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Effects Of Sequential Usage Of Four Teaching Methods On Secondary School Students' Chemistry Achievement In Delta State

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Abstract: ***The study investigated the effect sequential usage of four teaching methods on secondary school students' chemistry achievement in Delta state. Five research questions guided the study and six hypotheses were tested at 0.05 level of significance. The quasi-experimental design was adopted, specifically the pretest-posttest non-equivalent control group was used. The population of the study was 1, 440 (812 males and 628 female) SS2 chemistry students from the 17 secondary schools in Uvwie. The sample size for the study was 216 senior secondary year two (SS 2) chemistry students. The instruments for data collection Chemistry Achievement Test (CAT) validated by two lecturers in Departments of Science Education and Educational Foundations, from Nnamdi Azikiwe University, Awka and one experienced secondary school chemistry teacher. The reliability of the instruments were established using Kuder-Richardson Formula 20 which yielded coefficient of internal consistency of 0.62. The data obtained were analyzed using mean and standard deviation to answer the research questions and analysis of covariance was used to test the hypotheses. The findings of the study revealed that there was significant difference between the mean achievement scores of the students using different sequence of four teaching methods in favour of the lecture, laboratory, discussion and problem-solving methods sequence. Also, there was a significant disordinal interaction of sequences of teaching methods and gender on students' achievement. The study recommended that chemistry teachers should acquaint themselves with the knowledge and application of different teaching methods such as lecture, laboratory method, discussion and problem-solving methods and be able to employ them in different sequence in one lesson***

Keywords: achievement, sequential teaching methods, chemistry, mass and volume, volumetric analysis

I. INTRODUCTION

Advances in chemistry and its related fields have helped in the improvement of living standards all over the world. Chemistry is the study of the properties, synthesis, and uses of matter (Ababio, 2007). The various branches of chemistry namely: analytical, environmental, medical, industrial chemistry, chemistry of earth and space, biochemistry, quantum chemistry, physical, organic and inorganic chemistry among others find application in virtually all fields of human endeavour. Thus, the study of chemistry is an essential part of science education, required for the development of a nation's infrastructure, economy and growth.

Despite the importance of chemistry, students' achievement in chemistry in external examinations has continued to remain poor. The West African Examination Council's (WAEC) Chief Examiner's report from 2007 to 2012, the percentage number of students who made credit pass and above in chemistry remained below 50% except in 2010 when 50.7% made credit passes (see Appendix A, p. 83). There was a decreasing trend in the number of percentage credit pass and above from 2013 to 2016, from 72.34% in 2013, to 62.49% in 2014, 60.0% in 2015, and 57.74% in 2016. . Further statistics on students' performance in chemistry according to the National Bureau of Statistics (2019) shows that in Delta State, out of 49,445 students who sat for the examination in 2017, 64.86% made five credit passes including English language and mathematics while 51.83% of 53,546 had similar achievement in 2018. Again according to the Chief Examiner (2018) instead of students' performance

improving, the worst performance in chemistry since the inception of WAEC examination was observed in 2018.

According to the Chief Examiner, candidates did not show basic understanding of simple concepts in chemistry and lacked the requisite science process skills. They manifested such weaknesses in science process skills as the inability to identify colours, apply skills and theories to practical questions, inability to record observations and give logical inferences and inconsistency in reading burette among others.

A lot of factors have been reported to contribute to the poor academic achievement and poor science process skills acquisition among students in chemistry. Some of the factors according to Ojukwu (2016) include; lack of knowledge of common subjects, inadequate coverage of the syllabus and unfamiliarity with test format, lack of strong reading spirit in students who prepare for the WAEC examinations, teachers and teacher-related problems as well as institutional and government-related problems, home and parent-related problems among others. According to Cecilia (2016), poor performance in chemistry is attributed to factors such as lack of teacher motivation, discipline and negative attitude towards subject by students, inadequate instructional materials, lack of facilities like equipped libraries and ineffective teaching methods.

The problem of teaching method has continued to appear in literature as one of the major contributory factors to students' poor achievement in chemistry. The problem has persisted over time because chemistry teachers sometimes do not have the necessary and requisite instructional materials needed to adopt innovative and more suitable teaching methods like laboratory, experimental and discussion methods of teaching. Thus, teachers often make use of conventional method of teaching which in most cases involve presentation of facts and ideas to the students, an approach common with lecture method. Different teaching methods however have their advantages and disadvantages. Chemistry teachers could use a combination of the methods (lecture, discussion, laboratory and problem solving) sequentially to improve achievement and students' acquisition of science process skills.

