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Effect Of Problem Solving Strategy On Secondary School Students' Achievement In Chemistry In Onitsha Education Zone

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Abstract: ***The study determined the effect of problem solving strategy on secondary school students' achievement in chemistry. Two research questions and three hypotheses guided the study. The study adopted quasi-experimental design, specifically the pretest posttest non-randomized control group design. The population of the study comprised 9,101 senior secondary school two (SS2) students offering chemistry in Onitsha Education Zone of Anambra state. A sample of 107 SS2 students obtained through multi-stage sampling procedure was involved in the study. Chemistry Achievement Test (CAT) validated by three experts was used as instrument for data collection. The reliability of the CAT was established using Kuder-Richardson Formula 20 to be 0.70. The experimental group was taught using problem solving strategy while the control group was taught using conventional method. The data obtained were analyzed using mean, standard deviation, and Analysis of Covariance (ANCOVA). The findings showed that the use of problem solving strategy significantly improved SS2 students' achievement more than conventional method. Also, gender had no significant influence on students' achievement when taught using problem solving strategy. The researcher recommended among others that chemistry teachers should adopt problems solving strategy in order to actively engage students in the learning process and help them develop the skills of problem solving that can be applied in other academic exercises.***

Keyword: Problem-solving, achievement, chemistry, Nitrogen, conventional

I. INTRODUCTION

Science is one of the major drivers of national development. A country with skillful scientists thrives in all sectors of human endavour namely: health, education, economic development, agriculture, infrastructure and independence of foreign goods. The importance of science in the development of a nation cannot be over emphasized. This is why the Federal government of Nigeria in her admission policy increased the quota ratio for admission into science discipline to 60% with the remaining 40% for other study areas (Omeje, Egwa & Adikwu, 2016). The increment in quota notwithstanding, majority of the Nigeria students seem not to be interested in the study of science and applied science related disciplines. This is clearly expressed in the number of science students offering science subjects such as chemistry and physics in secondary schools.

Chemistry is the study of the properties, synthesis and uses of matter (Ababio, 2011). Chemistry as a subject taught in secondary schools and universities is divided into many branches which include; Biochemistry, Organic chemistry, Inorganic chemistry, Physical chemistry, Medical chemistry, Nuclear Chemistry, Environmental chemistry. It plays a major role in building the scientific base of a country in the sense that it's a prerequisite for higher learning of science based discipline such as Engineering, Medicine, Industrial and Pure Chemistry, Microbiology, Anatomy, Pharmacology and Pharmacy.

One major factor implicated for the poor enrolment in chemistry is unstable achievement of students enrolled in the previous year's chemistry examination which is poor most of the times (Ahmed, et al., 2015). Students have the notion that science subjects like chemistry is not easy to pass. Results of academic achievement in chemistry examinations in the years

past also did not show contrasting notion from what the students believed. Academic achievement of students in chemistry measured by the students' raw mean scores as shown by the WAEC Chief Examiner Reports is shown in Figure 1:

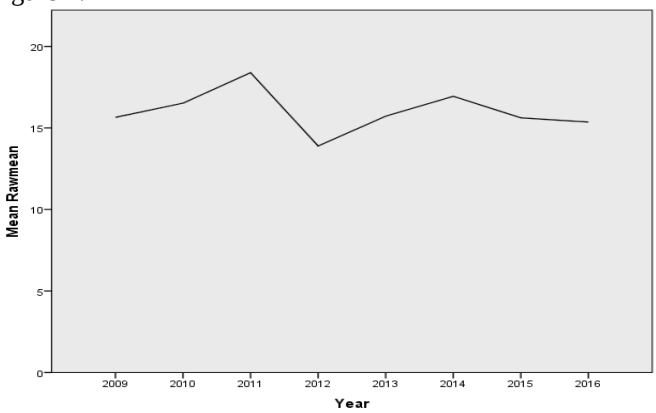

Figure 1: Plot of Students' Raw Mean Score in WAEC Chemistry Examinations

The results as shown in figure 1 depict unstable performance. Only in 2011 and 2014 were there increment in performance. Nevertheless, the students' performance across the years never exceeded the WAEC standard nine (stanine) pass mark of 40. Thus, on the average, students' average performance in chemistry is rated at a fail level. From 2014 however, there has been a persistent decline in chemistry achievement.

