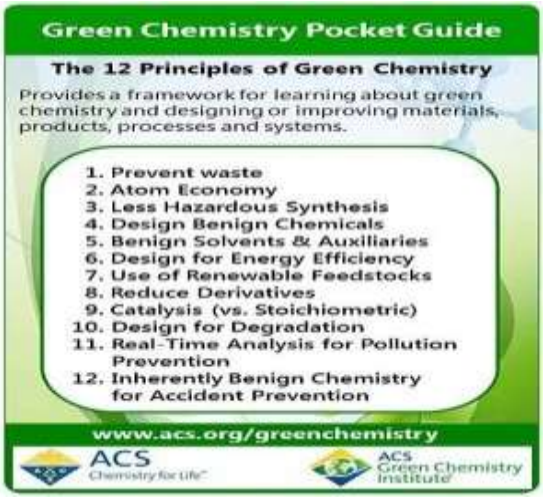
Meaning of Green Chemistry

The term Green Chemistry was coined by Paul T. Anastas in 1991 (Anastas & Warner, 1998). Green Chemistry is the universally accepted term to describe the movement towards more acceptable chemical processes and products. It encompasses education, research and commercial application across the supply chain for chemicals (Anastas & Warner, 1998). Green Chemistry refer to the creation of chemical products and processes that reduces or eliminates the use of production of harmful substances (Ivankovic, Dronjic, Bevanda & Talic, 2017).

Environmental Protection Agency (EPA) of America, defines Green Chemistry as Chemistry that is designed to produce chemical products and processes that are harmless to the environment, thus preventing the formation of pollution. Green Chemistry is the Chemistry which emphasizes the sustainability of the environment. It involves the use of environmental friendly chemicals in carrying out experiments in Chemistry. Kerr (2007) in Chinda (2011) defines Green Chemistry as the utilization of a set of principles that reduces or eliminates the use or generation of hazardous substances in the design, manufacture and application of chemical products. Green Chemistry involves molecular processes. Green or sustainable Chemistry as it is sometimes called was mandated by EPA to produce or design chemicals, chemical process and commercial products in a way that we will avoid the creation of toxics and waste. Saleh and Koller (2018) asserts that the primary purpose of Green Chemistry is the reduction of environmental damage accompanied by the production of materials and respective minimization and proper disposal of wastes generated during different chemical processes.

The major difference between Green Chemistry approach to environmental issues and the more traditional approaches are in the processes from the start rather than relying on regulatory restrictions after the process had produced toxic or pollutant, Green Chemistry advocate processes that will not damage the ecosystems from the very beginning. To achieve this effort, i.e. sustainable Chemistry, the international community, national governments, commercial and non-commercial organizations plus individual action by citizens must be directed towards the effective application of Green Chemistry.

Green Chemistry has to cover broad section of chemical and technological aspects in order to offer alternative vision for sustainable development. For this reason, Paul T. Anastas and John C. Warner jointly, developed the twelve principles of Green Chemistry in 1991. The twelve principles of Green Chemistry and their application to basic and applied research is briefly described below. These twelve principles provide the bedrock for the study of Green Chemistry.



1. Prevention Waste

It is better to prevent than to clean or to treat afterwards (waste or pollution). The ability of the chemists to redesign chemical transformation to minimize the generation of hazardous waste is an important first step in pollution prevention. In other to agree with old adage "prevention is better than cure".

2. Atom Economy

It is a method of expressing how efficiency a particular reaction makes use of the reactant atoms. It is better to use all the atoms in a process and those not used end up as waste.

3. Less Hazardous Chemical Syntheses

Green Chemistry must strive, wherever practical to design safer synthetic methods by using less toxic substance as well as products of the synthesis. Less toxic materials mean lower hazards to workers in industry and research laboratories and less pollution to the environment. For example, in the manufacture of polystyrene foam sheet packing material chlorofluorocarbon which contributes to O_3 depletion global warming, have now been replaced by CO_2.

4. Designing Safe Chemicals

This principle is aimed at designing product that are safe and non-toxic.

5. Safer Solvents

We use solvent regularly in our daily lives (cleaning product, nail polish cosmetics etc.) and in chemistry laboratory. Green Chemistry refines the role of solvents. An ideal desirable green solvent should be natural, non-toxic, cheap and readily available.

