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EFFECT OF SCAFFOLDING INSTRUCTIONAL STRATEGY ON THE STUDENTS' ACHIEVEMENT IN *STOICHIOMETRY*

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ABSTRACT

Students' poor achievement in Chemistry over the years in both internal and external examinations in senior secondary schools has attracted a lot of concern. Researchers had attempted to address the problem by proffering teaching methods to stimulate students' interest. However, most of the methods though useful have not succeeded in ameliorating students' difficulty, especially in stoichiometry. Hence, the need to examine the effect of scaffolding instructional strategy on students' achievement in stoichiometry. The study was carried out in Onitsha and Otuocha Education Zones of Anambra State. Three research questions and three hypotheses were formulated to guide the study. The study adopted quasi-experimental research design. The population of the study comprised of 5,368 SS2 Chemistry students from 45 Co-education Secondary Schools in the Zones. Simple random sampling technique was used to select six schools for the study. Sample of 313 SS2 Chemistry students was used for the study which comprised of 147 males and 166 females chemistry students. The instrument used for data collection was a validated Stoichiometry Achievement Test (SAT). The instrument was trial tested using 20 students from Aguata Educational Zone. The reliability coefficient for SAT was established at .73 using Kuder Richardson (K-R-20). The data obtained were analyzed using mean, standard deviation and Analysis of Covariance (ANCOVA). Results obtained from data analysis showed that there was a significant difference in the mean achievement scores of students taught stoichiometry using scaffolding instructional strategy as against those taught using conventional method. The mean achievement scores of students taught stoichiometry using scaffolding instructional strategy (SIS) appeared to be significantly higher than those taught using conventional method. The SIS was also gender friendly. The findings of the study showed that scaffolding instructional strategy enhanced students' achievement in stoichiometry. It was recommended that the use of scaffolding instructional strategy should be encouraged during pre-service teachers' training programs.

Key Words: Stoichiometry, Scaffolding Instructional Strategy, Achievement, Gender.

Introduction

Stoichiometry is a branch of chemistry that deals with the quantities of substances that enter into and are produced by chemical reactions. Stoichiometry provides the quantitative relationship between reactants and products in a chemical reaction and which every chemical reaction has its characteristic proportion. The method of obtaining proportion from chemical formulas, equations, atomic weight and molecular weights and determination of what and how much is used and produced in the chemical process is the major concern of stoichiometry (Boujaoude&Barakat, 2009). According to Hanson (2016), conceptional knowledge of stoichiometry enables learner to solve numerical problems on chemical reactions, concentration, amount of substance, titrimetry and chemical equilibrium. Calculations involving these principles are of great significance in engineering practice and existing operations or designing new manufacturing particles and equipment and thus a solid foundation in stoichiometry is necessary for understanding quantitative deductions in physical chemistry (Parker, 2004). Hence, stoichiometry is a major area in chemistry that receives much attention in the senior secondary school chemistry curriculum. Unfortunately, in spite of the indispensable nature of stoichiometry in the learning of chemistry and the contributions of chemistry to learners and the needs of the society, most chemistry teachers and students have difficulty in teaching and learning the concept. Calculations in chemistry have been regarded as a difficult area of study in chemistry and more so since it is not practically observable and demonstrable in the chemical process (Adigwe, 2016).

Chief Examiners yearly reports have continued to highlight students' weaknesses in chemical arithmetic which have resulted to overall poor performance of students in chemistry external examination such as; (i) inability of students to write chemical formulae; (ii) poor mathematical skills; (iii) inability of students to determine mole ratio and (iv) inability of students to balance chemical equations from stoichiometric equations (Chief Examiners' Report 2013; 2014, 2015, and 2016 respectively). In order hands, the students' poor problem solving skills which resulted to poor achievement in Chemistry in external examinations was also linked to the use of traditional (conventional) methods in teaching secondary school Chemistry (Ajeyami& Owoyemi,2014).

Conventional or traditional teaching methods are those teaching methods which are teacher oriented and involve mostly the use of lecture method where communication mostly flow from the teacher to the students. Conventional teaching method is a method of teaching in which the teacher is the controller of the classroom environment. The teacher held the authority and responsibilities as instructor and decision maker while the students are at the receiving end. Conventional teaching method is mainly teacher-centred, with students being constantly passive and contents taught as absolute knowledge (Obeka, 2019).According to Akinsola, in Onasanya and Omosewo (2011), the problem with respect to teaching methods is that most teachers still believes that the

most effective means of communicating knowledge is through the conventional talk and chalk methods. Yet, most teachers in the Nigerian school system use the traditional method because it enables them cover the stipulated content in the syllabus irrespective of students' inadequate understanding of Chemistry concepts. To this effect, researchers such as Effah and Okonkwo (2011) proposed the use of cooperative and collaborative learning in enhancing students' difficulty in stoichiometry. The problem however has persisted, hence the need to try the use of scaffolding where the teacher may have to provide temporary support and guide which act as a leverage to lift the students from initial difficulties. Unlike the lecture method, the teacher is concerned about students' active participation. Thus, they are not only free to ask questions, they are given room to provide feedback among peers, scaffolding one another and attempt to discover by themselves, areas of difficulties using step by step approach presented by the teacher, who acts as a facilitator and not as a knowledge transmitter.

