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Effect of Problem-Solving Instructional Technique on Secondary School Students' Achievement in Chemistry in Anambra State, Nigeria

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Abstract:

The study investigated the effect of Problem-Solving instructional technique on students' achievement in chemistry in Anambra State. Four research questions and four hypotheses guided the study. The study adopted a quasi-experimental specifically pretest-posttest non-equivalent control group design. The population of the study consisted of 541 senior secondary school two (SS2) chemistry students in Awka South local government area. A sample consisting of 87 chemistry students from the two sampled schools was used for the study. The design of the study was quasi-experimental. Chemistry Achievement Test on Electrolysis (CATE) was used as instrument for data collection. Reliability estimate of 0.79 was obtained on CATE using Kuder Richardson formula 20. Mean and standard deviation were used to answer the research questions while analysis of co-variance (ANCOVA) was used to test the null hypotheses at 0.05 level of significance. The result revealed that problem-solving method is more effective in enhancing the students' achievement in chemistry than the conventional lecture method. There was no significant difference on students' achievement in chemistry due to gender. Based on the findings of this study, it was recommended that chemistry teachers should incorporate problem solving technique as one of the methods used in teaching chemistry in secondary school so as to accommodate functional student-centred and activity oriented instructional technique that will make chemistry students good problem solvers.

Keywords: Problem-solving, chemistry, electrolysis, achievement, technique

1. Introduction

The role of chemistry in sustainable development and improvement of life in developing countries cannot be over emphasized. Chemistry is one of the core science subjects in the secondary school curriculum which is relevant in agricultural, industrial and technological development of a nation. According to Ababio (2010), chemistry deals with the study of matter; its composition, properties, uses and the changes which matter undergoes under different conditions. Bamidele and Oloye (2013) stated that the knowledge of chemistry is central to vocation, in health services, pharmaceutical, petroleum, and petro-chemical industries, agriculture, food processing, teaching services and extractive industries relevant for agricultural, industrial and economic development. Therefore, for a developing country like Nigeria to attain scientific and technological advancement, there is urgent need to arouse students' interest and enhance achievement in chemistry at various levels of educational system. The Federal Republic of Nigeria (FRN) (2013), state that secondary education shall provide entrepreneurial, technical knowledge and vocational job-specific skills for self-reliance, for agricultural, industrial and economic development. Hence, the teaching of chemistry should aim at developing in the students those manipulative and experimental skills necessary to make students to be competent and confident in the investigation of the material resources around him/her; so as to enable them acquire the required knowledge relevant for industrial and technological advancement of a nation.

Despite the fact that chemistry holds a central position to other fields of science learning, students perform below average in both internal and external examinations like West African Senior School Certificate Examination (WASSCE), National Examination Council (NECO) and National Business and Technical Examination Board (NABTEB). Studies revealed that academic achievement of students in chemistry at Senior Secondary School Certificate Examination (SSCE) has consistently been very poor and unimpressive (Njoku 2007; Nnamani 2006). Evidence from the Chief examiners report of WASSCE also stipulated a deteriorating achievement trend of candidates in chemistry. (See Appendix A page 84 for the analysis of May/June SSCE Chemistry results of 2009-2015). The report further stressed that the students' poor achievement in chemistry could be as a result of having a shallow knowledge of the subject matter which may be due to lack of understanding of the demand of the problem (question), poor manipulation skill, inability to

make proper observation and teaching method and strategy used by teachers. From the WASSCE chief examiner's report, it could be observed that students with grade A1 to C6 were not many. This, then implies, that few numbers of students had the opportunity of securing admission into science related courses like pharmacy, medicine, physical science, agriculture, science education and technology in the higher institution.

This poor academic achievement in science and chemistry is a disturbance to the government, educationist and science educators. Researches have revealed that efforts have been made on finding the causes or factors responsible for these students' poor academic achievement in chemistry. For example, Bamidele and Oloyele (2013), opined that the poor performance has been traced to several factors which may include the methods of teaching employed by the teacher which is not in line with the methods that involve the use of information technology and some other novel and interesting techniques that can make the students learn the subject meaningfully. Okonkwo (2007) also outlined several factors contributing to this problem. They include; insufficient number of qualified chemistry teachers, lack of instructional materials, over-loaded chemistry syllabus, abstract and difficult nature of many chemistry concepts, inappropriate use of teaching strategy, poor teaching methods and lack of interest among the chemistry students. Njoku (2004) also pointed out that the major cause of this poor academic achievement in chemistry and science subject generally lies on poor teaching methods.