Some of the difficulties students encountered in understanding and applying basic concepts of chemistry and the nature of science have been identified to include; lack of laboratory equipment and constant experiments, poor teaching resources and abstract nature of chemistry. Achievement in chemistry has also been shown to be affected by a number of other factors, of which the teaching method is the most common (Ahmed, et al., 2015).

Empirical data suggest that highlighting relevance or fostering active engagement of students in class through innovative teaching methods has positive effects on learning outcomes (Fraser, Aldridge & Adolphe, 2010). It suggests the need for chemistry educators to use more innovative teaching methods that will engage students actively. Such innovative teaching methods enable students to take responsibility of their own learning and improve on their understanding of chemical concepts. One of such innovative teaching that could give students very active engagement in the learning process of chemistry is the problem solving strategy (Broman & Ekborg, 2011).

Problem solving strategy is an instructional approach that takes students through the process of working through details of a problem to reach a solution (Anyafulude, 2014). Problem solving strategy involves the following stages: Identify the problems, be clear about what the problem is, understand everyone's interests, list the possible solutions (options), evaluate the options, select an option or options, document the agreement(s) and agree on contingencies, monitoring, and evaluation. One benefit of these stages in problems solving is that students tend to develop the skills of critical thinking. When solutions to the problems are correctly deciphered, students can apply them in solving problems and this could result in enhanced achievement.

In this study, the first task of the teacher in using problem solving strategy is to guide the students to identify the problems and help them to link with previous knowledge. The teacher also solves a related problem as an example to guide the students and give the students a similar problem. The students in a small group discuss the problem cooperatively, explain what they know, pose questions, develop initial plans and organize their knowledge, attempt to solve the problems with several modifications, derive learning goals and organize further work. Finally, the results are presented to larger groups through the guidance of the teacher, instructor or facilitator and the students are allowed to reflect on the learning that has taken place. Problem solving strategy has been show to engage students more fruitfully and reduces rote learning as is common with conventional teaching methods.

Conventional method (CM) involves the methods teachers use in the traditional classroom. These methods are often teacher-centered and do not give students the opportunity to actively engage in the learning process. Conventional method such as lecture method is profitable for teaching large number of students. However, it makes students less participative in the lesson because the teacher is seen as the authority. The passive nature of the students' involvement makes it difficult for students to be active during instruction like in students-centered method of teaching such as problem solving method. This is why this study seeks to compare the problem solving strategy with the conventional method to see which would improve achievement more significantly irrespective of gender.

Gender issues in science education have remained in conclusive. Studies show that in some cases, depending on the teaching method adopted by the teacher, the academic setting, and cultural background, chemistry achievement may favour the male or female students. In some studies, male achieve more than females (Abungu, Okere & Wachanga, 2014) while in yet others, females achieve more males (Eriba & Sesugh, 2006; Erinosho, 2005). Thus, this study seeks to further examine whether problem solving will equally enhance male and female students' achievement in chemistry.

PURPOSE OF THE STUDY

The purpose of this study was to investigate the effect of problem solving strategy on secondary school students' achievement in chemistry. Specifically, the study determine the:

- ✓ difference between the mean achievement scores of students taught chemistry using problem solving strategy (PSS) and those taught using conventional method (CM).
- ✓ Difference between the mean achievement scores of male and female students taught chemistry using PSS.
- ✓ Interaction effect of teaching methods and gender on students' achievement in chemistry.

RESEARCH QUESTIONS

- ✓ What is the difference between the mean achievement scores of students taught chemistry using problem solving

strategy (PSS) and those taught using conventional method (CM)?
- ✓ What is the difference in the mean achievement scores of male and female students taught chemistry using PSS?

HYPOTHESES

- ✓ There is no significant difference between the mean achievement scores of students taught chemistry using problem solving strategy (PSS) and those taught using conventional method (CM).
- ✓ There is no significant difference between the mean achievement scores of male and female students taught chemistry using PSS.
- ✓ There is no significant interaction effect of teaching methods and gender on students' achievement in chemistry.