The concept of sequential usage of teaching method refers to the use of different teaching methods by teachers in different order. However, the desire to use different methods sequentially comes with a corresponding problem about which sequence of teaching methods will be more effective for teaching chemistry; to improve achievement and enhance students' acquisition of science process skills. Thus, the need arose to investigate which sequence of usage of teaching methods namely: lecture method, discussion method, laboratory method and problem solving method will improve more than the others, students' achievement and acquisition of science process skills in chemistry. The study sought also to investigate which teaching methods presented in different sequence would improve students' achievement and science process skills irrespective of gender.

The issue of gender in science learning has remained inconclusive. Findings of research studies on the place of gender in science learning including chemistry has remained an issue of interest. While some studies found gender to be a significant factor in science learning (Chibabi, Umoru, Onah & Itodo, 2018) other study findings reported otherwise (Esther & Eni, 2015; Okigbo & Osuafor, 2008; Venita, Emmanuel & Comfort, 2016). There is need therefore, to further probe into the influence of gender and its interaction with different sequence of teaching methods on students' achievement and science process skills acquisition.

PURPOSE OF THE STUDY

The purpose of the study is to investigate the effects of sequential usage of four modes of teaching on achievement by secondary school students in chemistry. Specifically, the study sought to determine the:

- ✓ Difference in the pretest and posttest mean achievement scores of students taught chemistry using lecture, laboratory, discussion and problem-solving method of teaching presented in four different sequences.
- ✓ Difference between the pretest and posttest mean achievement scores of male and female students taught chemistry using the teaching sequence of Lecture-Laboratory-Discussion-problem-solving method (LeLaDiPs).
- ✓ Difference between the pretest and posttest mean achievement scores of male and female students taught chemistry using the teaching sequence of Laboratory-Discussion-problem-solving-Lecture method (LaDiPsLe).
- ✓ Difference between the pretest and posttest mean achievement scores of male and female students taught chemistry using the teaching sequence of Discussion-problem-solving-Lecture-Laboratory method (DiPsLeLa).
- ✓ Difference between the pretest and posttest mean achievement scores of male and female students taught chemistry using the teaching sequence of problem-solving-Lecture-Laboratory-Discussion method (PsLeLaDi).

RESEARCH QUESTIONS

The following research questions guided the study.

- ✓ What is the difference between the pretest and posttest mean achievement scores of students taught chemistry using lecture, laboratory, discussion and problem-solving methods of teaching presented in four different sequences?
- ✓ What is the difference between the pretest and posttest mean achievement scores of male and female students taught chemistry using the teaching sequence of Lecture-Laboratory-Discussion-problem-solving method (LeLaDiPs)?
- ✓ What is the difference between the pretest and posttest mean achievement scores of male and female students taught chemistry using the teaching sequence of Laboratory-Discussion- problem-solving-Lecture method (LaDiPsLe)?
- ✓ What is the difference between the pretest and posttest mean achievement scores of male and female students taught chemistry using the teaching sequence of Discussion- problem-solving-Lecture-Laboratory method (DiPsLeLa)?

- ✓ What is the difference between the pretest and posttest mean achievement scores of male and female students taught chemistry using the teaching sequence of problem-solving-Lecture-Laboratory-Discussion method (PsLeLaDi)?

HYPOTHESES

The following hypotheses were tested at 0.05 level of significance:

- ✓ There is no significant difference between the pretest and posttest mean achievement scores of students taught chemistry using lecture, laboratory, discussion and problem-solving methods of teaching presented in four different sequences.
- ✓ There is no significant difference between the pretest and posttest mean achievement scores of male and female students taught chemistry using the teaching sequence of Lecture-Laboratory-Discussion- problem-solving method (LeLaDiPs).
- ✓ There is no significant difference between the pretest and posttest mean achievement scores of male and female students taught chemistry using the teaching sequence of Laboratory-Discussion- problem-solving-Lecture method (LaDiPsLe).
- ✓ There is no significant difference between the pretest and posttest mean achievement scores of male and female students taught chemistry using the teaching sequence of Discussion- problem-solving-Lecture-Laboratory method (DiPsLeLa).
- ✓ There is no significant difference between the pretest and posttest mean achievement scores of male and female students taught chemistry using the teaching sequence of problem-solving-Lecture-Laboratory- Discussion method (PsLeLaDi).
- ✓ There is no interaction effect of the sequential modes of teaching methods and gender on students' academic achievement in chemistry.

