IJAAR PUBLISHING®

International Journal of Advanced Academic Research | ISSN: **2488-9849**
Vol. 9, Issue 7 (July, 2023) | www.ijaar.org

GUIDED INQUIRY LABORATORY-BASED INSTRUCTION AND SENIOR SECONDARY STUDENTS' LEARNING OUTCOME IN CHEMISTRY IN RIVERS STATE NIGERIA

BY

ONUEGBU, EDITH CHIZINDU
DEPARTMENT OF CURRICULUM AND INSTRUCTIONAL TECHNOLOGY
IGNATIUS AJURU UNIVERSITY OF EDUCATION PORT HARCOURT NIGERIA

Email: nchelemgeorge@gmail.com

Abstract

This study investigated the effect of guided inquiry laboratory-based instruction on senior secondary school students' learning outcome. The study which was conducted in Port Harcourt Local Government area of Rivers State was guided by four objectives, four research questions and four null hypotheses. Simple random sampling was used to draw a sample of one hundred and fifteen senior secondary class one students from a population of 2,564. The quasi experimental design was employed to present one experimental and one control group. The instrument used to collect data was a validated twenty-five item multiple-choice questions. The test retest method was used to obtain a reliability of 0.82 for the instrument. The experimental group was taught separation technique using the guided inquiry laboratory-based instruction while the control group was taught using the unguided inquiry laboratory-based instruction. Both groups were given pretest, posttest and post posttest. Mean and standard deviation were used to answer the research questions while the analysis of covariance was used to test the hypotheses at 0.05 significant level. The result showed that students taught with guided inquiry laboratory-based instruction had a higher performance and retention than those in the control group with a statistically significant difference. It was recommended amongst others that teachers should endeavor to use guided inquiry laboratory-based instruction to teach students chemistry in schools.

Keywords: Chemistry, student, guided-inquiry, performance, retention.

Published *21/07/2023*
Onuegbu, E.C. (2023). Guided Inquiry Laboratory-based Instruction and Senior Secondary Students' Learning Outcome in Chemistry in Rivers State Nigeria. *International Journal of Advanced Academic Research*, 9(7), 10-21.

Introduction

Science and technology hold the key to the progress and development of any nation. Science in its nature is the pivot to the present and future development in the area of wealth creation, improvement of quality of life, real economic growth and transformation in any society. Scientific progress allows for the efficient production of more and better goods and services. These improved and better goods and services are what prosperity depends on. Scientific progress usually hinges on the level of effectiveness and efficiency of the products of the educational sector (Garion & Davies, 2018). This is so because students who are scientifically inclined study science-based subjects such as physics, chemistry, biology, computer science, mathematics, data processing and the like.

Chemistry is one of the science subjects which is studied in the senior secondary schools. Chemistry is the branch of science that studies the properties and behavior of matter. It is a natural science that deals with the element that make up matter which can be in form of compounds composed of atoms, molecules and ions. Thus, the composition, structure, properties, behavior and the changes that every matter undergo during a reaction with other substances is the hub of studying chemistry.

American Chemical Society (2021) opined that everything we hear, see, smell, taste and touch involves chemistry and chemicals (matter). The reason why chemistry touches everything we do is because almost everything in existence can be broken down into chemical building blocks. Chemistry as an active science component has a vital importance in our world. It stands the central position among the basic sciences and its usefulness can be seen in oil refineries, chemical industries where cosmetics, soap, perfumes, plastic, glass, pesticides, food, clothing and many more products that can bring sustainable development to the nations' economy (Abdulhamid & Abdullahi, 2018). The role which the knowledge of chemistry play in the society cannot be overemphasized thus, the teaching and learning of chemistry should hinge on instructional strategies that are capable of meaningfully engaging students. Given that there are various active and innovative instructional strategies, there seems to be one that is called the laboratory-based instructional strategy.

From the perspective of promoting standard-based chemistry education, the instructional technique or method employed play important role in learning vital ideas and skills if standard education is to become a reality in the nation's educational system. The effective teacher has multiplicity of methods at his disposal and must be prepared to select the ones which will be most effective for leading the learner to desired behavior (Eze et al., 2018). This therefore calls for laboratory-based instruction for the teaching of chemistry concepts.

