



Examining the effect of Inquiry Teaching Method on Student Achievement in Writing and Balancing Chemical Equations

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Abstract.

The study examined the impact of the Inquiry Teaching Method on student achievement in writing and balancing chemical equations, using a quasi-experimental design. The population comprised 6,011 SS 1 chemistry students in 64 public secondary schools in Awka Education Zone, with 3,046 male and 2,965 female students. A sample of 195 SSI chemistry students from Awka educational zone, Anambra state, was obtained using multi-stage sampling procedure. Achievement Test in Writing and Balancing of Chemical Equation (ATWBCE) developed by the researcher was used to collect the pertinent data for the study. The internal consistency reliability coefficient of the validated ATWBCE of $r=0.84$ estimated inter-rater reliability (Kendall). Mean and standard deviation were used to answer the research questions while Analysis of Covariance (ANCOVA) was used to test the null hypotheses at 0.05 level of significant. Findings indicated that the Inquiry Teaching Method significantly enhanced student achievement in writing and balancing chemical equations compared to traditional/lecture teaching methods. Gender is not a significant factor in students' achievement if inquiry teaching method is used context. Furthermore, no significant interaction effect was observed between gender and the Inquiry Teaching Method on students' academic achievement. It was recommended that inquiry method needs to be emphasized by teachers of chemistry education to foster a more engaging and participatory learning environment, in enhancing student achievement.

Keywords: Chemical Equations, Gender, Inquiry Teaching Method, Student Achievement.

Introduction

Chemistry is one of the basic science subjects needed for sustainable development. Chemistry knowledge provides a natural link between home and school and the means through which student understand the world around them and explore the wider implications of science in relation to man (Umahaba, 2018). Chemistry is one of the science subjects that play a significant role in society. It's importance in the society cannot be over emphasized. It prepares students for the world of work through carrier opportunities such as chemical engineering, medicine, pharmacy, food science, and environmental studies (Mahdi, 2014). The medium of expression in chemistry is the chemical equation because formulae show chemistry at a standstill, while equation shows chemistry in action. Balancing of chemical equation is one of the initial topics taught in most preliminary chemistry courses (Hamid, 2019). The writing and balancing of chemical equation are of basic need as it is a means of communicating chemistry language especially the

overall reaction. When a student cannot write and balance chemical equation, he cannot communicate effectively within the chemistry community thereby learning of chemistry will become a problem to the student. A balanced chemical equation is an equation in which the total number of atoms of each element is the same on both sides of the equation (Zabadi & Assf, 2017).

In spite of the importance of writing and balance of chemical equation in the learning of chemistry, many chemistry teachers and students respectively have difficulties in the teaching and learning of the topic (Njoku 2017). The difficulties encountered by the students could be as a result of some errors made by students in writing and balancing of chemical equation. The nature of errors made by students in writing and balancing of chemical equations includes the following; Wrong symbol, wrong chemical formula, ignorance of valency, and so on, which are



contributed on how the concept is been taught to the students.

The use of the traditional lecture method for teaching all topics in chemistry has been found to be counter-productive and resulting in poor achievement in chemistry in external examination, like West African Examination Council. The West African Examination Council [WAEC, (2012)], stated that "the traditional lecture method is often ineffective in teaching chemistry". The report also states that "the lecture method can be boring and passive, and it does not allow students to engage with the material in a meaningful way". Some methods of teaching, like the use of inquiry in teaching is more effective than lecture method in a given circumstance.

Inquiry teaching method is a method that allows active participation of students in the learning process. Inquiry teaching method allows learners to play an active role starting from the problem statement, data collection and processing, data verification to concluding their findings (Yerizon, Putra & Subhan, 2018). Savery (2015) opined that the inquiry process means that students are introduced to open-ended questions, to which there are several possible solutions, which enhances their knowledge of a subject. Inquiry-based learning triggers students' curiosity.

This research study aims to address the limitations of traditional teaching methods in writing and balancing chemical equations. Specifically, it focuses on examining the effect of the Inquiry Teaching Method on student achievement in considering the influence of gender as an additional factor.

Traditional teaching method in writing and balancing of chemical equation often focus on rote memorization and passive learning, leading to limited skill development and understanding. This study aims to examine the effectiveness of the inquiry teaching method in addressing these challenges and improving students' achievement in writing and balancing of chemical equations.