II. METHOD

The design adopted for the study is quasi-experimental. The pretest posttest non-equivalent group design was used. . The design is presented in figure 1.

Group	Pre-test	treatment	Post-test
E1	0_1	X	0_2
E2	0_1	X	0_2
E3	0_1	X	0_2
E4	0_1	X	0_2

Figure 2: Diagrammatic Representation of the Research Design

Where,

E_1 = Experimental Group 1 on Lecture-Laboratory-Discussion- problem-solving method (LeLaDiPs) sequence

E_1 = Experimental Group 2 on Laboratory-Discussion-problem-solving-Lecture method (LaDiPsLe) sequence

E_1 = Experimental Group 3 on Discussion- problem-solving-Lecture-Laboratory method (DiPsLeLa)

E_1 = Experimental Group 4 on Problem-solving-Lecture-Laboratory- Discussion method (PsLeLaDi)

0_1 = Pre-test

0_2 = Post-test

X_1 = Treatment using the Lecture-Laboratory-Discussion-problem-solving method (LeLaDiPs) sequence

X_2 = Treatment using the Laboratory-Discussion-problem-solving-Lecture method (LaDiPsLe) sequence

X_3 = Treatment using the Discussion- problem-solving-Lecture-Laboratory method (DiPsLeLa) sequence

X_4 = Treatment using the Problem-solving-Lecture-Laboratory- Discussion method (PsLeLaDi) sequence

…. = non-equivalence of the groups

The area for the study is Uvwie local government area (LGA) of Delta state. The population of the study consist of 1, 440 (812 males and 628 female) SS2 chemistry students from the 17 secondary schools in Uvwie. The sample size for the study was 216 senior secondary year two (SS 2) chemistry students in four secondary schools in Uvwie local government area of Delta state. Purposive sampling was used to select four secondary schools among others, that are co-education and which have functional laboratory, to take care of the gender variable and experiments in the study respectively. The selected schools were assigned to experimental using random sampling (balloting with replacement). The experimental group 1 school has 51 students (28 males and 23 females), group 2 school has 59 students (27 males, 32 females) group 3 has 63 students (37 males, 26 females) while experimental group 4 has 43 students (29 males, 14 females).

The instruments for data collection are Chemistry Achievement Test (CAT). The CAT was made up 50 multiple choice questions selected from past WAEC questions on the concepts of mass-volume relationship, volumetric analysis and qualitative analysis. CAT has answer options lettered A-D (See Appendix B, p. 84). The CAT was designed to measure the students achievement in the concepts aforementioned before and after treatment with the different sequences. Each correct answer earned the students 5 marks, totalling a 100marks. A table of specification was used to ensure that adequate number of questions were sampled from each content area taught. Instructional packages were also formulated using the different teaching methods on the concepts of mass and volume relationships, quantitative analysis (volumetric analysis) and qualitative analysis (salt identification).

The instrument was validated by one lecturer in the Department of Science Education, one other in the Department of Educational Foundations, another in the Department of Industrial Chemistry, Nnamdi Azikiwe University, Awka and one experienced secondary school teacher. The reliability of the CAT were established Kuder-Richardson 20 (KR-20) to be 0.62. The experiment was carried out in two phases. In the first phase, the regular classroom chemistry teachers in the four schools were trained. The briefing was carried out in two contacts.

The teachers administered a pretest for which the students were not given any feedbacks or corrections. After the pretest, the treatment commenced using the different sequence for the four experimental groups. Basically, four teaching methods are combined in the sequences namely: lecture method,

laboratory, discussion and problem-solving method. For each lesson, a combination of these methods in different sequence was used for teaching a concept.

In the first lesson, using Lecture-Laboratory-Discussion-problem-solving method (LeLaDiPs) sequence, the teacher introduced the students to the concept of mass and volume relationship. The teacher using lecture method explained to the students the S.I. units of quantities, relationship between quantities, mole ratios and mass relationship. The students during the lecture time has only to take down notes while listening to the teachers, ask questions and on the directive of the teacher carry out any classroom exercise such as balancing a chemical equation.