Irrespective of the fact that the causes of poor achievement in chemistry have been identified by many researchers, achievement of students in chemistry has not improved. Many researchers who try to find out the cause of students' poor academic achievement in chemistry, end up pointing out that most chemistry teachers use conventional lecture method in their teaching not minding the outcome of their teaching. This implies that, despite the fact that a good number of recommendations have been made by researchers for teachers to use varieties of teaching methods/strategies, teachers adhere strictly to the use of conventional method that is merely teacher centered in their teaching. This might be due to their desire to cover the syllabus or their attitude towards teaching. Moreover, the poor economy of Nigeria does not encourage the average Nigerian teachers in trying out new methods of teaching because of the perceived costs of teaching materials and laboratory equipment. As a result, it could lead to the teachers not exposing the students to acquire skills which would have given them the opportunity to explore ideas or to give them the chance to extend their creativity thereby making their learning interesting and meaningful.

The particular use of one teaching method in teaching chemistry or the inability of the teacher to apply different teaching methods, had made the students to perceive chemistry as abstract and a very difficult subject to understand. Ihuarulam (2012) pointed out that the poor academic achievement of the students in chemistry is as a result of poor and ineffective lecture method which most chemistry teachers used in teaching at senior secondary school and discourage that lecture method should not be used at this level. Ihuarulam further described secondary education as a terminal stage for a large number of students and as a preparatory stage for higher education for those who wish to continue their education. Therefore, at this stage, science teacher should ensure that students are well grounded in their field of learning to enable them get the skills required to solve problems.

Lecture method of teaching according to Liddle (2000), is the type of teaching technique that is mainly teacher-centered and subject –content driven. This is the type of teaching method mostly used by chemistry teacher in teaching in order to cover a large syllabus. Lecture method does not promote much achievement because it appeals mainly to the sense of hearing which encourages rote learning and regurgitation of information without necessarily aiding the learners to construct their own meaning that are consistent with their prior ideas (Ezeani, 2004). On the other hand, appropriate teaching and learning situation demands innovative teaching technique like problem-solving. However, for the students to use what they have learnt in chemistry or the skills they acquire in chemistry in solving problems, it then entails that such experiences should be mastered or internalized. Onyemerekeya as cited in Uwaleke (2013) pointed out that good teaching leads to good learning and comprehension. Also, Akalonu (2002) was of the view that, for science subjects to be understood and comprehended well by the students, good teaching methods and skills need to be applied.

Education cannot be made more effective without effective teaching. There are so many devices for effective teaching and an effective technique ensures effective learning. It is being felt that there should be new technique (Eniayeju, 2001). There is, therefore, need for serious research for pedagogical methods and techniques that will adequately develop students' interests and potentials, assess and report students' achievement more appropriately. This search for strategies and techniques for effective teaching and learning, has led to the birth of many procedures and techniques that include problems- solving techniques and activities for teaching of science. It was on this premises that the researcher wants to investigate the effect of problem-solving instructional technique on students' interest and achievement in chemistry.

Problem-solving according to Danjuma, (2011) is the ability to identify and solve problems by applying appropriate skills systematically. It is a process of an on-going activity in which we use what we know to discover what we don't know. It involves overcoming obstacle by generating hypotheses, testing those prediction and arriving at a satisfactory solution. Problem solving can also be defined as a thinking process in which the learner discovers a combination of previously learned rules that he can apply to solve a novel problem (Gagne, 1997). It can be very helpful to ask yourself what have been done in the past when you are faced with similar problems and how other people you know have dealt with similar situation. Most often, students get confused whenever they come across a problem that is not exactly the same as the one solved in the classroom. This could be as a result of not understanding the subject or topic because before the student could apply what he /she has learnt to the present situation, he /she might have understood the topic. Riasat, (2010) pointed out that merely telling is not teaching and simply listening is not learning. According to Riasat, some learning process revolves around the teacher, where the students are only passive information receivers. Teachers

are therefore advice to always imbibe students centered learning activities in their teaching, where the teacher will be merely the facilitator or the guide. According to Akalonu (2002), every chemistry teacher should try as much as possible to make the students see chemistry as an interesting subject because of its future benefits. This could be achieved by allowing the students to participate actively in all the activities in the class. Problem solving instructional technique is a kind of technique that makes an attempt to make science learning an active process for the child because the student himself is responsible for his learning.