6. Design for Energy Efficiency

Chemist must recognize that until now there was very little thought to energy requirement in synthetic chemical processes designing more efficient method is a necessity and if possible synthetic method should be conducted at room temperature to reduce energy requirements.

7. Use of Renewable Feed Stocks

This principle seeks to shift our dependence on petroleum and to make products from renewable materials.

8. Reduce Intermediate Derivatives

Chemists must aim for reducing unnecessary derivate (use of blocking group, protection/de-protection) because such steps require additional regents and can generate more waste.

9. Catalysis

Catalysts are used to alter the rate of a reaction and the yield product. New catalyst and more emphasis on catalytic process is the future of Green Chemistry techniques.

10. Design for Degradation

Most chemical products and consumer item do not degrade very easily thus causing environmental problems. Green Chemistry aimed at designing product so that at the end of their useful life break down into innocuous materials. E.g. plastic do not degrade in our landfills.

11. Real Time for Pollution Prevention

Pollution prevention is using material processes that reduced or eliminate pollution or waste at the source.

12. Safer Chemistry for Accident Prevention

Raw materials and chemical substances used in chemical process should be safe, their properties and their degradation products to be non-toxic or not dangerous.

Teaching of Green Chemistry

Teachers are the bedrock on which the entire education system is anchored. The success or failure of education and indeed sustainable Chemistry is centered on the teacher. Teaching must be in harmony with practice. Green Chemistry is meant to influence the way we practice Chemistry; be it teaching children, researching a route to an interesting molecule, carrying out an analytical procedure, manufacturing a chemical or chemical formulation or designing a product. The Chemistry teacher should teach the students to practice these twelve principles of Green Chemistry in school and in their everyday life.

Green Chemistry program should lead to sustainability by designing and using the methods in which natural raw materials will be economically processed, rational usage of energy sources, elimination of hazardous gaseous, liquid and solid wastes and by introduction of safety products for man. The broad usages of Green Chemistry achievements will enable us to balance eco-development profitable for society economy and the environment (Lancaster, 2002). The numerous educational materials, available currently on market and on the internet are very useful in everyday teaching of Green Chemistry Principles. Hence, it is in accordance with the above brief that the researchers deem it necessary to investigate into students understanding of Green Chemistry by guided inquiry method in Rivers State

Consequently, to give direction to this investigation the following research questions and hypotheses served as guide for the study.

Research Questions

1 To what extent does the achievement of students taught the concept of Green Chemistry with guided inquiry differ from those taught using discussion method?
2 What is the difference in academic achievement between students of Ignatius Ajuru University of Education (IAUE) and those in Rivers State University (RSU) when taught Green Chemistry?

3 What is the difference in academic achievement between B.Sc degree students taught the concept of Green Chemistry and those of B.Sc.Edu degree student?

Hypotheses

To answer the research questions of the study the following null hypotheses were formulated and tested at 0.05 level of significance.

1. There is no significant difference in academic achievement between student taught the concept of Green Chemistry with guided inquiry method and those taught with discussion method.
2. There is no significant difference in academic achievement between IAUE students taught the concept of Green Chemistry and those taught the same concepts in RSU.
3. There is no significant difference in academic achievement between B.Sc degree students taught the concept of Green Chemistry and those taught the same concept for B.Sc.Ed degree.

II. METHODOLOGY

The study adopted the quasi experimental design of the pre-test post-test nonequivalent control group design. One hundred year two undergraduate Chemistry students of Ignatius Ajuru University of Education (IAUE) and Rivers State University (RSU) both in Rivers State, Nigeria, were randomly selected and assigned into two groups; fifty students for the experimental group (guided inquiry group) and the other fifty students for the control group (discussion group). Three research questions and three null hypotheses guided the study. After four weeks of the teaching of the twelve principles of Green Chemistry, a test instrument titled "Green Chemistry Test-GCT" which is a 36 multiple choice objective test questions which was well validated and had a reliability co-efficient of 0.92 on Cronbach alpha technique were administered to the students in the two groups before and after the application of the teaching strategies on the two groups. Mean, standard deviation and ANCOVA were the statistical tools used for data analysis.