In the laboratory method for the same lesson, the teacher directed the students to measure out 25 grams of limestone using weighing balance and dissolve it in excess of HCl. The students weighed a clean litmus paper on a weighing balance to determine the individual weight of the litmus paper before adding the limestone. They transfer the 25g they have weight out into a clean beaker with excess of diluted HCl. The students observed the changes in both substances and record their observation.

Data obtained from the study were analysed using mean, standard deviation and analysis of covariance. The hypotheses were tested using analysis of covariance in order to eliminate the problem of initial group difference that may confound the outcome of the study. The decision rule for the null hypotheses was: Reject null hypotheses if probability value (P) is less than or equals significant value of 0.05 ($P \leq 0.05$) and do not reject if P is greater than 0.05 ($P > 0.05$).

During the time for discussion, the teacher directed the students to listen and think about the relationship between the mass and volume of limestone and HCl. The teacher asks the students questions to facilitate discussion among them. The questions were used to guide the students' from distractions and make them stay focused on the lesson. For instance, in the first lesson, the teacher asked the students how mole ration is obtained as a discussion question. The student made attempt to explain that mole ratio is obtained from the numerical coefficients of a balanced equation. They discussed how equations are balanced and how the number of moles of the reactant and products depict their reaction.

For problem solving, the teacher solved one or more examples of a given problem relating to the concepts being taught and give the students' class exercise on the same concepts to solve. For instance, in the first lesson, teacher may ask the students to calculate the number of moles of calcium chloride, $CaCl_2$, that can be obtained from 25g of limestone, $CaCO_3$, in the presence of excess hydrogen chloride, HCl. (Ca-40, C-12, O-16, H-1, and Cl-35.5). The students following the teacher's examples, paying attention to the explanations given and taking down the points, now used the same to solve the problems given to them.

At the end of each lesson, the teacher evaluated the lesson by asking students some questions. The students on their part attempted to answer the question and the teacher summarized the key points of the lessons. The same approach was used all through the lesson for the group on Lecture-Laboratory-Discussion- problem-solving method (LeLaDiPs) sequence. In the other sequences, the same thing was done, except the methods presented sequentially changed.

After the four weeks treatment, the teachers gave the students posttest. The scores were collated and given to the researcher who supervised the activities of the teachers in the schools from time to time. Students also were given feedback on the posttest, followed with a correction and revision of all the content taught.

III. RESULT

RESEARCH QUESTION 1: What is the difference between the pretest and posttest mean achievement scores of students taught chemistry using lecture, laboratory, discussion and problem-solving methods of teaching presented in four different sequences?

Sequence	N	Pretest Mean	Pretest SD	Posttest Mean	Posttest SD	Mean Gain
LeLaDiPs	51	18.80	3.30	79.10	5.80	60.30
LaDiPsLe	59	23.69	3.25	71.97	3.96	48.28
DiPsLeLa	63	29.78	3.15	63.83	7.42	34.05
PsLeLaDi	43	32.33	5.22	55.79	9.78	23.46

Table 1: Mean Pre-test and Posttest Mean Scores of Students taught chemistry using lecture, laboratory, discussion and problem-solving methods of teaching presented in four different sequences

Table 1 shows that the group taught chemistry using LeLaDiPs sequence has mean gain achievement score of 60.30, those taught using LaDiPsLe sequence has mean gain achievement score of 48.28, those in DiPsLeLa group has mean gain achievement score of 34.05 while those taught using PsLeLaDi sequence has mean gain achievement score of 23.46. The spread of score was greatest in the posttest mean of those taught using PsLeLaDi sequence and least among those taught using LaDiPsLe sequence.

RESEARCH QUESTION 2: What is the difference between the pretest and posttest mean achievement scores of male and female students taught chemistry using the teaching sequence of Lecture-Laboratory-Discussion- problem-solving method (LeLaDiPs)?

Gender	N	Pretest Mean	Pretest SD	Posttest Mean	Posttest SD	Mean Gain
Male	28	19.00	3.29	76.50	6.13	57.50
Female	23	16.35	2.74	82.26	3.37	65.91

Table 2: Mean Pre-test and Posttest Achievement Scores of Male and Female Students taught Chemistry using LeLaDiPs Sequence

Table 2 shows that the male students taught chemistry using the teaching sequence of Lecture-Laboratory-Discussion- problem-solving method (LeLaDiPs) has mean gain achievement score of 57.50 while the females has mean gain achievement score of 65.91. The spread of scores in the posttest was highest among the males.