The laboratory-based instruction according to Akani (2015) is the mode of instruction which consists of student learning activities, under the direction and supervision of a faculty member using instruments, equipment and techniques appropriate to a particular discipline in which the student observe, measures phenomena and conduct experiments. This type of instruction can be likened to the form of learning that takes place through practical experimentation. The American Chemical Society (2021) stated that chemistry is a laboratory science and cannot be effectively taught without a robust laboratory experience for students. The identification, manipulation and general use of laboratory equipment are integral part of the subject. Laboratory-based instruction in chemistry education lends credence to practical work. Practical work in science and chemistry in particular has several purposes which includes, development of practicing skills, specific knowledge and an understanding of the processes of scientific enquiry. This makes it imperative that secondary school chemistry

should be active, interesting and fun by employing laboratory-based instruction. Udemba (2015) asserted that laboratory-based instruction has the potential to contribute to meaningful learning in chemistry.

Being creative as a chemistry teacher is the focus of teaching chemistry by a creative approach professional development (Marshak et al., 2021). This approach builds on creative opportunities for content elaboration, building shared knowledge, inter-personal interaction, both social and individual active learning. Most of the concepts taught in chemistry are expected to be taught using active and engagement activities. Teaching chemistry concepts by placing the students to be passive during instruction makes learning to be ineffective. Research evidences in educational effectiveness of laboratory-based instruction in chemistry has shown that the mode of instruction offers a unique way of instruction, assessment and evaluation.

The laboratory instruction is an integral and important part of learning process used to encourage the development of high order learning and thinking skills such as collaboration, problem-solving, communication, argumentation and metacognition (Hofstein & Hugerat, 2017). The high order thinking skills are the skills that characterizes the 21st century era. Twenty first century skills refer to the knowledge, life skills, career skills, habits and traits that are critically important to students' success in today's society as students move to higher learning, labour market and adult life. The twenty first century skills are considered the most important skills to succeed in today's workplace. These skills are generally used to refer to certain core competencies such as critical thinking, creativity, flexibility, information literacy and technology literacy. Students therefore, need to develop these skills via the scientific method of which laboratory-based instruction is capable of doing.

The use of laboratory-based instruction to carry out implementation of curriculum contents comes in various forms. To this end Ekwe (2019) opined that laboratory-based instruction can broadly be categorized into guided inquiry mode or unguided non-inquiry mode. The guided inquiry mode of laboratory-based instruction is superior to unguided non inquiry mode. Inquiry-based learning method is a process which involves exploration of natural or material world through the use of asking leading questions, making discoveries and testing those discoveries in search for new knowledge. Gupta et al. (2019) asserted that carrying out hands-on activities in the chemistry laboratory is best done by employing the inquiry-based method. This could be attributed to the level at which the society is operationalizing. The world is functioning at a level that expects students improved knowledge in communication, collaboration, critical thinking and problem-solving skills. Guided inquiry is a type of inquiry-based learning where a teacher provides scaffolding to guide the students through their inquiries. The teacher does this by giving students only the goal and the process before, during or after the laboratory instruction.

One of the important skills that the chemistry student should possess is the skill of separation techniques. Chemistry deals with matter, compounds and mixtures of substances. A mixture is composed of two or more types of matter that can be present in varying amounts and can be physically separated by using methods that use physical properties to separate the components of the mixture. Examples of some separation techniques in chemistry are evaporation, filtration, distillation, chromatography, decantation, magnetism and decantation. Sehgal and Arrington (2021) asserted that many of the substances we use everyday were actually once part of a mixture. This implies that someone somewhere separated that substance from the mixture so we could use it. It turns out that many compounds and elements are not found in nature in their pure form, but are found as parts of mixtures, for instance separating salt from water in salt water.

Separating substances from mixtures is an important part of chemistry and modern industry. The purposes of separation of substances are to:

1. Remove unwanted particles
2. Obtain vital substances
3. Obtain pure substances.

It is important to note that separation techniques have gained importance in various fields and industries such as petroleum industry, biotechnology, biochemical processes, forensic science, pharmaceutical industry, chemical industry and medical laboratory. Anastasopoulou (2013) opined that separation processes constitute an integral part of the chemical, oil, food and material processing industries. In today's world, when the need for more purified chemical products becomes even more imperative, proper selection of a suitable separation technique and profound understanding of its operation principles are very important and critical.