Problem solving techniques consist of the steps that one would use to find the problem(s) that are in the way to getting to one's own goal (Brainsford & Stein, 1993). They went further to say that some would refer to this as the problem-solving cycle. In this cycle, one will recognize the problem, define problem and develop a strategy to fix the problem, organize the knowledge of the problem cycle, figure- out the resources at the user's disposal, monitor one's progress and evaluate the solution for accuracy. Obodo (2004) contended that problem-solving techniques comprise of identifying and choosing Mathematical problems which grow out of the experience of individual students, placing these problems before the students and guiding them in their solutions. It follows the steps of scientific method as well as those of reflective thinking. The teacher guides the class in solving the chemistry problem as a group. This technique allows the students to learn from their successes and failures and culminate into real comprehension of facts since it permits the students to participate in their learning. Many scholars have outlined the sequence of problem-solving technique and one of them is Polya's Problem Solving Language Model. Polya in his problem-solving model in 1945, developed four basic principles of problem-solving language which include; Understanding the problem; Devise a plan; Carrying out the plan and Looking back. As good as this technique may sound, research evidence still has no definite answer to how effective it is in teaching chemistry and improving students' achievement especially in topic like electrolysis.

Achievement is the success in bringing an effort to the desired end. According to Bell (2012), achievement is something accomplished through great efforts, skills, perseverance or courage. In teaching-learning process, it is the measure of the students learning outcome at the end of teaching-learning activities. Bell went further to state that in educational institution, success attained is measured by achievement or how well a student meet standard set out by an institution. Students' academic achievement is the outcome of education and the extent to which a student has achieved their educational goals. Achievement test questions are used to assess a student's performance in a course of study which he has undergone. The extent of achievement in science courses does not depend on whether the student is male or female but, on the skills, and abilities acquire through the activities in the classroom.

Nevertheless, gender has been an issue of concern to educator and researchers because of the notion people have that science courses like engineering is mainly for male students. Gender in science is the classification of the roles male and female play in science. Ezirim (2006) opined that gender has impact on science education. Several studies have been done to check if gender really has influence on interest and achievement in science, chemistry in particular. Unfortunately, there were contradictory statements by the researchers on this issue. Some studies revealed that male students are academically higher than their female counterparts (Ifeako, 2004; Offiah&Egolum, 2007). On the contrary, Aniodoh and Egbo (2013) revealed in their studies that female students scored significantly higher than male students in science subjects. Some studies such as Egolum, (2011) and Okeke, (2014) revealed that there is no significant difference in the performance of male and female in science subjects. Therefore, because of the contradictory evidence in academic achievement due to gender, this study will also investigate if differences exist in the interest and achievement on chemistry students using problem solving instructional technique due to gender.

1.1. Purpose of the Study

The purpose of this study was to investigate the effects of problem-solving instructional technique on secondary school students' academic achievement and interest in chemistry. The study specifically aims at determining:

- The difference between the mean achievements scores of students taught the concept of electrolysis using problem solving instructional technique and those taught with conventional method.
- The Influence of gender on mean achievements scores of students when taught the concept of electrolysis.

1.2. Research Questions

The following research questions guided the study.

- What is the difference between the mean achievement scores of students taught the concept of electrolysis using problem solving instructional technique and those taught using conventional method?
- What is the difference between the male and female students' mean achievement scores when taught the concept of electrolysis?

1.3. Hypotheses

The following null hypotheses were formulated and tested at 0.05 level of significance.

- There is no significant difference between the mean achievement scores of students taught the concept of electrolysis using problem solving instructional technique and those taught using conventional method
- There is no significant difference between the male and female students' mean achievement scores when taught the concept of electrolysis.