RESEARCH QUESTION 3: What is the difference between the pretest and posttest mean achievement scores of male and female students taught chemistry using the teaching sequence of Laboratory-Discussion-Problem-solving-Lecture method (LaDiPsLe)?

Gender	N	Pretest Mean	Pretest SD	Posttest Mean	Posttest SD	Mean Gain
Male	27	23.30	3.79	72.44	4.089	49.14
Female	32	24.88	2.15	71.56	3.860	46.68

Table 3: Mean Pre-test and Posttest Achievement Scores of Male and Female Students taught Chemistry using LaDiPsLe Sequence

Table 3 shows that the male students taught chemistry using the teaching sequence of Laboratory-Discussion-Problem-solving-Lecture method (LaDiPsLe) has mean gain achievement score of 49.14 while the females has mean gain achievement score of 46.68. The spread of scores in the posttest was highest among the males.

RESEARCH QUESTION 4: What is the difference between the pretest and posttest mean achievement scores of male and female students taught chemistry using the teaching sequence of Discussion-Problem-solving-Lecture-Laboratory method (DiPsLeLa)?

Gender	N	Pretest Mean	Pretest SD	Posttest Mean	Posttest SD	Mean Gain
Male	37	30.22	2.48	67.51	6.30	37.29
Female	26	29.15	3.89	58.58	5.54	29.43

Table 4: Mean Pre-test and Posttest Achievement Scores of Male and Female Students taught Chemistry using DiPsLeLa Sequence

Table 4 shows that the male students taught chemistry using the teaching sequence of Discussion-Problem-solving-Lecture-Laboratory method (DiPsLeLa) has mean gain achievement score of 37.29 while the females has mean gain achievement score of 29.43. The spread of scores in the posttest was highest among the males.

RESEARCH QUESTION 5: What is the difference between the pretest and posttest mean achievement scores of male and female students taught chemistry using the teaching sequence of Problem-solving-Lecture-Laboratory-Discussion method (PsLeLaDi)?

Gender	N	Pretest Mean	Pretest SD	Posttest Mean	Posttest SD	Mean Gain
Male	29	30.21	3.64	56.45	9.64	26.24
Female	14	36.71	5.36	54.43	10.29	17.72

Table 5: Mean Pre-test and Posttest Achievement Scores of Male and Female Students taught Chemistry using PsLeLaDi Sequence

Table 5 shows that the male students taught chemistry using the teaching sequence of Problem-solving-Lecture-Laboratory-Discussion method (PsLeLaDi) has mean gain achievement score of 26.24 while the females has mean gain achievement score of 17.72. The spread of scores in the posttest was highest among the females.

HYPOTHESIS 1: There is no significant difference between the pretest and posttest mean achievement scores of students taught chemistry using lecture, laboratory, discussion and problem-solving methods of teaching presented in four different sequences.

Source of variation	SS	Df	MS	F	P-value	Decision
Corrected Model	14764.365[a]	4	3691.091	78.062	.000	
Intercept	21493.131	1	21493.131	454.552	.000	
Pretest	47.669	1	47.669	1.008	.316	
Method	4270.423	3	1423.474	30.105	.000	S
Error	9976.968	211	47.284			
Total	1025158.000	216				
Corrected Total	24741.333	215				

Table 6: ANCOVA on Difference between the Mean Achievement Scores of Students taught using Lecture, Laboratory, Discussion and Problem-solving Methods of Teaching presented in four different Sequences

Table 6 shows that at 0.05 level of significance, 1df numerator and 215 df denominator, the calculated F is 30.105 with Pvalue of .000 which is less than 0.05. Thus, the null hypothesis was rejected. Therefore, there is a significant difference between the pretest and posttest mean achievement scores of students taught chemistry using lecture, laboratory, discussion and problem-solving methods of teaching presented in four different sequences.