III. RESULTS

The results for each research question and its corresponding hypothesis are presented on the same table and a brief interpretation presented below.

Research Question 1: To what extent does the achievement of students taught the concept of Green Chemistry with guided inquiry differ from those taught using discussion method?

Hypothesis 1: There is no significant difference in academic achievement between student taught the concept of Green Chemistry with guided inquiry method and those taught with discussion method.

The answer to research question 1 and test of hypothesis 1 outcome are as presented in Table 1.

Table 1: Summary of ANCOVA analysis on the difference in academic achievement between guided inquiry and discussion methods

Group	n	$\bar{x}$	SD
Guided Inquiry Method (Exp.)	50	28.82	3.43
Discussion method (con.)	50	19.90	2.25

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	2323.001	2	1161.500	229.911	.000
Intercept	1320.017	1	1320.017	261.288	.000
PRESCORE	333.841	1	333.841	66.082	.000
GROUP	103.839	1	103.839	20.554*	.000
Error	490.039	97	5.052		
Total	62154.000	100			
Corrected Total	2813.040	99			

* Significant, $p < 0.05$ level of significance

From Table 1 above it can be observed that student taught the principles of Green Chemistry using guided inquiry method has a mean of 28.82 and standard deviation of 3.43 while that of discussion method has a mean of 19.19 and standard deviation of 2.25. This shows that students taught with guided inquiry method has a higher mean score than those taught using discussion method. This implies that students in guided inquiry method performed better than their counterparts in discussion method. On further statistical testing via ANCOVA analysis, the result shows a calculate $F_{(1, 97)}$ of 20.554 at P (0.000) < 0.05 level of significance. This means that the F is significant. Therefore, null hypothesis was rejected. This implies that there is significant difference in academic achievement between student taught the concept of Green Chemistry with guided inquiry method and those taught with discussion method in favour of guided inquiry method.

Research Question 2: What is the difference in academic achievement between students of Ignatius Ajuru University of Education (IAUE) and those in Rivers State University (RSU) when taught Green Chemistry?

Hypothesis 2: There is no significant difference in academic achievement between IAUE students taught the concept of Green Chemistry and those taught the same concepts in RSU.

The answer to research question 2 and test of hypothesis 2 outcomes are as presented in Table 2.

Table 2: Summary of ANCOVA analysis on the differences in academic achievement between IAUE Chemistry students and RSU Chemistry students

University	n	$\bar{x}$	SD
Ignatius Ajuru University of Education (IAUE)	42	28.79	3.36
Rivers State University (RSU)	58	29.66	2.18

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	300.110	2	150.055	32.168	.000
Intercept	1397.496	1	1397.496	299.587	.000
PRESCORE	281.694	1	281.694	60.388	.000
UNIVERSITY	14.356	1	14.356	3.078	.083
Error	452.480	97	4.665		
Total	86543.000	100			
Corrected Total	752.590	99			

Not significant, p > 0.05 level of significance

The result in Table 2 reveals that the mean and standard deviation of Ignatius Ajuru university of Education (IAUE) is 28.79 and 3.36 respectively while those of River State University (RSU) are 29.66 and 2.18. This revealed that students in the two schools performed equally well in the concept of Green Chemistry. The ANCOVA analysis showed that the calculated $F_{(1, 97)} = 3.078$ at P (0.083) > 0.05 level of significance which is an indication that the F value is not significant. The null hypothesis is therefore accepted. This implies that there is no significant difference in academic achievement between IAUE students taught the concept of Green Chemistry and those taught the same concepts in RSU.

Research Question 3: What is the difference in academic achievement of B.Sc degree students taught concept of Green Chemistry and those of B.Sc.Edu degree student?

Hypothesis 3: There is no significant difference in academic achievement between B.Sc degree students taught the concept of Green Chemistry and those taught the same concept in B.Sc.Ed degree.

The answer to research question 3 and test of hypothesis 3 outcomes are as presented in Table 3.