2. Method

2.1. Research Design

The research design that was used for this study is quasi experimental research design. Specifically, non-equivalent control group design was used. Quasi-experimental research design is a design where random assignment of subjects to experimental and control group is not possible (Nworgu, 2015). Hence, complete randomization of subjects in group was not possible but intact classes were used.

2.2. Area of the Study

The area of the study was Awka South Local Government Area in Awka Education Zone of Anambra State. Awka Education zone is situated under Anambra Central Senatorial district of Anambra State. It is located on a rolling flat land on the Eastern plain of the river Niger. It comprises of five local Government Areas namely; Anaocha, Awka North, Awka South, Dunukofia and Njikoka Local Government Areas respectively. Awka South was chosen because the researcher is residing, schooling and also familiar with the area.

2.3. Population of the Study

The population of the study consists of all the SS 2 chemistry students of 2015/2016 academic session in the eighteen public secondary schools in Awka South Local Government Area in Anambra State. The population of SS 2 students is 541 with males totaling 203 and female totaling 338.

2.4. Sample and Sampling Techniques

The sample of this study consists of 87 SS 2 chemistry students drawn from two schools out of the 18 public secondary schools in Awka South L.G.A of Anambra State. First, purposive sampling technique was used to select nine out of 18 public secondary schools for the study. Purposive sampling technique according to Gay and Arrasian (2003), involves the selection of a sample that possesses particular characteristic relevant to achieving the purpose of the study. The criteria considered for the inclusion of any school in this study includes; mixed gender school, willingness of authority for school to be used; experience chemistry teacher; schools that have not less than 25 students studying chemistry; schools that have presented students in WAEC and NECO examinations for at least five years and schools that have standard and well equipped laboratory. Based on this fact, nine out of the 18 public secondary schools in Awka South L.G.A were selected.

Secondly Simple random sampling technique with replacement was used to select two out of the nine selected co-educational schools. The names of the nine schools were written on small pieces of paper each, folded and put into a bag. The researcher shuffled and deepened her hand into the bag and picked out one of the papers; opened it and wrote the name of the school. The paper was folded and put back into the bag. The researcher shook very well and deepened her hand again and brought out the second paper; opened and wrote the name of the school. This was to ensure that all chemistry students in the nine selected schools had equal chances to participate in the study and to obtain unbiased assessment of students' achievement. The two schools were assigned into experimental and control group using a flip of coin. Experimental group was made up of 35 students (14 males and 21 females) while control group was made up of 52 students (32 males and 20 females).

2.5. Instrument for Data Collection

The instrument for data collection was Chemistry Achievement Test on Electrolysis (CATE). The CATE comprises of 25 multiple choice questions with four options which were selected from West African Senior School Certificate Examination (WASSCE) past questions. The CATE was used to measure students' achievement on electrolysis, in both experimental and control group.

2.6. Validation of the Instrument

The instrument was given to three experts, two from the Department of Science Education and one from Department of Educational Foundations in Nnamdi Azikiwe University. The Chemistry Achievement Test on Electrolysis was validated by the experts in Chemistry in the Department of Science Education while the chemistry interest scale was validated by the experts in the Department of Education foundations. They were requested to comment on the clarity of the expressions used in the test and check the extent of coverage of the instruments on the topic under study. All corrections and suggestions were taken into consideration in producing the final copy of the instruments which at this stage were certified and due to be administered.

2.7. Reliability of the Instrument

The reliability of the instruments was determined using one school from Aniocha Local Government Area of Anambra State which is outside the research sample area. One intact class of SS 2 students with a total population of 30 students offering chemistry was used. The reliability of the instrument was established using Kuder Richardson Formula 20 (KR-20). This is as a result of the dichotomously scored items and also the items are not of equal difficulty. The CATE was administered to 30 SS2 chemistry students and the scores were obtained from students. The reliability of the instrument was found to be 0.78.

2.8. Method of Data Collection

Data for this study were collected before and after treatment. The instruments (CATE and CIS) were used to generate data on two different times during and after the study, namely pretest and posttest. Participants of the experimental and the control groups were given pretest before treatment and posttest after treatment. The results of the test formed part of the data of this study.