(I) Method	(J) Method	Mean Difference (I-J)	Std. Error	Sig.[b]	95% Confidence Interval for Difference[b]	
					Lower Bound	Upper Bound
LeLaDiPs	LaDiPsLe	6.379*	1.513	.000	3.396	9.363
	DiPsLeLa	13.743*	2.000	.000	9.801	17.685
	PsLeLaDi	21.452*	2.332	.000	16.854	26.050
LaDiPsLe	LeLaDiPs	-6.379*	1.513	.000	-9.363	-3.396
	DiPsLeLa	7.364*	1.467	.000	4.473	10.255
	PsLeLaDi	15.073*	1.763	.000	11.598	18.547
DiPsLeLa	LeLaDiPs	-13.743*	2.000	.000	-17.685	-9.801
	LaDiPsLe	-7.364*	1.467	.000	-10.255	-4.473
	PsLeLaDi	7.709*	1.398	.000	4.953	10.466
PsLeLaDi	LeLaDiPs	-21.452*	2.332	.000	-26.050	-16.854
	LaDiPsLe	-15.073*	1.763	.000	-18.547	-11.598
	DiPsLeLa	-7.709*	1.398	.000	-10.466	-4.953

Based on estimated marginal means

**. The mean difference is significant at the .05 level.*

b. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).

Table 7: Scheffe PostHoc

Table 7 reveals that significant difference exists between the mean achievement scores of students taught using LeLaDiPs sequence and LaDiPsLe in favour of LeLaDiPs sequence. Table 7 also reveals that a significant difference exists between the mean achievement scores of students taught using LeLaDiPs sequence and DiPsLeLa in favour of LeLaDiPs sequence. Table 7 further shows that there is significant difference between the mean achievement scores of students taught using LeLaDiPs sequence and PsLeLaDi in favour of LeLaDiPs sequence. There is significant difference between the mean achievement scores of students taught using LaDiPsLe sequence and DiPsLeLa in favour of LaDiPsLe sequence. There is significant difference between the mean achievement scores of students taught using LaDiPsLe sequence and PsLeLaDi in favour of LaDiPsLe sequence. There is significant difference between the mean achievement scores of students taught using DiPsLeLa sequence and PsLeLaDi in favour of DiPsLeLa sequence. This shows that the direction of significance moves from LeLaDiPs, LaDiPsLe and DiPsLeLa sequence.

HYPOTHESIS 2: There is no significant difference between the pretest and posttest mean achievement scores of male and female students taught chemistry using the teaching sequence of Lecture-Laboratory-Discussion-Problem-solving method (LeLaDiPs).

Source of variation	SS	Df	MS	F	P-value	Decision
Corrected Model	464.373[a]	2	232.186	9.149	.000	
Intercept	7751.194	1	7751.194	305.431	.000	
Pretest	45.298	1	45.298	1.785	.188	
Gender	459.972	1	459.972	18.125	.000	S
Error	1218.137	48	25.378			
Total	320764.000	51				
Corrected Total	1682.510	50				

Table 8: ANCOVA on Difference between the Mean Achievement Scores of Male and Female Students taught Chemistry using LeLaDiPs

Table 8 shows that at 0.05 level of significance, 1df numerator and 50df denominator, the calculated F is 18.125 with Pvalue of 0.000 which is less than 0.05. Thus, the null hypothesis was rejected. Therefore, there is a significant difference between the pretest and posttest mean achievement scores of male and female students taught chemistry using the teaching sequence of Lecture-Laboratory-Discussion-Problem-solving method (LeLaDiPs) in favour of the females.

HYPOTHESIS 3: There is no significant difference between the pretest and posttest mean achievement scores of male and female students taught chemistry using the teaching sequence of Laboratory-Discussion- problem-solving-Lecture method (LaDiPsLe).

Source of variation	SS	Df	MS	F	P-value	Decision
Corrected Model	17.305[a]	2	8.653	.544	.583	
Intercept	5082.530	1	5082.530	319.575	.000	
Pretest	5.915	1	5.915	.372	.544	
Gender	4.528	1	4.528	.285	.596	NS
Error	890.627	56	15.904			
Total	306476.000	59				
Corrected Total	907.932	58				

Table 9: ANCOVA on Difference between the Mean Achievement Scores of Male and Female Students taught Chemistry using LaDiPsLe

Table 9 shows that at 0.05 level of significance, 1d numerator and 58df denominator, the calculated F is 0.28 with Pvalue of 0.596 which is greater than 0.05. Thus, the nul hypothesis was not rejected. Therefore, there is no significan difference between the pretest and posttest mean achievemer scores of male and female students taught chemistry using th teaching sequence of Laboratory-Discussion- problem solving-Lecture method (LaDiPsLe).

HYPOTHESIS 4: There is no significant difference between the pretest and posttest mean achievement scores of male and female students taught chemistry using the teaching sequence of Discussion- problem-solving-Lecture-Laboratory method (DiPsLeLa).