II. METHOD

The design adopted for the study quasi-experiment, specifically, the pretest posttest non-equivalent control group design. The area of the study is Onitsha Education Zone of Anambra state. The population of the study consists of 9,101 SS2 students offering chemistry in all the public secondary schools in Onitsha Education Zone. The total sample for the study is 107 senior secondary school year two (SS2) students offering chemistry. The sample was obtained through multi-stage sampling procedure. First, the two local government areas out of the three local government areas in Onitsha Education Zone were selected at random (balloting without replacement). Secondly, all the public schools in each of the two selected local government areas were stratified into coeducational and single sex schools. Thirdly, one coeducation school was purposively selected from the list of coeducational schools in each selected local government area. The reason for selecting the schools is because they have similar school characteristics. The two schools were randomly categorized into experimental and control groups.

The instruments for data collection are Chemistry Achievement Test (CAT) developed by the researcher. Both instruments were validated by lecturers from the Department of Science Education, and Educational Foundations (Measurement and Evaluation Expert), both from Nnamdi Azikiwe University, Awka, and one experienced secondary school chemistry teacher. The reliability of the CAT was established using Kuder-Richardson formula 20 (KR-20) to be 0.70.

The experiment was conducted in two phases. In the first phase, the two regular chemistry teachers in the experimental group school were trained by the researcher on how to use the problem solving strategy. The training lasted for one week in three contacts. In the second phase of the experiment, students in the experimental and control groups were given a pretest using the CAT. There was no feedback or revision and corrections after the pretest. The treatment using problem solving consisted mainly in the teachers probing the students with questions that are related to all the contents to be taught. Before each question, the teacher solved one similar question to give the students guide on how to approach the problem on their own. The approach that was used by the teacher in the problem solving classroom was that of Wood (1975) stated as follows:

- ✓ Begin with a task embedded in a familiar setting
- ✓ Introduce problem-solving techniques that might be applicable
- ✓ Allow students to create their own paths to a solution
- ✓ Emphasize collaborative learning and problem solving
- ✓ Help develop collaborative working skills
- ✓ Provide different roles for individuals in a group setting
- ✓ Identify, confront and discuss misconceptions.

The step to step procedure in using problem solving strategy is as follows:

STEP 1: The teacher introduced the concept of Nitrogen and guided the students to identify the problem (Occurrence and preparation of Nitrogen) and help them to link it with their previous knowledge. The teacher then organized the students in groups of five and appoints group leaders. The teacher further instructs the students to make sure they take down points during the lesson as each group shall be called upon to summarize any part of the lesson contents and answer the questions that follows.

STEP 2: The teacher then gave the students notes and ask them to discuss it among their groups. Students will discuss the notes, bring out the major points and summarize for presentation. The teacher thereafter calls on various group members to summarize the different contents of the topic taught.

STEP 3: The teacher asked the various groups to use different textbooks, discuss and write about the laboratory and industrial preparation of nitrogen. Students in their groups tried to solve the problem which is how nitrogen is prepared in the laboratory and in the industry. They also wrote down equations of different means of preparing nitrogen in the laboratory and in the industry.

STEP 4: The teacher called on the various groups to come and present their findings. Each group made their presentation on only on method of laboratory and industrial preparation of nitrogen. Other group members asked questions to the presenting group and the teacher was the facilitator. After the presentation from all the groups, the teacher asked the students question to evaluate the instruction and at this time, they answered individually and not as a group.

Step 5: The teacher summarize the important points of the lesson and gave students assignment to be done as a group.

The same content was taught in the control group using conventional method where no group activity was conducted and no problem solving of questions emphasized. After the four weeks of teaching the control and experimental group schools, the teachers in both schools administered the instruments as posttest. Data collected was analyzed using mean and standard deviation. The hypotheses were tested using Analysis of covariance (ANCOVA). Where Pvalue is less than or equal to 0.05, the null hypothesis was rejected but where it is greater than 0.05 the null hypothesis was not rejected

III. RESULTS

RESEARCH QUESTION 1: What is the difference between the mean achievement scores of students taught chemistry using problem solving strategy (PSS) and those taught using conventional method (CM)?

Source of Variation	N	Pretest Mean	SD	Posttest Mean	Posttest SD	Gained Mean
PSS	54	27.09	5.44	60.35	11.75	33.26
CM	53	29.38	6.00	45.49	6.81	16.11
Difference in Mean		-2.29		14.86		17.15

Table 1: Mean Achievement Scores of Students taught Chemistry using Problem Solving Strategy and Conventional Method

Table 1 shows that the students taught chemistry using PSS has pretest mean achievement score of 27.09 and posttest mean achievement score of 60.35 with gained mean achievement score of 33.26, while those in the control group taught with conventional method had pretest mean achievement score of 29.38 and posttest mean achievement score of 45.49 with gained mean 16.11. The difference in the gain in mean achievement scores of both groups is 17.15 in favour of PSS.