The general purpose of the study is to Examine the effect of Inquiry Teaching Method on Student Achievement in Writing and Balancing Chemical Equations

Research Questions.

The following question are posed to guide the study

1. What are the mean achievement scores of chemistry students taught writing and balancing of chemical equations using inquiry teaching method and those taught using traditional teaching method.
2. What are the mean achievement scores of male and female chemistry students in writing and balancing of chemical equations?
3. What is the interaction effect of instructional methods and gender on students' achievement in writing and balancing of chemical equations?

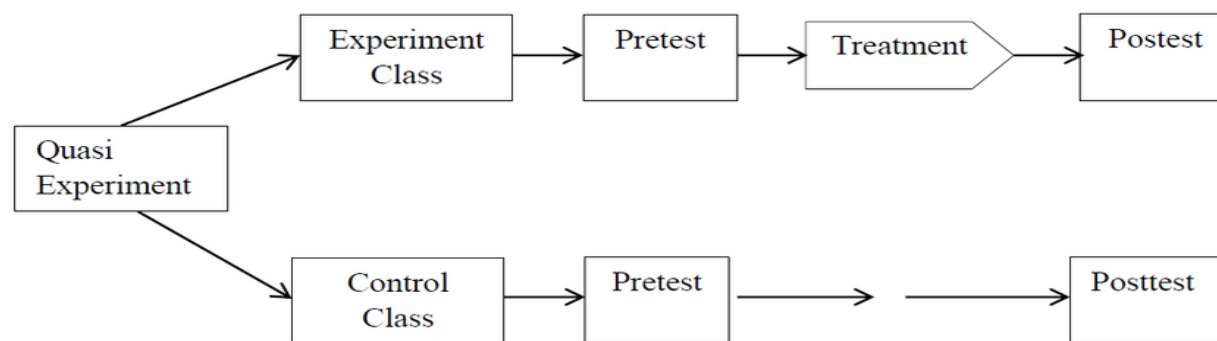
Hypotheses

The following null hypotheses were formulated to guide the study and will be tested at 0.05 level of significance.

- H0₁:** There is no significant difference in the mean achievement scores of chemistry students taught writing and balancing of chemical equations using inquiry teaching method and those taught using traditional teaching method.
- H0₂:** There is no significant difference in the mean achievement scores of male and female chemistry students in writing and balancing of chemical equations.
- H0₃:** There is no significant interaction effect of instructional methods and gender on students' achievement in writing and balancing of chemical equations.

Research Method

The study employed Quasi-Experimental Design with pre-test, posttest non equivalent control research design. This design made use of intact classes, as students were assigned to two groups: an experimental group receiving inquiry-based teaching and a control group receiving traditional instruction. Both groups take pre-tests in writing and balancing chemical equations before the intervention and post-tests afterward. This allows to compare the achievement gains of each group and attribute them to the inquiry method with some degree of confidence.



The population of the study comprise of 6,011 SS 1 chemistry students in all the 64 public secondary schools in Awka Education Zone. The population consists 3,046 male and 2,965 female students (Post primary schools service commission, Awka. Termly statistics of Anambra State Secondary Schools as at third term 2022/2023 academic session).

The sample size for this study is 195 SSI chemistry students in Awka educational zone of Anambra state. The study adopted multi-stage sampling procedures. The selection of the sample is done in three stages; firstly, simple random sampling technique (by balloting with replacement) was used to select three out of the five Local Government Areas in the Zone and this is to make sure that each member of the population has equal chance of being selected. Secondly, purposive sampling technique was used to select the 32 co-educational schools from the three Local Government Area sampled. The choice of the co-educational schools is because gender is a variable in the study. Thirdly, simple random sampling through balloting without replacement is used to select four (4) schools from the co-educational public secondary schools. One intact class of SS1 students will be sampled from each of the four (4) co-educational public secondary schools giving a total of four intact classes for the study, the choice of the co-educational schools is because gender is a variable in the study. Two of the intact classes is assigned to experimental group (inquiry teaching method) while the other two is assigned to control group (traditional teaching method).

