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Effect of 5e's Inquiry Instructional Technique on Chemistry Students' Skill Acquisition in Delta State

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Abstract

This study sought to x-ray chemistry students' skill acquisition in Delta State. The study was necessitated because of the need to equip future scientists especially chemistry students with the 21st century skills as specified in the curriculum needed to excel in the present day technology driven world. Two research questions and three hypotheses that were tested at 0.05 level of significance guided the study. Quasi- experimental design was used for the study because intact classes were used. The population of the study consisted of all the Senior Secondary School two (SS2) chemistry students in Asaba Educational Zone of Delta State numbering one thousand two hundred (1,200). The sample of the study consisted of two co-educational schools numbering two hundred and ten (210). The two schools were randomly assigned to 5E's inquiry instructional technique and demonstration method of instruction using toss of coin. Hence, it became necessary to expose the male and female chemistry students to an inquiry based instructional technique in order to equip them for the task ahead. The Test of Critical Thinking (TOCT) developed by the researchers and found to be valid and reliable was used for data collection. The groups received pre-test and post-test independently. The research questions were answered using mean and standard deviation while Analysis of Covariance (ANCOVA) was used to test the hypotheses. The findings revealed that 5E's inquiry instructional technique was more efficacious than the demonstration method of instruction in making chemistry students' to acquire critical thinking skills required in this 21st century amongst others. Based on the findings it was recommended amongst others that the government should incorporate 5E's inquiry instructional technique in the senior secondary school curriculum for the teaching of science subjects especially chemistry.

Keyword: Science, Chemistry, 5E's inquiry model, Critical Thinking Skill Acquisition and Demonstration Method

Introduction

Science is both a process (scientific method) and a product (knowledge, fact and principles). Both the process and product of science are acquired through education. Issues challenging the sustainability of man and general wellbeing are evolving. This has necessitated a need to equip current and future citizens in general with the skills to address the rapidly evolving technology needs/challenges of this 21st century (Ezema, 2011) [13]. Chemistry is one of such sciences. It is a branch of science that deals with the study of

the composition, structure, properties and change of matter (Mordi, 2014). Chemistry plays fundamental roles in the economic, scientific and technological development of nations. This is because it is required in the training of chemists, physicists, engineers, pharmacists, doctors, agriculturists and science educators that nations depend on for economic development and progress. Furthermore, Eze (2015) described chemistry as the oracle of modern science. This description is based on the pivotal role which chemistry plays in industrial establishments (fertilizer, petroleum, cement, pharmaceutical amongst other industries), the execution of other professions (example engineering, agriculture, medicine) and the improvement of quality of life of the citizenry. This implies that there is need to ensure that a solid foundation is laid for effective and efficient chemistry education. In fact, the basic knowledge and skills got from chemistry concepts at the secondary school level are needed for sustainable development. Such fundamental skills can be got from titration process and electrochemistry.

Electrochemistry is a branch of chemistry that deals with the chemical action of electricity and the production of electricity by chemical reactions (Alkins, 2006). Petrurei (1998) sees electrochemistry as the study of chemical processes that cause electrons to move. This movement of electrons is called electricity, which can be generated by movements of electrons from one element to another in a reaction known as an oxidation-reduction (redox) reaction. On the other hand titration process involves a neutralization process involving an acid and a base using a pipette and a burette. Echekwube (2009) [9], Obomanor and Onuoha (2012) [6] however noted that students enter the chemistry class with some held misconceptions regarding these topics that tend to affect their understanding of electrochemistry. The misconceptions in electrochemistry that have been noted include; electrons flow in an electrolyte¸ by this, students perceive that since electrons flow in a metallic conductor used during electrolysis, it is also flowing inside the electrolyte (Obomanor & Onuoha, 2012; Echekwube, 2009) [9, 6]. Students also view the movement of ions in solution as not constituting electric current. The students believe that all substances in the liquid state can allow current to pass through them, thus electrocution can occur. Wrong perception of acids and bases is that the calculations are hard and titration process is difficult amongst others. These are wrong non-scientific idea of electrochemical cells which must be erased from the students' minds by exposing them to practical sessions that will make them to think critically. Iwuozor (2013) [16] from the zone under study opined that students have difficulties in understanding the concept of electrochemistry as well as calculating some acid-base questions. Could this difficulties be as a result of lack of practical activities that are meant to equip the students' with critical thinking skills? The quest to answer this question necessitated this study.