RESEARCH QUESTION 2: What is the difference in the mean achievement scores of male and female students taught chemistry using PSS?

Gender	N	Pretest Mean	SD	Posttest Mean	Posttest SD	Gained Mean
Male	29	27.93	5.90	62.97	10.10	35.04
Female	25	26.12	4.79	57.32	12.96	31.20
Difference in Mean		1.81		5.65		3.84

Table 2: Mean Achievement Scores of Male and Female Students taught Chemistry using Problem Solving Strategy

Table 2 shows that the male students taught chemistry using PSS has pretest mean achievement score of 27.93 and posttest mean achievement score of 62.97 with gained mean achievement score of 35.04, while those in the females had pretest mean achievement score of 26.12 and posttest mean achievement score of 57.32 with gained mean 31.20. The difference in the gain in mean achievement scores of both groups is 3.84 in favour of males.

HYPOTHESIS 1: There is no significant difference between the mean achievement scores of students taught chemistry using problem solving strategy (PSS) and those taught using conventional method (CM).

Source of variation	**SS**	**Df**	**MS**	**F**	**P-value**	**Decision**
Corrected Model	5934.364[a]	2	2967.182	31.811	.000	
Intercept	10548.565	1	10548.565	113.091	.000	
Pretest	26.933	1	26.933	.289	.592	
Method	5832.553	1	5832.553	62.531	.000	S
Error	9700.627	104	93.275			
Total	316092.000	107				
Corrected Total	15634.991	106				

Table 3: ANCOVA on Significance of Difference in Mean Achievement Scores of Students taught Chemistry using PSS and Conventional Method

Table 3 shows that at 0.05 level of significance, there was a significant main effect of the teaching methods on students' achievement in chemistry, F (1, 104) = 62.531, P(0.000) < 0.05. Therefore, the null hypothesis was rejected. Thus, there is a significant difference between the mean achievement scores of students taught chemistry using problem solving strategy (PSS) and those taught using conventional method (CM).

HYPOTHESIS 2: There is no significant difference between the mean achievement scores of male and female students taught chemistry using PSS.

Source of variation	**SS**	**Df**	**MS**	**F**	**P-value**	**Decision**
Corrected Model	432.871[a]	2	216.435	1.604	.211	
Intercept	6899.698	1	6899.698	51.120	.000	
Pretest	4.962	1	4.962	.037	.849	
Gender	400.813	1	400.813	2.970	.091	NS
Error	6883.444	51	134.969			
Total	204003.000	54				
Corrected Total	7316.315	53				

Table 4: ANCOVA on Significance of Difference in Mean Achievement Scores of Male and Female Students taught Chemistry using PSS

Table 4 shows that at 0.05 level of significance, there was no significant main influence of gender on students' achievement in chemistry, F (1, 51) = 2.970, P(0.091) > 0.05. Therefore, the null hypothesis was not rejected. Thus, there is no significant difference between the mean achievement scores of male and female students taught chemistry using PSS.

HYPOTHESIS 3: There is no significant interaction effect of teaching methods and gender on students' achievement in chemistry.

Source of variation	**SS**	**Df**	**MS**	**F**	**P-value**	**Decision**
Corrected Model	6809.879[a]	4	1702.470	19.677	.000	
Intercept	11307.612	1	11307.612	130.693	.000	
Pre	.422	1	.422	.005	.944	
Method	5414.361	1	5414.361	62.579	.000	
Gender	875.267	1	875.267	10.116	.002	
Method * Gender	.798	1	.798	.009	.924	NS
Error	8825.111	102	86.521			
Total	316092.000	107				
Corrected Total	15634.991	106				

Table 5: ANCOVA on Significance of Interaction Effect of Teaching Methods and Gender on Students' Achievement in Chemistry

Table 5 shows that at 0.05 level of significance, there was no significant interaction effect of teaching method and gender on students' achievement in chemistry, F (1, 102) = 0.009, P(0.924) > 0.05. Therefore, the null hypothesis was not rejected. Thus, there is no significant interaction effect of teaching methods and gender on students' achievement in chemistry.