Table 3: Summary of ANCOVA analysis on the differences in academic achievement between B.Sc degree students and B.Sc.Ed degree students

Degree	n	$\bar{x}$	SD
B.Sc	40	28.83	3.411
B.Sc.Ed	60	21.38	4.179

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	2259.919	2	1129.960	198.159	.000
Intercept	1497.666	1	1497.666	262.644	.000
PRESCORE	930.838	1	930.838	163.240	.000
DEGREE	40.757	1	40.757	7.148*	.009
Error	553.121	97	5.702		
Total	62154.000	100			
Corrected Total	2813.040	99			

* Significant, p < 0.05 level of significance

From data analysis using ANCOVA in Table 3 above the F-value is 7.148 obtained at 1 and 97 degrees of freedom with a P value of 0.009 which is lesser than the 0.05 level of significance which means that the F value is significant. The null hypothesis is rejected meaning that there is significant difference in the achievement between B.Sc degree students taught the concept of Green Chemistry and those taught the same concept in the B.Sc Ed degree in favour of those in B.Sc degree.

IV. DISCUSSION OF FINDINGS

In other to determine the effect of guided inquiry and discussion methods of teaching on student's academic achievement in the principles of Green Chemistry, two groups of students were taught the principles of Green Chemistry. One group was taught using guided inquiry method and another group taught using discussion method. The findings of the study reveal that students in the guided inquiry method significantly differ from that taught using discussion method. The significant result is because guided inquiry method is a technique where a teacher provides language items and helps the learner to find the rules themselves. It enables the student to gain knowledge through active participation and develop their mind by using it to solve problems. The result of the study is in agreement with what Cornel (2014) found out that guided inquiry method increases performance in practical Chemistry and the students were better at became self-directed learners. In the same vein, Vlassi and Karaliota (2013) asserted that guided inquiry is significantly supreme to traditional method for the teaching of the structure of matter. Similarly, Nwafor and Nwanekezi (2018) found out that guided inquiry significantly affects student academic performance in acid-base reaction. The work of Bromfield-lee (2019) also buttresses the efficacy of guided inquiry in teaching the principles of Green Chemistry.

From the result of Table 2 of this study there is no significant difference in academic achievement between IAUE students taught the concept of Green Chemistry and those taught the same concept in RSU. The result agrees with what Chinda and Ikiroma (2020) found out as it concerns university type. In their study, they found out that university type was not a significant factor influencing undergraduate Chemistry Education student mastery and use of conventional nomenclature in Chemistry. However, the finding disagrees with Edomwonyi and Avaa (2011) who found out that type of institution has an active role to play in the performance of undergraduate student in Chemistry.

The third concern is the type of degree. The result in Table 3 shows that there is significant difference in academic

achievement between B.Sc degree students taught the concept of Green Chemistry and those taught the same concept studying for a B.Sc Ed degree. The students in B.Sc. degree performed better than students in the B.Sc. Ed.

VI. CONCLUSION AND RECOMMENDATIONS

The study investigated Chemistry by guided inquiry and students' academic achievement in tertiary institutions in Rivers state. Guided inquiry is a learner centered strategy where the teacher helps the learner to develop the 3Hs; the head, the heart, and the hand. It is a constructive instructional design model that combines principles from discovery learning and radical constructivism with the principles from cognitivist instructional design theory. The study reveals that guided inquiry method is more effective than discussion method in undergraduate students understanding of the principles of Green Chemistry which leads to sustainable development and greener experiments. In addition, university types do not influence students' achievement and understanding of Green Chemistry but the degrees of study do influence students' achievement and understanding of Green Chemistry. It is therefore recommended that:

- Guided inquiry should be adopted by university lecturers in delivery their lessons especially in the teaching of concepts such as Green Chemistry.
- The curriculum contents of the B.Sc.Ed degree programme should be enriched by curriculum planners with themes and concepts that promote the study of Green Chemistry in all its ramifications.

REFERENCES

[1] Abraham, T.W. (2011). Challenges of Teaching Chemistry. *Open Access and Academic Journal*, 2(1), 61-70.

[2] Achuonye, K.A. & Ajoku, L.I. (2013). *Foundations of curriculum development and implementation*. Port Harcourt: Pearl Publishers.

[3] Ajienka (2019*). Blessed are the Teacher*. A paper presented at the 10th Anniversary of Ignatius Ajuru University of Education Port Harcourt Rivers State Nigeria 20th August, 2019.