Considering the importance of chemistry to man, there is need to equip the students will modern skill such as critical thinking skill. Several research reports (Olodu 2013; Obiekwe, 2008 & Ogbonna, 2003) [30, 27] indicate that many science teachers prefer the traditional methods of teaching and shy away from innovative activity-oriented teaching methods. Such teaching involve the use of conventional teaching methods such as demonstration method that is not learner-centered and does not promote meaningful learning of chemistry concepts such as titration and electrochemistry since students are not actively involved in the learning process.

Critical thinking is a rational thinking in the pursuit of relevant and reliable knowledge about the material world. It is a purposeful, self-regulatory judgement which results in interpretation, analysis, evaluation and inference as well as explanation of the evidential consideration upon which judgement was made (Danladi, 2017) [27]. There is an outcry against below average manpower production characterized by poverty of skills amongst others from educational system (Pollyn, 2014) [31], substantiating the paucity of innovative instructional strategies in our traditional classrooms leading to lack of acquisition of scientific skills. Hence, there is need to expose the chemistry students to an inquiry –based techniques such as the 5E's inquiry instructional technique that involves five (5) stages which are Engagement, Exploration, Explanation, Elaboration and Evaluation that will help to equip the chemistry students with the needed 21st century skills. The engagement phase initiates learning, the exploration phase provides students with a common basic experience within which concepts, processes and skills are identified and developed, explanation phase provides opportunities for teachers to introduce concepts, processes or skills amongst others. The elaboration phase challenges and extends the students' conceptual understanding and skills. Lastly, the evaluation phase encourages students to assess their understanding. This underscores the need for this research.

Gender involves the biological dimension of being a female or male. This has been a crucial matter to the educationists. Providing quality education and skill acquisition for both males and females ensures sustainable development and this is a factor of the instructional methodology. Hence, the problem of the study posed as a question is: what is the effect of 5E's inquiry instructional technique on critical thinking skill acquisition of male and female chemistry students?

Science learning should involve an active participation on the part of the learner (Madu, 2004) [18]. To construct knowledge, the teaching-learning process should be learner centered and inquiry-based involving hands-on and minds-on science activities that will help the learner to develop some scientific skills (Obi, 2003 & Nwosu, 1991) [24]. Some of the activity-based teaching methods/strategies advocated by constructivists include: the concept mapping, co-operative learning, computer animation, 5E's inquiry instructional technique, experimentation among others. Researchers (Okotcha, Eze & Ewuotu, 2025; Nwosu, 2012; Obi, 2003) [24, 28] attested to the efficacy of the 5E's inquiry instructional technique on the achievement of science students. Hence there is need to ascertain the efficacy of 5E's inquiry instructional technique in instilling in chemistry students' critical thinking skill.

Statement of Problem

Research has shown that students have conceptual difficulty in solving acid-base reaction problems as well as electrochemistry questions amongst others. This difficulty may stem from the inability of the chemistry students to think critically erasing some held misconceptions about the concept which have been identified by researchers. Alternative conceptions play a larger role in learning chemistry as well as other sciences. This tends to affect the performance of chemistry students in internal and external examinations and will hamper sustainable development. These misconceptions can only be removed through hands-on and minds-on activities that gives students the opportunity of thinking critically. The traditional demonstration method of instruction amongst others predominantly used in teaching

chemistry do not encourage active participation of learners and acquisition of critical thinking in the teaching-learning process. The 5E's inquiry based instructional technique has been found to foster critical thinking skills among pre-service integrated science teachers in Delta State (Okotcha, Eze & Ewuotu, 2025) [28]. The effectiveness of the 5E's inquiry based instructional technique in bringing about critical thinking skill acquisition by secondary school chemistry students need to be ascertained. Hence the major issue of this study posed as a question is: What are students' critical thinking skill acquisition in chemistry using the 5E's inquiry based instructional technique?