The instrument used for data collection in this study was Achievement Test in writing and balancing of Chemical Equation (ATWBCE) developed by the researcher. The ATWBCE is made up of forty (40) essay questions test designed items to test the students' achievement in writing and balancing of chemical equation. The achievement test was constructed based

on the senior secondary one (SSI) chemistry syllabus. The ATWBCE items were spread over six sub-topics as follows: Writing of chemical symbol, States of matter, Chemical formula of compounds, Coefficients/stoichiometry, Chemical equation, use of sign (+, arrow). It is a researcher developed instrument. In scoring the test, each of the questions carries one and half marks, giving a total of hundred (100) marks in all.

The instrument (ATWBCE) was subjected to face and content validations. It was done by giving the instrument and lesson plan to three experts in department of Science Education, two from Chemistry Unit and one from Measurement and Evaluation in the science education department, all from Science Education, University of Nigeria Nsukka. The experts were requested to examine the instrument based on scope of coverage, clarity of the questions, relevance of the questions to the student's level of understanding, ambiguity and vagueness of expression as well as agreement in addressing the purpose of the study.

The experts modify the topic, and also suggested that the stages of inquiry methods should be involved in the lesson plan. Their comments and suggestions were incorporated into the final draft of Achievement Test in writing and balancing of chemical Equation (ATWBCE). To ensure content validity of the instrument, a table of specification was designed.

The researcher administered the final draft of ATWBCE to thirty (30), SSI chemistry students in Awka education zone who were not part of the sampled schools but shared similar characteristics as that of those in the Awka education zone using the test re-test method. The trial testing was done to establish the internal consistency of the instrument using inter-rater reliability (kendall). A reliability co-efficient of $r=0.84$ was obtained which was considered adequate for the research. Kendell's was used because it is an



appropriate correlation technique when there are more than two raters.

Before the commencement of the experiment, the pre-test was administered to the students in the different experimental groups. This enabled the researcher to know the achievement status of the subjects before treatment. The students in their different groups were taught by their regular chemistry teachers under the supervision of the researcher. The two lesson plans prepared by the researcher (inquiry teaching method and traditional teaching method lesson plan) were used by the teachers for the different groups.

The researcher organized a uniform training for the research assistants that will be involved in this study. This helps to control the teachers' variable. The

topics within the content scope was taken care of during the training session. Also, the researcher clarified the research assistants on any misconceptions that might introduce errors during the course of the experiment.

Research questions were answered using mean and standard deviation, while the hypotheses were tested using Analysis of Covariance (ANCOVA) at 0.5% level of significance. This is because intact classes were used and ANCOVA will takes care of the error of initial difference in the ability levels among the research subjects. The pre-test scores were used as covariates for students' achievement. Decision rule; reject the null hypotheses if the calculated value is greater than the critical value. Otherwise, do not reject.

Results

Table 1: mean and standard deviation (SD) of mean achievement scores of students taught writing and balancing of chemical equation using Inquiry teaching method and those taught using traditional teaching method.

Groups	Pre-test			Post-test		
	N	\bar{X}	SD	\bar{X}	SD	Gain Score
Experimental	96	48.58	6.16	76.29	5.49	27.71
Control	99	48.95	5.81	66.27	11.58	17.32

Table 1. above revealed that experimental group has a pretest mean score of 48.58 with a standard deviation of 6.16 and posttest mean score of 76.29 with a standard deviation of 5.49 while the control group has a pretest mean score of 48.95 with a standard deviation of 5.81 and posttest mean score of 66.27 with a standard

deviation of 11.58. The posttest mean for each of the groups shows that students in the experimental group achieved significantly better than their control group counterpart. This shows that inquiry teaching method enhances students' academic achievement.

Table 2. the mean and standard deviation of the mean achievement scores of male and female chemistry students in writing and balancing of chemical equations?

Treatment	Gender	Mean	Std. Deviation	N
Experimental	Male	77.2885	5.73375	52
	Female	75.1136	5.00797	44
	Total	76.2917	5.49434	96
Control	Male	56.8095	7.20514	42
	Female	56.3860	6.05851	57
	Total	56.5657	6.53743	99



Total	Male	68.1383	12.07023	94
	Female	64.5446	10.88258	101
	Total	66.2769	11.58141	195

Table 2. above revealed that male in the experimental group has a posttest mean score of 77.29 with a standard deviation of 5.73 and the female counterpart had a mean of of 77.11 with a standard deviation of 5.00.

With the mean of 77.29 for male and 75.11 for the female students in the experimental group, it shows that

gender has no significant influence on student's achievement.