[4] Alamina, J.I. (2001). *Fundamentals Principles of Science Teaching and Learning.* Port Harcourt: Votex publishers.

[5] Anastas, P.T & Warner, J.C. (1998). *Green Chemistry Theory and Practice.* Uk: Oxford University Press.

[6] Bromfield-Lee, D.C. (2019). Re-Casting traditional organic experiments into green, guided- inquiry based experiment; Student Perceptions. *Journal of Green Chemistry Letters and Reviews*, 12(2), 1-14.

[7] Chinda, W. & Ikiroma, B. (2020). An investigation of Undergraduate Chemistry Education Student Mastery and Use of Standard Nomenclature in Rivers State. *International Journal of Multidisciplinary Research and Development*, 7(1), 66 -72.

[8] Chinda, W**.** (2011). Culture and Motivation as Determinates of Performance in Chemistry. *African Journal of Professional Research in Human Development*, **7** (3), 60-69.

[9] Chinda, W. (2011). Green Chemistry and Sustainable Development. *Haitan Research Journal on Development Studies*, 9(4), 84 – 87.

[10] Edomwonyi-Ofu, L. & Avaa, A. (2011). The Challenge of Effective Teaching of Chemistry. *Leonardo Electronic Journal of practices and Technologies*, 10(18), 1- 8.

[11] Environmental Protection Agency (EPA) (2020). Guided Discovery Learning. Retrieved 25 March 2020 from www.edutech.wiki.unige.chehttp//www.teachingenglish.org.uk/article-presenting-newlanguage

[12] Ivankovic, A., Dronjic, A., Bevanda, A.M. & Talic, S. (2017). Review of 12 Principles of Green Chemistry in Practice. *International Journal of Sustainable and Green Energy*, 6(3), 39-48.

[13] Jegede, S.A. (2012). Nigeria Students' Perception of Technical words in Senior Secondary School Chemistry Curriculum. *Pakistan Journal of Education*, 5(3), 205-220.

[14] Kuhthau, C.C., Manioks, L.K. & Caspari, A.K. (2018). Guided inquiry learning in the 21st century. Retrieved from http://aes-as-in-ubguides.comk.php?=768531.

[15] Lancester, M. (2002). *Green Chemistry an Introductory Text*. Cambridge: Royal Society of Chemistry.

[16] Nwafor, C. L. & Nwanekezi, A.U. (2018). Effects of Guided Inquiry and Test Hierarchy analysis model in Cooperative Learning Strategy on Chemistry Students' Performance in Imo State. *European Scientific Journal*, 14(25), 54-62.

[17] Nwanekezi, A.U. & Arokoyu, A.A. (2014). *Teaching Integrated Science Constructively*. Port Harcourt: Soteria Publishing House.

[18] Okoth, R., Keener, J., Laner, M., & Rosado-Flores, P. (2019). A Guided-inquiry experiment: Separation of Five Component Mixture by Liquid-Liquid Extraction and Column Chromatograph. *Journal of Laboratory Chemical Education*, 7(1), 19-21.

[19] Salah, H.E. & Koller, M. (2018). Principles of Green Chemistry. Open access peer reviewed, dio:10.577/intechopen.71191. Retrieved from https://www.intechopen.com/book/greenchemistry/introductory-chapter-principle-of-green-chemistry.

[20] Teague (2016). Discovery through guided inquiry. *Chemistry*. London: Cornel Report Spring.

[21] Ugwu, S.H. (2015). Impact of Guided Inquiry Instructional Strategy on Chemistry Students' Performance in Ikwuato Local Government Area, Abia State, Nigeria. *Journal of Science and Technical Education*, 4(1), 112-125.

[22] Vlassi, M.S. & Karaliota, A. (2013). The comparison between Guided inquiry and Traditional teaching method. A case study for the teaching of the structure of matter to 8th grade Greek students. *Procedia-Social and Behavioural Science*, 93, 494-491.

[23] Wood, H. (2018). Cleaning the cleaning industry: The truth about Green Chemistry. Citizen truth. Retrieved on 30th April 2020 from, https://www.Cleaning%20the%20Cleaning%20Industry%20%20The%20Truth%20About%20Green%20Chemistry%20-%20Citizen%20Truth.htm