Goals and Objective

The general objective of this study was to find out the effect of 5E's inquiry instructional technique on skill acquisition of chemistry students in Delta State. Specifically, the study sought to determine the:

1. Relative effectiveness of 5E's inquiry instructional technique and the demonstration method of instruction on chemistry students' critical thinking skill acquisition.
2. Influence of gender on chemistry students' critical thinking skill acquisition.
3. Interaction effect of method and gender on chemistry students' critical thinking skill acquisition.

Research questions

1. What is the effect of 5E's inquiry instructional technique and the demonstration method on chemistry students' critical thinking skills acquisition?
1. What is the influence of gender on chemistry students' critical thinking skills acquisition?

Hypotheses

The following hypotheses that was tested at 0.05 level of significance guided the study

H_{o1}: There is no significant difference in the mean critical thinking skill acquisition scores of chemistry students' exposed to 5E's inquiry instructional technique and those exposed to demonstration method of instruction.

H_{02}: There is no significant difference in the mean critical thinking skill acquisition scores of male and female chemistry students when exposed to 5E's inquiry instructional technique and those exposed to demonstration method of instruction.

H_{03}: There is no significant interaction effect of methods and gender on chemistry students mean critical thinking skill acquisition scores in chemistry.

Methodology

The study adopted the quasi-experimental design. Specifically, it is non-equivalent control group design because intact classes were used to ensure that regular class periods are not altered. The intact classes were randomly assigned to experimental group and control group. The study was carried out in Delta State. The choice of the state was based on the emphasis placed on the acquisition of skills by the Government at all levels of education. The population of this study consisted of all the co-educational Senior Secondary School 2(SS2) chemistry students in Asaba educational zone of Delta State numbering one thousand two hundred students (1,200). The sample of the study consisted of two hundred and ten (210) chemistry students in two co-educational secondary schools which were selected using simple random sampling (balloting technique). The two schools were randomly assigned to 5E's inquiry instructional technique and the demonstration method using toss of coin. The instrument for this study was Test of Critical Thinking (TOCT). The Test of Critical Thinking (TOCT) developed by the researchers was used to test students' critical thinking. It consisted of ten (20) questions. The Test of Critical Thinking (TOCT) was constructed by the researchers and validated by experts in science education. The instrument was trial tested by administering the test twice to twenty (20) chemistry students in a zone outside the zone under study who are not originally part of the population of the study. Pearson coefficient of correlation was used to analyze the data and a correlation coefficient of 0.82 was got which indicates that the instrument is reliable. Before the experiment, researchers with the help of the research assistants administered the pre-test to the students in the two groups. After this, the two treatment groups were exposed to the treatment which lasted for five weeks, afterwards the post-test was administered. The research questions were answered using mean and standard deviation while Analysis of Covariance (ANCOVA) was used to test the hypotheses at 0.05 level of significance.

Results

Research Question One: What is the effect of 5E's inquiry instructional technique and the demonstration method on chemistry students' critical thinking skills acquisition?

Table 1: Mean and Standard deviation of pretest and posttest of the effect of 5E's inquiry instructional technique and demonstration method on chemistry students' critical thinking skills acquisition

			Pretest		Posttest		
SN	**Instructional Mode**	**N**	$\bar{X}$	**SD**	$\bar{X}$	**SD**	**Mean difference**
1	5E's model-based inquiry instructional technique	90	44.88	8.997	78.42	7.046	33.54
2	Demonstration method	120	47.57	7.863	57.60	6.318	10.03

Result on Table 1 shows that for each of the groups, the post-test mean scores were greater than the pretest mean scores with the students exposed to the 5E's inquiry instructional technique having a higher mean gain (33.54 > 10.03). This is an indication that the 5E's inquiry instructional technique improved chemistry students' critical thinking skills than the demonstration method of instruction.

Hypothesis One

H_{01}: There is no significant difference in the mean critical thinking skill acquisition scores of chemistry students' exposed to 5E's inquiry instructional technique and those exposed to demonstration method of instruction.