2.9. Experimental Procedure

Before the proper commencement of the study, the researcher visited the two selected schools for an official permission from the school authorities. This was done by writing to the principals of the respective schools an official letter to make use of their schools for research activities (see Appendix k in page 95 for the letter). The chemistry teachers of the two sampled schools were trained and used as research assistants

The treatment was in two phases. The first stage was the teaching of the students. The teaching lasted for five weeks with one contact of 80 minutes (double period) each week. The experimental group was taught electrolysis using Polya's four steps of problem solving. The control group was taught the same topics as in experimental group during their normal class period. To this group their teacher taught them with conventional method. The extensive teaching and revision lasted for five weeks. The second phase was the evaluation period. At the end of extensive teaching and revision period, post chemistry interest and post achievement test were administered to the students immediately on the sixth week.

2.10. Control of Extraneous Variables

- **Experimental Bias-** This occurs when the researcher uses another teacher who is not their regular class teacher. This will make the students to start faking their responses with the teacher. Therefore, to avoid any experimental bias, the regular class teachers in the participating schools were used to teach their own students in both the experimental and control groups. Also, the researcher was not directly involved in administering the research instruments and treatment.
- **Teacher Variable:** Teachers usually possess different standards in terms of the methodology and knowledge of the content, therefore to have uniformity in their teaching, the two research assistants were trained and the lesson plans on electrolysis prepared by the researcher was used for teaching the students. She made sure that both teachers strictly adhere to the lesson plan by regular supervision of their teachings.
- **Class Interaction:** In order to control inter class interaction among the students, different schools were used for the study.
- **Effect of Pre-test and Post-Test:** In order to reduce influences of memory and forgetfulness, the time tag between the pre-test and post-test were six weeks which is considered not too short and long enough as not to allow the pre-test to affect the post test.

2.11. Method of Data Analysis

The data obtained was analysed using mean and standard deviation to answer the research questions and analysis of covariance (ANCOVA) was used to test all the hypotheses at 0.05 significant levels. This is because they involved more than two groups and it takes care of initial differences of the research group. The decision for the null hypothesis was to reject the null hypothesis if the p-value is less than 0.05 otherwise, do not reject the null hypothesis.

3. Results

- **Research Question 1:** What difference between the mean achievement scores of students taught the concept of electrolysis using problem solving instructional technique and those taught using conventional method?

Source of Variation	N	Pretest	Posttest Mean	Gained Mean
Problem solving Method	35	25.73	72.69	46.96
Conventional Method	52	23.58	45.38	21.80

Table 1: Pretest and Posttest Mean Achievement Scores of Students taught with Problem Solving and those taught with Conventional Method

Table 1 shows that the students taught with problem solving method had pretest mean score of 25.73 and posttest mean score of 72.69 with gained mean 46.96 in their chemistry test, while the students taught with conventional method had pretest mean score of 23.58 and posttest mean score of 45.38 with gained mean 21.80 in their chemistry test.

- **Research Question 2:** What difference between male and female students' mean achievement scores when taught the concept of electrolysis?

Source of Variation	N	Pretest	Posttest Mean	Gained Mean
Male	14	25.00	72.86	47.86
Female	21	25.71	72.57	46.86

Table 2: Pretest and Posttest Achievement Mean Scores of Male and Female Students

Table 2 indicates that male students taught with problem solving method had pretest mean score of 25.00 and posttest mean score of 72.86 with gained mean 47.86 in their chemistry, while the female students in the group had pretest mean score of 25.71 and posttest mean score of 72.57 with gained mean 46.86.

- Null hypothesis 1: There is no significant difference between the mean achievement scores of students taught the concept of electrolysis using problem solving instructional technique and those taught using conventional method.