With the foregoing, it becomes evident that separation technique is very important in any chemical pursuit. For separation techniques to be deeply understood, students should not be taught by mere verbal instruction which places them in the passive mode or taught in the laboratory with lack of guided inquiry. This study raises a question to address the issue of effectiveness of use of guided inquiry laboratory-based instruction to teach senior secondary school students separation techniques. The researcher asks, can the use of guided inquiry laboratory-based instruction improve the academic performance of senior secondary school students in separation techniques? This study will therefore be carried out to investigate the possible effect that guide inquiry laboratory-based instruction will have on the academic performance of senior secondary school students in chemistry.

Statement of the Problem

The role chemistry plays in technology and national development is acknowledged globally. Consequently, the past decades have witnessed significant reforms in the field of education with emphasis in the objectives of science education shifting from teaching the information aspect with minimal attention to the processes of science to teaching sciences as they relate to real life activities. The process approach to science sees science education as a human enterprise requiring both teachers and students to be actively involved in the teaching and learning process to make both teaching and learning effective, meaningful, explorative and applicable. This process approach of teaching chemistry therefore calls for the use of guided inquiry laboratory-based instruction to teach students chemistry concepts.

By its nature, the laboratory-based instruction is cost intensive and in Nigeria, the harsh economic realities in the country has made it virtually impossible for the government to provide adequate science equipment and facilities for meaningful hands-on activities to take place. This has made teachers continue to teach science, particularly chemistry as a body of abstract knowledge with little or no students involvement in the learning process. Thus, the performance of students in chemistry at both internal and public examinations has persistently remained poor, a general lack of interest on the part of the students to study chemistry and declining enrolment in science has taken the order of the day.

Separation techniques forms a significant part of students' practical work in external examination in chemistry at the senior secondary level in Nigeria. The West African chief examiner's report (2017, 2019, 2020) has published that students' performance in the practical chemistry had remained poor and attributed the performance to students' inadequate exposure to unguided laboratory practical work which lacks inquiry. The question raised

therefore is thus stated; Could inadequate exposure of students to guided inquiry laboratory practical work be the reason behind their poor performance in chemistry? This study therefore proposes to investigate the effect of guide inquiry laboratory-based instruction on students' academic performance in chemistry.

Aim and Objectives of the Study

The aim of this study was to investigate the effect of guided inquiry laboratory-based instruction on the academic performance and retention of senior secondary school students in chemistry. The objectives were to:

1. Find out whether there is any difference between the performance mean score of senior secondary students taught separation techniques with guided inquiry laboratory-based instruction and those taught with unguided inquiry laboratory-based instruction.
2. Ascertain whether any difference exists between the retention mean score of senior secondary students taught separation techniques with guided inquiry laboratory-based instruction and those taught with unguided inquiry laboratory-based instruction.

Research Questions

The following two research questions guided the study.

1. What is the difference in the mean performance scores of senior secondary students taught separation techniques with guided inquiry laboratory-based instruction and those taught with unguided inquiry laboratory-based instruction?
2. What is the difference in the mean retention scores of senior secondary students taught separation techniques with guided inquiry laboratory-based instruction and those taught with unguided inquiry laboratory-based instruction?

Hypotheses

The following two null hypotheses were tested at 0.05 significant level.

H_{O1}: There is no significant difference between the performance mean score of senior secondary students taught separation techniques with guided inquiry laboratory-based instruction and those taught with unguided inquiry laboratory-based instruction**.**

H_{O2}: There is no significant difference between the retention mean score of senior secondary students taught separation techniques with guided inquiry laboratory-based instruction and those taught with unguided inquiry laboratory-based instruction.

Research Design

The study employed the quasi experimental research design. This design entailed a pretest, posttest, non-randomized, non-equivalent control group research design. Two intact groups were presented in this design. One experimental and one control group. The outline of the design is illustrated in Table 1.

Table 1: Outline of the design

Group	Pretest	Treatment	Posttest	Post-Posttest
E	O_1	X_{GILI}	O_2	O_3
C	O_1	X_{UILI}	O_2	O_3

Where:
O_1 = Pretest
O_2 = Posttest
O_3 = Post-Posttest
E = Experimental Group
C = Control Group
X_{GILI} =Taught with Guided Inquiry Laboratory-Based Instruction
X_{UILI} = Taught with Unguided Inquiry Laboratory-Based Instruction

Population of the Study

The population of this study comprised all the 2,564 Senior Secondary Class one (SSC1) students that offer chemistry in the twenty public senior secondary schools in Port Harcourt Local Government Area of Rivers State (Source: Universal Basic Education Commission, 2022).