Table 2: Analysis of Covariance (ANCOVA) of the difference between the mean critical thinking skill acquisition scores of chemistry students' exposed to 5E's inquiry instructional technique and those exposed to demonstration method of instruction.

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Dec.
Corrected Model	22796.590[a]	4	5699.147	134.758	0.00	0.724	
Intercept	23447.787	1	23447.787	554.430	0.00	0.730	
Pretest	398.047	1	398.047	9.412	0.00	0.044	
Group	19744.438	1	19744.438	466.864	0.00	0.695	S
Gender	90.013	1	90.013	2.128	0.15	0.010	NS
Group * Gender	6.335	1	6.335	.150	0.69	0.001	NS
Error	8669.791	205	42.292				
Total	960804.000	210					
Corrected Total	31466.381	209					

Note: S = Significant, $\alpha = 0.05$

Table 2 shows an ANCOVA result which compares the 5E's inquiry instructional technique with the demonstration method. The result shows that the effect of instructional technique on students' critical thinking skill acquisition is statistically significant ($F = 466.864$, $p = 0.00 < 0.05$, $\eta^2p = 0.695$). Since the p-value is less than the 0.05 significance level, the null hypothesis (H_{01}) was rejected. Therefore, the study concludes that there was a statistically significant difference in the mean critical thinking skill acquisition scores of students taught using the 5E's inquiry instructional technique compared to those taught using the demonstration method, in favour of the 5E's inquiry technique.

Research Question Two: What is the influence of gender on chemistry students' critical thinking skills acquisition when exposed to 5E's inquiry instructional technique?

Table 3: Mean and Standard deviation of pretest and posttest of the influence of gender on chemistry students' critical thinking skills acquisition when exposed to 5E's inquiry instructional technique

			Pretest		Posttest		
SN	Gender	N	$\bar{X}$	SD	$\bar{X}$	SD	Mean difference
1	Male	28	47.04	8.230	79.50	7.270	32.46
2	Female	62	43.90	9.220	77.94	6.947	34.04

Result on Table 3 shows that for the male and female students, the post-test mean critical thinking skills acquisition scores were greater than the pretest mean critical thinking skills acquisition scores with the female students having a higher mean gain (34. 04 > 32.46). This is an indication that the female students performed slightly higher than the male students.

Hypothesis Two

H_{02}: There is no significant difference in the mean critical thinking skill acquisition scores of male and female chemistry students when exposed to 5E's inquiry instructional technique.

Result from Table 2 shows that the effect of gender was not statistically significant ($F = 2.128$, $p = 0.15 > 0.05$, $\eta^2p = 0.010$).

Hypothesis Three

H_{03}: There is no significant interaction effect of methods and gender on chemistry students mean critical thinking skill acquisition scores in chemistry.

The ANCOVA results on Table 2 show that the interaction between instructional method (Group) and gender was not statistically significant ($F = 0.150$, $p = 0.69$, $\eta^2p = 0.001$). This indicates the effectiveness of the instructional method.

Discussion of Findings

Effects of 5E's inquiry instructional technique and demonstration method of instruction on chemistry students' critical thinking skill acquisition

The result on Table 1 indicate that chemistry students taught with 5E's inquiry instructional technique had a higher mean gain in critical thinking skill acquisition than the control group that was taught with demonstration method of instruction (33.54 > 10.03) as shown in Table 1 and the difference is significant as revealed in hypothesis 1. The chemistry students that used the 5E's inquiry technique displayed higher order thinking skills in answering their questions. Such skills include their ability to analyze situations, evaluate and interpret relationships. Thus, 5E's inquiry technique offered the students more opportunity to think critically than the students that used the demonstration method of instruction. This finding is in line with the study of Okotcha *et al.* (2025) [28] who noted a significant a significant difference in critical thinking skill acquisition of pre-service teachers when exposed to 5E's model-based inquiry technique. This result also aligns with the result of Danladi (2017) [27] who observed that the experimental group that were exposed to Model Based Inquiry (MBI) instructional technique did significantly better than the control group taught with conventional inquiry (CI). Consequently, chemistry students in the 5E's inquiry group performed better than those that used the demonstration method having more of the ability to identify central issues and assumptions in an argument, recognize important relationships, make correct inferences from data, deduce conclusions, interpret whether conclusions are warranted on the basis of the data given and evaluate evidence. Critical thinking skill is very necessary in this century because it enables students to deal with practical, social and scientific problems.