It is worthy of note that some researchers such as Ogunleye&Babajide(2011), Ezeudu and Obi (2013) opined that boys perform better in areas of science involving mathematics and Chemistry. Nevertheless, Opara (2013) also showed that female friendly method used in teaching stoichiometry give no gender gap. That is, both male and female students performed equally. In attempting to employ scaffolding as a teaching strategy, one needs to ascertain the extent both boys and girls would benefit from the step-wise process and peer group support which scaffolding provides.

Statement of problem

Students' poor achievement in chemistry over the years in both internal and external examinations in senior secondary schools has attracted a lot of concern. Studies have shown that students' lack of understanding and problem-solving skills in stoichiometry has persistently contributed to the overall poor achievement in chemistry. Similarly, traditional teaching methods persistently used by teachers lacked the prerequisite procedure for promoting qualitative reasoning, enthusiasm and leverage needed for helping students appreciate stoichiometric concepts and chemical arithmetic. Students therefore continue to perceive stoichiometry as one of the difficult aspects of chemistry and such tend to lose interest in studying it. However, owing to consistent poor achievement in external examination especially SSCE, researchers had attempted to address the problem by proffering teaching methods to stimulate students' interest. Most of the methods though useful have yet not succeeded in ameliorating students' difficulty in this very important aspect of chemistry. Hence, the need to proffer a method that serves leverage to students while at the same time allowing them to be full participators in the learning process. Put in a question form therefore, the statement of problem of this study is 'what is the effect of scaffolding on the secondary school students' achievement in stoichiometry irrespective of gender'?

Research Questions

1.What is the mean achievement score of secondary school students taught stoichiometry scaffolding instructional strategy and those taught using conventional method?

2.What is the effect of scaffolding instructional strategy on mean achievement scores of male and female in stoichiometry?

3.What is the interaction effect of scaffolding instructional strategy and gender on secondary school students' achievement in stoichiometry?

Hypotheses

The following hypotheses were tested at $P < 0.05$.

$Ho_{1.}$ There is no significant difference in the mean achievement score of students taught stoichiometry scaffolding instructional strategy and those taught using conventional method?.

$Ho_{2.}$ There is no effect of scaffolding instructional strategy on mean achievement scores of male and female in stoichiometry.

$Ho_{3.}$ There is no significant interaction effect of scaffolding instructional strategy and gender on students' achievement in stoichiometry.

METHODOLOGY

The design of the study is quasi-experimental. Specifically, pre-test, post-test non-equivalent control group design is employed. The fact that intact classes that were non-equivalent were used justified the research design. Onitsha and Otuocha Education Zones in Anambra State which consist of six Local Government Areas were used for the study. Justification for the choice is Otucha Education Zone (rural area) usually performance low in science (chemistry) than Onitsha Education Zone (urban area), thereby creating room if scaffolding instructional strategy would improve achievement irrespective of location. The population of the study consisted 45 Co-education secondary schools in zones with a total of 5,368 students (3138 males and 2230 females).Out of forty five (45) co-education schools in Onitsha and Otuocha Education Zones, twenty four (24) have single stream of chemistry classes each with one qualified chemistry teacher. Simple random sampling technique was used to select the six (6) schools that have one stream of students offering chemistry with a teacher. The sample size of the study consisted 313 (147 males and 166 females) chemistry students. The sampled schools were randomly assigned to experimental group and control group. The experimental groups which were exposed to scaffolding instructional strategy comprised of three intact classes with 170 students (78 males and 92 females), while the control group which were exposed to conventional method comprised of three intact classes with 143 students (69 males and 74 females). Stoichiometric Achievement Test (SAT) was used for data collection.

Stoichiometric Achievement Test (SAT)

The SAT is a 40-item multiple choice objective test which is developed by the researcher. The test blue print emphasizes the areas as weighted by the past WAEC and NECO question papers which were validated by experts and a reliability index of .73 was established using test re-test.The data to be obtained from the pre-test and post-test will be analyzed using mean and standard deviation to answer the research questions while Analysis of Covariance (ANCOVA) will be used to test the hypotheses at .05 level of significance.