Sample and Sampling Technique

A sample of one hundred and fifteen (115) senior secondary class one chemistry students was used for this study. A multi-stage simple random sampling technique was used to select the sample from the population.

Instrument for Data Collection

The instrument that was used to collect data for this study was a teacher-made achievement test. The title of the instrument was "Chemistry Separation Techniques Achievement Test" (CSTAT). This instrument was used to measure the performance and retention of students in chemistry. The instrument had a preliminary part where students are to write their class and gender. For anonymity the schools were tagged E (Experimental School) and C (Control School) on the script. Students were also instructed on the preliminary part of CSTAT to answer all the questions. The items of CSTAT were drawn from past examination chemistry questions of West African Examination Council (WAEC) on separation techniques.

Twenty five test-items made up CSTAT. The type of test items that made up CSTAT was the multiple choice questions which had a stem and four options lettered A to D that the students chose from. Out of the four options for each test item, only one was the correct answer while the remaining three were distractors. Each correct response of the students to the test items in the instrument, CSTAT was scored 4 marks while each incorrect answer of the students was scored zero mark. There was no in-between scoring such as 1,2 or 3 for any test item. The total mark for the instrument, CSTAT was one hundred. This made the marking to be in percentage.

Validation of Instrument

The instrument, CSTAT was face and content validated by the supervisor and two other experts in chemistry education. The lesson plans and the instrument CSTAT were given to

them to scrutinize and pass their expertise judgement which was used to review the initial submitted CSTAT. The comments pointed out were used to effect all the corrections which enhanced the instrument. The test items with wrong answers or no answer at all were corrected. The lesson plans were modified based on wrong entry behavior and statement of instructional objectives. All these corrections were made before administering the instrument to the sample.

Reliability of Instrument

The test retest method of reliability was used to establish an internal consistency of 0.82 for the instrument of the study. To do this, a group of twenty students that did not participate in the main study were given the instrument, CSTAT to answer. After a forth night, the same instrument was re-administered to the same group of twenty students. This group of students were not taught before the administration of the instrument to them. The first test and second test were marked in percentage and the scores graded. The Pearson Product Moment Correlation was used to correlate the scores of the first and the second tests. A reliability coefficient of 0.82 that was established indicated that the instrument, CSTAT was reliable for the conduct of the study.

Method of Data Collection

The researcher briefed the intact class teachers who were used as the research assistants on the modality of the research. This briefing was done in one day. A pretest of CSTAT was first administered to the sample students in both the experimental and the control groups. After the administration of the pretest, the scripts were collated, marked and graded in percentage.

The next phase was the teaching of the chemistry content (separation techniques) to both the experimental and the control groups by their intact class teachers in the chemistry laboratory. The intact class teachers were used for the teaching to avoid Hawthorne effect (when sample of an experimental study attempt to change or improve their behavior because it is being studied). The experimental group was taught using guide inquiry laboratory-based instruction while the control group will be taught same content using unguided inquiry laboratory-based instructional mode.

After the teaching, a posttest was given to the two groups. The scripts of the students for the posttest were also collated, marked and graded in percentage. A period of two weeks was allowed after which the sample students were administered a post-posttest of CSTAT. The essence of administering a post-posttest was to measure the retention of the taught chemistry curriculum content. The scripts of the post-posttest of the students were also collated, marked and graded in percentage.

The pretest of CSTAT was reshuffled to obtain a parallel test item that was tagged posttest-CSTAT. The posttest-CSTAT was further reshuffled to obtain a further parallel test tagged post-posttest-CSTAT. The essence of this reshuffling was to avoid the memorization of the test items by the students.

Method of Data Analysis

The research questions were answered descriptively using mean and standard deviation while the null hypotheses were tested inferentially using Analysis of Covariance (ANCOVA) at 0.05 significant level.

Results

Research Question 1: What is the difference in the mean performance scores of senior secondary students taught separation techniques with guided inquiry laboratory-based instruction and those taught with unguided inquiry laboratory-based instruction?