Influence of gender on chemistry students' critical thinking skill acquisition

The result of the findings as shown in Table 3 indicates that the female chemistry students performed slightly better than their male counterparts in the acquisition of critical thinking skills (mean gain 34.04 > 32.46). However, the test of hypothesis two shows that there was no significant difference in the mean critical thinking skill acquisition rating of male and female when taught with 5E's inquiry instructional strategy. This result indicates that gender is not a significant factor in determining students' critical thinking skills in chemistry. The findings of this study is similar to that of Heong, Yunos and Hassan (2011) which showed no higher order thinking skill existed between male and female technical education students in higher education. The study of Okotcha, Eze and Ewuotu (2025) [28] also throws more weight to the efficacy of 5E's inquiry technique in providing equal opportunities for the males and female students. The non - existence of significant gender influence on the acquisition of critical thinking skill as revealed by this study indicates that the 5E's inquiry instructional technique offered

unique and equal opportunity devoid of the influences of socio-cognitive and stereotypical orientations for both males and female chemistry students to become stimulated/excited in the manipulative activities culminating into the development of critical thinking skills. These attributes eventually promote students' cognitive, higher order thinking skill and learning satisfaction. This result supports the position of Piaget, Dewey and Vygotsky in the construction of authentic knowledge. Critical thinking skills are crucial in this millennium because it enable students to deal effectively with social, scientific and practical problems. Mere having knowledge or information is not enough to be effective in the workplace (and in personal life), students must be able to think critically and solve problems to make effective decisions and inputs. Hence, the instructional strategy provided the environment where all students irrespective of their gender actively participated in the learning process. Hence, this is in line with the sustainable development goal.

Interaction effect of treatment and gender on chemistry students' critical thinking skill acquisition

The outcome of this study as shown in Table 2 showed that there was no significant interaction effect of strategy and gender on chemistry students' critical thinking skill. This means that the inquiry technique used had constant effect on the critical thinking skill acquisition of chemistry students independent of their gender. This could be explained by the fact that both male and female chemistry students were provided with equal environment to operate and this environment was gender friendly and all students benefitted from it. Hence, acquisition of more critical thinking skills by the students using the 5E's inquiry instructional technique was mainly due to the treatment. The absence of interaction effect of method and gender on the students' critical thinking skill acquisition indicated that the strategy benefitted both male and female chemistry students equally in terms of critical thinking skill acquisition.

Conclusion

From the foregoing discussions based on the findings of the study, 5E's inquiry instructional technique improved male and female chemistry students' critical thinking skill acquisition. There was no significant difference in the mean critical thinking skill acquisition of male and female chemistry students' when taught with 5E's inquiry instructional technique. Finally, the interaction effect of instructional strategies and gender on chemistry students' mean critical thinking skill acquisition score was not statistically significant. This means that gender did not interact with the instructional strategy to affect chemistry students' critical thinking skill acquisition. Hence, critical thinking skill acquisition of the concepts under study was due to the specific treatment that was given.

Recommendations

Based on the findings reached in this study, the following recommendations are made:

1. 5E's inquiry instructional technique should be incorporated in the senior secondary school curriculum as one the instructional techniques for the teaching of science subjects in general and chemistry in particular.
2. Train –the-Trainer courses should be organized for the science teachers as regards the use of 5E's inquiry instructional technique in teaching. This will make the teachers to acquire the nitty-gritty involved in using the instructional technique as well as other innovative strategies.
3. The National Commission for Colleges of Education (NCCE) charged with the responsibility of training teachers should incorporate 5E's inquiry instructional technique in the Nigeria Certificate of Education (N.C.E) minimum standard as part of the strategies for teaching the pre-service teachers especially those in the sciences.

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