Results

Research Question 1:

What is the mean achievement score of secondary school students taught stoichiometry scaffolding instructional strategy and those taught using conventional method?

Table 1: Mean and Standard Deviation of Pretest and Posttest Achievement Scores of Students Taught stoichiometry using Scaffolding Instructional Strategy and Conventional Teaching Method.

		Pretest		Posttest		
Instructional Approaches	N	$\bar{x}$	SD	$\bar{x}$	SD	Mean Gain
Scaffolding	170	9.53	2.94	20.83	4.75	11.30
Conventional	143	7.77	2.82	11.24	3.65	3.47

The result in Table 1 shows that the group taught chemistry using Scaffolding Instructional Strategy had a pretest achievement mean score of 9.53 with a standard deviation of 2.94 and a posttest achievement mean score of 20.83 with a standard deviation of 4.75. The difference between the pretest and posttest achievement mean score for the group taught using scaffolding instructional strategy was 11.30. The group taught stoichiometry using conventional method had a pretest achievement mean of 7.77 with a standard deviation of 2.82 and a posttest achievement mean of 11.24 with a standard deviation of 3.65. The difference between the pretest and posttest achievement mean for the group taught using conventional method was 3.47. The mean gain scores of 11.30 and 3.47 for the two groups respectively suggest that the group taught Chemistry (stoichiometry) using Scaffolding Instructional Strategy having a higher achievement than those taught using conventional method.

Hypothesis 1

There is no significant difference in the mean achievement scores of students taught stoichiometry using scaffolding instructional strategy and conventional teaching method.

Table 2:Analysis of Covariance (ANCOVA) of the Significant Difference in the Mean achievement scores of students taught stoichiometry using Scaffolding Instructional Strategy and Conventional Teaching Method.

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Dec.
Corrected Model	3891.303	6	648.551	35.171	0.000	
Intercept	4628.751	1	4628.751	251.020	0.000	
Pre-Achievement	8.829	1	8.829	.479	0.490	
Strategies	2957.258	2	1478.629	80.187	0.000	S
Gender	58.049	1	58.049	3.148	0.078	NS
Strategies * Gender	83.013	2	41.506	2.251	0.108	NS
Error	3466.676	306	18.440			
Total	70466.000	313				
Corrected Total	7357.979	312				

The result in Table 2 shows that with respect to mean achievement scores of students taught stoichiometry using scaffolding instructional strategy and conventional teaching method, an F-ratio of 80.18 was obtained with associated probability value of 0.00. Since the associated probability value of 0.00 was less than 0.05 set as bench mark, the null hypothesis (H_{01}) which stated that there is no significant difference in the mean achievement scores of students taught stoichiometry using scaffolding instructional strategy and conventional teaching method was rejected. Inference drawn therefore is that, there was a significant difference in the mean achievement scores of students taught stoichiometry using scaffolding instructional strategy and conventional teaching method with those taught using scaffolding instructional strategy achieving higher.

Research Question 2:
What is the effect of scaffolding instructional strategy on mean achievement scores of male and female in stoichiometry?

Table 3: Mean and Standard Deviation of Pretest and Posttest achievement Scores of the effect of male and female on student achievement in stoichiometry.

		Pretest		Posttest		
Gender	N	$\bar{x}$	SD	$\bar{x}$	SD	Mean Gain
Female	92	53.08	5.85	59.25	6.09	6.17
Male	78	52.32	6.23	58.82	6.17	6.50

The result in Table 3 shows the influence of gender on students' achievement in stoichiometry. Results show that the female students taught stoichiometry had a pretest achievement mean score of 53.08 with a standard deviation of 5.85 and a posttest mean achievement score of 59.25 with a standard deviation of 6.09. The difference between the pretest and posttest achievement mean scores for the female students was 6.17. The male students taught stoichiometry had a pretest achievement mean of 52.32 with a standard deviation of 6.23 and a posttest achievement mean of 58.82 with a standard deviation of 6.17. The difference between the pretest and posttest achievement mean for the male students was 6.50. For each of the groups, the posttest mean achievement scores were greater than the pretest achievement scores with the male students having a higher achievement mean gain than their female counterparts. This indicated that the male students had higher achievement than their female counterparts in stoichiometry

Hypothesis 2
There is no significant effect of gender on the mean achievement scores of students' in stoichiometry.

The result in Table 2 shows that with respect to influence of gender on the mean achievement scores of student in stoichiometry, an F-ratio of 3.14 was obtained with associated probability value of .07. Since the associated probability value of .07 was greater than .05 set as bench mark, the null hypothesis (H_{02}) which stated that there is no significant effect of gender on the mean achievement scores of students' in stoichiometry was not rejected. Inference drawn therefore is that, there was no significant effect of gender on the mean achievement scores of students' in stoichiometry.