Table 2: Mean and standard deviation on performance mean score of students taught separation techniques with guided and unguided inquiry laboratory-based instruction

		Pretest		Posttest		Performance Gain	
Group	**N**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**
GILI	54	34.85	9.25	58.33	12.63	23.48	12.83
UILI	61	35.47	9.61	47.91	11.21	12.44	8.54

GILI= Guided Inquiry Laboratory-Based Instruction
UILI= Unguided Inquiry Laboratory-Based Instruction

Table 2 showed the mean and standard deviation on performance of students that were taught separation techniques with guided and unguided inquiry laboratory-based instruction. From table 2, it is evident that the students who were taught separation techniques with guided inquiry laboratory-based instruction in the experimental group had a performance mean gain of 23.48, SD = 12.83 and those taught with unguided inquiry-based instruction in the control group had a performance mean gain of 12.44, SD = 8.54. The data analysed in table 2 showed that the students that were taught separation techniques with guided inquiry laboratory-based instruction performed better than those that were taught with unguided inquiry laboratory-based instruction.

Research Question 2: What is the difference in the retention mean scores of senior secondary students taught separation techniques with guided inquiry laboratory-based instruction and those taught with unguided inquiry laboratory-based instruction?

Table 3: Mean and standard deviation on retention of students taught separation techniques with guided and unguided inquiry laboratory-based instruction

		Post-test		Retention		Difference	
Group	**N**	**Mean**	**S.D**	**Mean**	**SD**	**Mean**	**SD**
GILI	54	58.33	12.63	82.53	14.02	24.20	10.12
UILI	61	47.91	11.21	59.86	12.62	11.95	9.54

Table 3 showed the mean and standard deviation on retention of students that were taught separation techniques with guided and unguided inquiry laboratory-based instruction. From table 3, it is evident that the students who were taught separation techniques with guided inquiry laboratory-based instruction in the experimental group had a retention mean gain of 24.20, SD = 10.12 and those taught with unguided inquiry-based instruction in the control group had a mean gain of 11.95, SD = 9.54. The data analysed in table 3 showed that the students that were taught separation techniques with guided inquiry laboratory-based instruction had a higher retention than those that were taught with unguided inquiry laboratory-based instruction.

H_{O1}: There is no significant difference between the performance mean score of senior secondary students taught separation techniques with guided inquiry laboratory-based instruction and those taught with unguided inquiry laboratory-based instruction**.**

Table 4: Summary of ANCOVA on the difference in the performance of students taught separation techniques with guide and unguided laboratory-based instruction

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	4847.40[a]	2	2423.70	38.52	.00	.42
Intercept	6772.02	1	6772.02	107.63	.00	.25
Group	100.52	1	100.52	1.60	.03	.06
Pretest	4662.46	1	4662.46	74.10	.00	.40
Error	7613.38	112	62.92			
Total	461264.00	115				
Corrected Total	12460.77	114				

a.R Squared = .425 (Adjusted R Squared = .406)

Table 4 showed the presentation of the summary of analysis of covariance (ANCOVA) on the difference between the performance of students that were taught separation techniques with guided inquiry laboratory-based instruction and those taught with unguided inquiry laboratory-based instruction. It can be deduced from table 4 that a significant difference exists between the performance mean score of students who were taught with guided inquiry laboratory-based instruction and those who were taught with unguided inquiry laboratory-based instruction F1, 112=1.60, p = .03; p< .05, partial eta squared = .40. H_{O1} was rejected at a probability level of .05 since p-value was less than .05.

H_{O2}: There is no significant difference between the retention mean score of senior secondary students taught separation techniques with guided inquiry laboratory-based instruction and those taught with unguided inquiry laboratory-based instruction.

Table 5: Summary of ANCOVA on the difference in the retention of students taught separation techniques with guided and unguided laboratory-based instruction

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	9386.62[b]	2	4693. 31	236.01	.00	.40
Intercept	999.89	1	999.89	50.28	.00	.27
Group	574.81	1	574.81	28.91	.00	.54
Posttest	8145.29	1	8145.29	409.59	.00	.38
Error	2406.25	112	19.89			
Total	559620.00	115				
Corrected Total	11792.87	114				

a. R Squared = .583 (Adjusted R Squared = .529)

Table 5 showed the presentation of the summary of analysis of covariance (ANCOVA) on the difference between the retention ability of students taught separation techniques with guided inquiry laboratory-based instruction and those taught with unguided inquiry laboratory-based instruction. It can be deduced from table 5 that there is a significant difference between the retention ability mean score of students who were taught with guided inquiry laboratory-based instruction and those taught with unguided inquiry laboratory-based instruction F1,

112=28.91, p = .00; p< .05, partial eta squared = .38. H_{O2} was rejected at a probability level of .05 since p-value was less than .05.