Source of Variation	SS	Df	MS	F	P-value	Decision
Corrected Model	18227.321	2	9113.660			
Intercept	32791.839	1	32791.839			
Pretest	2634.941	1	2634.941			
Instructional Methods	14472.123	1	14472.123	168.07	.000	S
Error	7232.909	84	86.106			
Total	301888.000	87				
Corrected Total	25460.230	86				

Table 3: ANCOVA on the Posttest Achievement Mean Scores of Students taught Electrolysis with Problem Solving and Those Taught with Conventional Method

Table 3 shows that at 0.05 level of significance, 1df numerator and 84df denominator, the calculated F 168.07 with P-value 0.00 which is less than the 0.05. Therefore, the first null hypothesis is rejected. So, there is significant difference in the effectiveness of problem-solving method and conventional method in enhancing secondary school students' achievement in chemistry.

- Null Hypothesis 2: There is no significant difference between the male and female students' mean achievement scores when taught the concept of electrolysis.

Source of Variation	SS	Df	MS	F	P-value	Decision
Corrected Model	191.756	2	95.878			
Intercept	25979.332	1	25979.332			
Pretest	191.070	1	191.070			
Gender	1.582	1	1.582	0.02	0.900	S
Error	3183.787	32	99.493			
Total	188288.000	35				
Corrected Total	3375.543	34				

Table 4: ANCOVA on the Posttest Achievement Mean Scores of Male and Female Students

Table 6 shows that at 0.05 level of significance, 1df numerator and 32df denominator, the calculated F 0.02 with P-value 0.900 which is greater than 0.05. Therefore, the second null hypothesis is accepted. So, there is no significant difference in the effectiveness of problem-solving method in enhancing achievements of male and female students in chemistry.

4. Discussion

The findings of this study appeared to be consistent with those of Festus and Ekpote (2012) that students taught chemistry using problem solving instructional technique out performed those taught with conventional method. Also, Bawa (2011) findings aligned with the findings of the present study. Bawa found out that learners exposed with problem solving instructional technique performed better than those taught with conventional lecture method. Finding of Jegede and Faloke (2014) on the effect of problem-solving instructional technique on academic achievement in chemistry is in conjunction with the present study. They found out that the use of problem-solving instructional technique increases the academic of students more than the conventional lecture methods.

The superiority of the problem-solving instructional technique over the conventional method could be explained by the fact that problem solving adequately develop interest and potentials, asses and report students' achievement appropriately. Problem solving encourages students to think for themselves and to arrive at a deeper understanding of what data they have. The students in experimental group were able to seek information, generate new knowledge and make decisions in chemistry concepts that were otherwise impossible to observe and manipulate by students in control group. This implies that problem solving technique improves students' academic achievement more when compared with conventional lecture method.

The finding of this study reveals that mean achievement scores of male and female students taught chemistry using problem solving instructional technique and conventional method were at the same achievement level. The finding also indicates that gender did not influence students' achievement in chemistry significantly. This finding was in conjunction with the findings of Egolum (2011), Jegede and Faloke (2014) Okeke (2014) and Udousoro (2011) that there is no significant difference in academic achievement of students in chemistry due to gender.

Contrary to the present findings were the reports of Aniodoh and Egbo (2013), Awoniyi, (2000), Cheung (2009), Ifeako (2004) and Uwaleke (2013). Among the results, Aniodoh and Egbo, Cheung and Uwaleke's study revealed that female students perform better than male in chemistry while Awoniyi, Ifeako, Offiah and Egolum revealed a significant gender difference on student's achievement in favour of males. The differences in their performance can be attributed to

gender stereotyping which encourages male and female students to show interest in subjects relevant and related to the role expected of them in the society. The present study reveals that there is no significant difference in gender. This could be because it promoted much cooperation on the students.

5. Conclusion

The study shows that problem solving had significant effect on students' overall mean achievement and interest in chemistry. This experimental group taught chemistry with problem solving instructional technique had higher mean achievement score than their counterpart taught with conventional teaching methods. The influence of gender on the students' academic achievement in chemistry concepts studied was not significant.

6. Recommendations

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

- Chemistry teachers should incorporate problem solving technique as one of the methods used in teaching chemistry at secondary school to minimize the use of talk and chalk method that is conventional lecture method.
- If problem solving instructional technique could improve the academic achievement in chemistry, it would be necessary to overhaul the mode of instruction of teaching chemistry at the senior secondary so as to accommodate functional student centered and activity- oriented instructional technique that will make chemistry students good problem solvers, thereby causing improvement in the performance of students in school Certificate Examinations.

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