Research Question 3:
What is the interaction effect of scaffolding instructional strategy and gender on secondary school students' achievement in stoichiometry?

Table 4: Mean and Standard Deviation of Respondents on the Interaction Effect of Methods and Gender on Students' Achievement in Stoichiometry

			Pretest		Posttest		
Instructional Approach	Gender	N	$\bar{x}$	SD	$\bar{x}$	SD	Mean Gain
Scaffolding	Male	78	11.27	3.31	22.91	5.29	11.64
	Female	92	11.68	2.74	21.21	4.53	9.53
Conventional	Male	69	8.51	2.57	12.08	3.62	3.57
	Female	74	9.56	3.39	12.72	3.80	3.16

The Result in Table 4 shows the interaction effect of gender and teaching approach on students' achievement in stoichiometry. Results show that the male students taught stoichiometry using Scaffolding instructional strategy had a pretest achievement mean score of 11.27 with a standard deviation of 3.31 and a posttest mean achievement score of 22.91 with a standard deviation of 5.29. The difference between the pretest and posttest achievement mean for the male students was 11.64. The female students taught stoichiometry using scaffolding instructional strategy had a pretest achievement mean of 11.68 with a standard deviation of 2.74 and a posttest achievement mean of 21.21 with a standard deviation of 4.53. The difference between the pretest and posttest achievement mean for the female students was 9.53. The result also shows that the male students taught stoichiometry using conventional method had a pretest achievement mean score of 8.51 with a standard deviation of 2.57 and a posttest mean achievement score of 12.08 with a standard deviation of 3.62. The difference between the pretest and posttest achievement mean for the male students taught using conventional method was 3.57. The female students taught stoichiometry using conventional method had a pretest achievement mean of 9.56 with a standard deviation of 3.39 and a posttest achievement mean of 12.72 with a standard deviation of 3.80. The difference between the pretest and posttest achievement mean for the female students taught using conventional method was 3.16. In all cases, the posttest achievement mean scores were greater than the pretest achievement means scores with the male students having a higher achievement mean gain. This implies that there may an interaction between methods and gender on students' achievement in stoichiometry.

Hypothesis 3
There is no significant interaction effect of methods and gender on students' achievement in stoichiometry.
The result in Table 2 shows that with respect to the interaction effects of methods and gender on students' achievement in stoichiometry, an F-ratio of 2.25 was obtained with associated probability value of .10. Since the associated probability value of .10 was greater than 0.05 set as bench mark, the null hypothesis (H_{05}) which stated that there is no significant interaction effect of methods and gender on students' achievement in stoichiometry is not rejected. Inference drawn therefore is that, the interaction effect of methods and gender on students' achievement in stoichiometry is not statistically significant.

Summary of major Findings

From the data analysis and interpretation of the results, the following findings emerged;

1. Scaffolding instructional strategy improved students' achievement in stoichiometry than the conventional method. Further analysis showed that there was a significant difference in the mean achievement scores of students taught

stoichiometry using scaffolding instructional strategy and conventional teaching method. Moreover, scaffolding instructional strategy proved to enhance higher achievement than conventional method.

2. Female students had higher achievement mean score than their male counterparts in Stoichiometry. However, further analysis revealed that there was no significant effect of gender on the mean achievement scores of students in Stoichiometry
3. The result of the study showed that the interaction effect of methods and gender on students' achievement in stoichiometry was not statistically significant.

CONCLUSION

Based on the findings and discussion of this study the following conclusions were made:

1. Scaffolding instructional strategy enhances students' achievement in stoichiometry. The methods also avail the students the opportunity of a direct experience and active participation in the learning process.
2. There is no significant effect of gender on the mean achievement scores of students in stoichiometry. Hence, gender is not an affecting factor in the achievement of student in stoichiometry. However, the teacher should avoid any gender biased instructional strategy in teaching and learning of stoichiometry.
3. There is no significant interaction effect of methods and gender on students' achievement in stoichiometry.

Recommendations

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

1. The use of scaffolding instructional approach should be encouraged during pre-service teacher training programmes.
2. The use of scaffolding instructional approach should be adopted by science teachers especially Chemistry teachers. This can be done by recommending and reflecting the instructional approach in the curriculum materials such as textbooks, instructional materials among others.
3. Stakeholders in Chemistry educations like Ministries of education, Science Teachers' association of Nigeria (STAN), education commissions, school principals and state school management board should organize seminars, workshops and conferences where teacher in the field would be trained on how to use scaffolding instructional approach in teaching stoichiometry/Chemistry.
4. Government in conjunction with international agencies and professional bodies like (STAN) should sponsor further research on the use of scaffolding instructional approach.

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