Discussion of Findings

The first finding of the study revealed that the performance of the students that were taught separation techniques in chemistry with guided inquiry laboratory-based instruction was higher than that of their counterpart in the control group that were taught same topic with unguided inquiry laboratory-based instruction. This finding is evident from the analysed data in table 2 which showed the mean and standard deviation on performance of students that were taught separation techniques with and without guided inquiry laboratory-based instruction. From table 2, it is evident that the students who were taught separation techniques with guided inquiry laboratory-based instruction in the experimental group had a performance mean gain of 23.48, SD = 12.83 and those taught without guided inquiry-based instruction in the control group had a performance mean gain of 12.44, SD = 8.54. The data analysed in table 2 showed that the students that were taught separation techniques with guided inquiry laboratory-based instruction performed better than those that were taught with unguided inquiry laboratory-based instruction. This result could be attributed to the effect of the instructional strategy employed. This finding is in line with the findings of Samphina (2022) who investigated the effect of guided laboratory activities on students' academic performance in chemistry and found that exposure of students to guided laboratory activities improved their academic performance and there was significant difference between the academic performance of students exposed to guided laboratory activities and those exposed to unguided laboratory activities. Also in line with this finding is the result of Zudonu and Njoku (2018), Okam and Zakari (2017) whose research findings showed that the guided laboratory approach improved students' performance in chemistry.

Table 4 showed the presentation of the summary of analysis of covariance (ANCOVA) on the difference between the performance of students that were taught separation techniques with guided inquiry laboratory-based instruction and those taught with unguided inquiry laboratory-based instruction. When subjected to statistical analysis, it was deduced from table 4 that a significant difference exists between the performance mean score of students who were taught with guided inquiry laboratory-based instruction and those who were taught with unguided inquiry laboratory-based instruction F1, 112=1.60, p = .03; p< .05, partial eta squared = .40. H_{O1} was rejected at a probability level of .05 since p-value was less than .05. This finding agrees with the findings of Kyakuwa (2017) and Olubu (2015) whose findings revealed that The result showed that there was a significant difference between the students that were exposed to the five dimensions of chemistry laboratory learning environment (materials environment, students' cohesiveness, integration, open endedness, rule clarity) and those taught using conventional teacher expository method.

The second finding of the study revealed that the retention of the students that were taught separation techniques in chemistry with guided inquiry laboratory-based instruction was higher than that of their counterpart in the control group that were taught same topic with unguided inquiry laboratory-based instruction. This finding is evident from the analysed data in table 3 which showed the mean and standard deviation on retention of students that were taught separation techniques with and without guided inquiry laboratory-based instruction. From the table 3, it is evident that the students who were taught separation techniques with guided inquiry laboratory-based instruction in the experimental group had a retention mean gain of 24.20, SD = 10.12 and those taught without guided inquiry-based instruction in the control group had a mean gain of 11.95, SD = 9.54. The data analysed in table 3 showed that the students that were taught separation techniques with guided inquiry laboratory-based

instruction had a higher retention than those that were taught with unguided inquiry laboratory-based instruction.

Table 5 showed the presentation of the summary of analysis of covariance (ANCOVA) on the difference between the retention ability of students taught separation techniques with guided inquiry laboratory-based instruction and those taught with unguided inquiry laboratory-based instruction. It can be deduced from table 5 that there is a significant difference between the retention ability mean score of students who were taught with guided inquiry laboratory-based instruction and those taught with unguided inquiry laboratory-based instruction F1, 112=28.91, p = .00; p< .05, partial eta squared = .38. H_{O2} was rejected at a probability level of .05 since p-value was less than .05.