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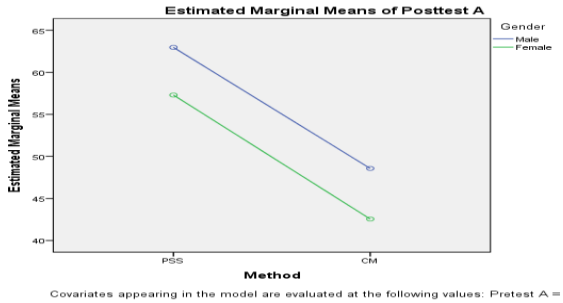

Figure 1: Plot of interaction effect of teaching methods and gender on students' achievement in chemistry

IV. DISCUSSION

The finding of the study revealed that a significant difference exist between the mean achievement scores of students taught chemistry using problem solving strategy (PSS) and those taught using conventional method (CM). The observed result is attributable to the fact that problem solving strategy spurs the students to look at the academic tasks or problem and think critically about them. This simple cognitive exercise enabled the students to see the problem from different view point while at the same time deciphering several approaches to the solution of the problem. The students through these actions become fully engage in the learning process and take responsibility for their own learning. The resultant effect is improvement in achievement.

Students through problem solving are exposed to multiple intelligence owing to the trial and errors solutions by which they try to solve the problem. The process makes them spontaneously go through a metacognition phase through which they ask themselves if they have really learnt how to solve the problem and other similar problems. Thus, as they learn through problem solving, they avoid rote learning and learn the concepts more meaningfully. Again, the process of problem solving being a personal cognitive process enabled the students to develop effective and useful strategies to solve everyday tasks or problems that are academically related thereby enhancing their academic achievement.

The finding of the study is related to the findings of Ntibi and Neji (2018) that the experimental groups taught with problem-solving method had a higher mean score than the control group taught with conventional method in Physics and Chemistry. The finding of the study also support the finding of Orji and Ogbuanya (2018) that that the experimental group taught using problem based strategy achieved higher in achievement scores than the control group for electronic works achievement test at the posttest and follow-up test stages. The findings of Akpogho, Samba and Asemave (2018) that there was a significant difference between the post-test mean scores of the students taught using PSS and those taught using the conventional method lends credence to the finding of the study. The findings of Ojaleye and Awofala (2018) also supports the findings of the current study when they reported that there was a statistically significant main effect of treatment on students' achievement in algebra and that the students' achievement in algebra was enhanced when PBL and BL strategies were used than when TLM was used.

The finding of the study also revealed that no significant difference exist between the mean achievement scores of male and female students taught chemistry using PSS. This is because, the use of problem solving strategy uniformly affected students participation in chemistry. All students both male and female were actively engaged in the learning process resulting in overall improved performance.

The findings of the study contradict the finding of Ojaleye and Awofala (2018) that there was a statistically significant main effect of gender on students' achievement in algebra. The findings of the study contravene the findings of Anyafulude (2014) that problem-based strategy significantly improved female students' achievement more than male counterparts. The finding of the study is also not in line with the findings of Abungu, Okere and Wachanga (2014) that there was significant difference in the mean scores between boys and girls in the experimental group in favour of the boys. The finding of Jegede and Fatoke (2014) that that the effect due to gender on students' achievement in chemistry was not significant supports the finding of the study. The finding of study is in line with the finding of Olufemi and Ibukun (2013) that gender had no significant influence on students' achievement in biology.

Also, no significant interaction effect of teaching methods and gender on students' achievement in chemistry was observed. The findings of the study support the finding of Ojaleye and Awofala (2018) that there was no statistically significant interaction effect of treatment and gender on students' achievement in algebra.

V. CONCLUSION

The conclusion drawn from the findings of the study is that problem solving strategy is an effective instructional strategy for enhancing students' achievement. The strategy enables students to develop skills of problem solving which helps them to become independent learners. The strategy of problem solving ensures significant improvement of students' achievement in chemistry irrespective of gender.

VI. RECOMMENDATIONS

Based on the finding and conclusion of the study, the following recommendations were made:

- ✓ Chemistry teachers should adopt problems solving strategy in order to actively engage students in the learning process and help them develop the skills of problem solving that can be applied in other academic exercises.
- ✓ Seminars and Workshops should be organized by Science Teachers' Association of Nigeria and school heads on how to effectively plan chemistry lesson using problem solving strategy and its implementation in the classroom.

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