The result in the table 2 above shows no significant interaction effect of instructional methods and gender on students' achievement in writing and balancing of chemical equations.

Table 3. The analyses of co-variance (ANCOVA) of the post-test performance of students by treatment and gender

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	19181.240 ^a	4	4795.310	133.207	.000	.737
Intercept	10207.627	1	10207.627	283.553	.000	.599
Pretest	99.284	1	99.284	2.758	.098	.014
Main Effect						
Treatment	18531.401	1	18531.401	514.776	.000	.730
Gender	71.914	1	71.914	1.998	.159	.010
Interaction Effect						
Treatment * Gender	54.261	1	54.261	1.507	.221	.008
Error	6839.806	190	35.999			
Total	882584.000	195				
Corrected Total	26021.046	194				

a. R Squared = .737 (Adjusted R Squared = .732)

The results suggest a significant difference in mean achievement scores, favoring the Inquiry Teaching Method over the Traditional Teaching Method. (F(1,190) =514.776, P <.05, η^2 = .730). the effect size (Partial Eta Squared) of 73% was good. Therefore, the null hypotheses is not accepted.

The result in table 3 above indicates that the Gender variable does not have a significant effect on posttest achievement scores, with an F-value of (F(1,190) =1.998, and a p-value of .159 (P <.05, η^2 = .010). The effect size is 10%. Therefore, the null hypotheses H₀₂ is accepted.

The result in table 3 above indicates that there was no significant interaction effect of treatment (inquiry teaching method) and gender on students' academic achievement scores in writing and balancing of chemical equations with F-value of (F(1,190) =1.507, and a p-value of .221 (P <.05, η^2 = .008). the

effect size of 8%. Therefore, the null hypotheses H₀₃ is accepted.

Discussion

The study aimed to investigate the effect of Inquiry Teaching Method on student achievement in writing and balancing chemical equations. The results suggest a significant positive impact of the inquiry teaching method on students' academic achievement in this area. The experimental group, exposed to the inquiry teaching method, outperformed the control group, which received traditional teaching. This finding aligns with the literature suggesting that inquiry-based learning enhances student engagement and understanding (Savery, 2015; Wolpert-Gawron, 2016).

Moreover, the study did not find a significant gender difference in students' achievement in writing and balancing chemical equations. The results indicated no significant interaction effect, implying that the impact of the inquiry teaching method was consistent



across genders. This finding is crucial as it suggests that the benefits of the inquiry teaching method apply uniformly to both male and female students. The research addressed a critical issue in chemistry education – the need for effective teaching methods to improve student performance, especially in writing and balancing chemical equations. The identified errors made by students, such as wrong symbols, chemical formulas, and coefficients, underscore the importance of targeted instructional methods to address these challenges. The finding is in agreement with the result obtained by Oladejo, 2018 which showed that interaction effect of instructional approaches with gender on students' achievement in Chemistry was not significant. Contrarily, the study of Agboghroma (2015) revealed a significant interaction effect of instructional approach with gender on students' academic achievement in basic science.

Conclusion:

The study provides empirical evidence supporting the effectiveness of the Inquiry Teaching Method in enhancing students' achievement in writing and balancing chemical equations. The inquiry-based approach fosters active student participation, curiosity, and a deeper understanding of the subject matter. Importantly, the benefits of this teaching method extend to both male and female students, contributing to gender-neutral academic outcomes in this domain. Based on the findings, the following recommendations are suggested:

1. **Integration of Inquiry Teaching Method:** Educators and curriculum developers should consider incorporating the inquiry teaching method into chemistry instruction. This could involve training teachers in inquiry-based pedagogy and providing necessary resources for its implementation.
2. **Professional Development:** Chemistry teachers should undergo continuous professional development to familiarize themselves with innovative teaching strategies. Workshops, seminars, and training programs can enhance teachers' skills in implementing inquiry-based learning effectively.
3. **Curriculum Review:** Educational authorities should consider reviewing and updating the chemistry curriculum to emphasize student-centered and inquiry-based learning approaches. This can help address the

shortcomings of traditional lecture methods, as identified by previous examination reports.

4. **Further Research:** Future research could explore the long-term effects of the inquiry teaching method on students' retention of knowledge and their performance in advanced chemistry topics. Additionally, investigating the impact of other variables, such as students' prior knowledge and teacher experience, could provide a more comprehensive understanding of effective teaching strategies in chemistry education.

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