This result agrees with the findings of Chijioke (2019) who carried out a study on effect of the use of guided laboratory-based on secondary school student's retention in chemistry and found that there was a significant difference between the two groups with respect to retention, which was in favour of experimental group. This finding also agrees with the finding of Kepul et al. (2019), when the hypothesis was subjected to statistical test, the result revealed that there was a significant difference between the retention of students in the experimental group and those in the control group.

Conclusion

Based on the findings of the study it was concluded that the use of guided inquiry laboratory-based instruction in teaching chemistry enhanced the performance and retention of students in chemistry. Students taught separation technique with guided inquiry laboratory-based instruction performed better than their counterparts taught with unguided inquiry laboratory-based instruction. The students taught with guided inquiry laboratory-based instruction had the ability to retain separation technique concept better than those taught with unguided inquiry laboratory-based instruction.

Recommendations

The following recommendations were made based on the findings of the study.

1. Guided inquiry laboratory-based instruction should be employed by teachers to teach students hands-on activities in the laboratory to enhance their performance in taught chemistry concepts.
2. Teachers should engage in continued practice of guiding students during laboratory activities to enhance their retention of taught chemistry concepts.

References

Abdulhamid, A. A., & Abdullahi, Y. (2018). *Entrepreneurship education*. Jenny Printers.

Akani, O. (2015). Laboratory teaching: Implication on students' achievements in chemistry in secondary schools in Ebonyi state of Nigeria. *Journal of Education and Practice, 6*(30), 206-213. https://files.eric.ed.gov

American Chemical Society (2021). By a creative approach. Adapting a teachers' course for active remote learning. *Journal of Chemical Education, 98*(9), 2809-2819. DOI: https://doi.org/10.1021/acs.jjchemed.Oco1341

Anastasopoulou, H.L. (2013). *Ground chemistry*. May and Mar Printing Press.

Chijioke, O.T. (2019). Effect of the use of guided laboratory-based on secondary school student's retention in chemistry. *Chemistry Education Review, 3,* 84-93.

Ekwe, H.A. (2019). *Introduction to chemistry laboratory practical.* Kerry Publishers

Eze, L., Nihu, H.V., & Ibekwe, B.E. (2018). *Principles and practice of teaching*. Kelp Publishers.

Garion, F., & Davies, D. S. (2018). *Science learning in schools*. Kelp Publishers.

Gupta, I. O., Eneh. G., & Onunwor, S.T. (2019). *Creativity and problem-solving skills.* Orange Press.

Hofstein, A., & Hugerat, M. (2017). Teaching and learning in the school chemistry laboratory. Ama Books Press.

Kepul, S., Anayochukwu, O.C., & Iyabowei, U.I. (2019). Effect of laboratory-based instruction on the academic performance of public senior secondary students in chemistry. *Science Teachers' Association Journal, 2*(1), 290-298.

Kyakuwa, J. (2017). The effect of laboratory exposure on students' academic achievement in practically-based subjects in secondary school in Wakaso District Kampala Uganda. https://lir.kiu.ac.ug

Marshak, H. A., Udoh, E., Akpan, F.C., & Nwankwo, T. (2021). Chemistry laboratory report writing. https://www.labwriting_report

Okam, C.C. & Zakari, I.I. (2017). Impact of laboratory-based teaching strategy on students' attitudes and mastery of chemistry in Katsina metropolis. Katsina state Nigeria. *International Journal of Innovative Research and Development, 6*(1), 112-121.

Olubu, O. M. (2015). Effects of laboratory learning environment on students learning outcomes in secondary school chemistry. *International Journal of Arts and Sciences, 8*(2), 507-525.

Samphina, G. (2022). Effect of guided laboratory activities on students' academic performance in chemistry. *Journal of Educational Research and Development, 1*(1), 80-88.

Sehgal, G. & Arrington, D. (2021). Mixture: Characteristics and examples. https://study.com>learn

The West African examination chief examiners' report (2017). http://www.waconline.org

The West African examination chief examiners' report (2019). http://www.waconline.org

The West African examination chief examiners' report (2020). http://www.waconline.org

Udemba, J.G. (2015). *Innovative teaching strategies in chemistry education*. Fisher & Karim Press.

Zudonu, O.C. & Njoku, Z. Z. C. (2018). Laboratory instructional method on students' attitude and performance in some selected chemistry concepts at senior secondary school level. *Global Scientific Journals,* 6(7), 46-61. http://www,globalscientificjournal.com