Source of variation	SS	Df	MS	F	P-value	Decision
Corrected Model	1255.322[a]	2	627.661	17.437	.000	
Intercept	2094.635	1	2094.635	58.191	.000	
Pretest	35.832	1	35.832	.995	.322	
Gender	1117.526	1	1117.526	31.046	.000	S
Error	2159.757	60	35.996			
Total	260057.000	63				
Corrected Total	3415.079	62				

Table 10: ANCOVA on Difference between the Mean Achievement Scores of Male and Female Students taught Chemistry using DiPsLeLa

Table 10 shows that at 0.05 level of significance, 1df numerator and 62df denominator, the calculated F is 31.046 with Pvalue of 0.000 which is less than 0.05. Thus, the null hypothesis was rejected. Therefore, there is a significant difference between the pretest and posttest mean achievement scores of male and female students taught chemistry using the teaching sequence of Discussion- problem-solving-Lecture-Laboratory method (DiPsLeLa) in favour of the males.

HYPOTHESIS 5: There is no significant difference between the pretest and posttest mean achievement scores of male and female students taught chemistry using the teaching sequence of problem-solving-Lecture-Laboratory- Discussion method (PsLeLaDi).

Source of variation	SS	Df	MS	F	P-value	Decision
Corrected Model	256.893[a]	2	128.447	1.366	.267	
Intercept	3532.853	1	3532.853	37.561	.000	
Pretest	218.378	1	218.378	2.322	.135	
Gender	13.940	1	13.940	.148	.702	NS
Error	3762.223	40	94.056			
Total	137861.000	43				
Corrected Total	4019.116	42				

Table 11: ANCOVA on Difference between the Mean Achievement Scores of Male and Female Students taught Chemistry using PsLeLaDi

Table 11 shows that at 0.05 level of significance, 1df numerator and 42df denominator, the calculated F is 0.148 with Pvalue of 0.702 which is greater than 0.05. Thus, the null hypothesis was not rejected. Therefore, there is a significant difference between the pretest and posttest mean achievement scores of male and female students taught chemistry using the teaching sequence of problem-solving-Lecture-Laboratory-Discussion method (PsLeLaDi) in favour of males.

HYPOTHESIS 6: There is no interaction effect of the sequential modes of teaching methods and gender on students' academic achievement in chemistry.

Source	SS	df	Mean Square	F	Sig.	Decision
Corrected Model	16417.313[a]	8	2052.164	51.033	.000	
Intercept	16091.344	1	16091.344	400.156	.000	
Pretest	12.147	1	12.147	.302	.583	
Gender	3561.469	3	1187.156	29.522	.000	
Method	97.664	1	97.664	2.429	.121	
Method * Gender	1496.757	3	498.919	12.407	.000	S
Error	8324.020	207	40.213			
Total	1025158.000	216				
Corrected Total	24741.333	215				

Table 12: ANCOVA for Testing Significance of Interaction Effect of Sequential Modes of Teaching Methods and Gender on Students' Achievement

Table 12 shows that at 0.05 level of significance, 1df numerator and 215 df denominator, the calculated F is 12.407 with Pvalue of .000 which is less than 0.05. Thus, the null hypothesis was rejected. Therefore, there is a significant interaction effect of the sequential modes of teaching methods and gender on students' academic achievement in chemistry.

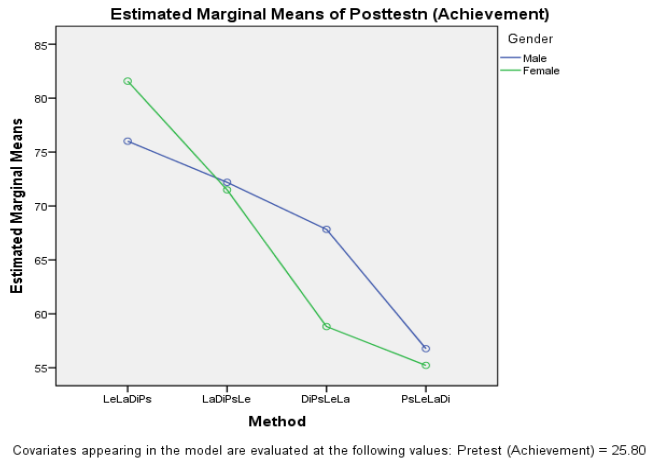

Figure 3: Plot of significant Interaction between sequential modes of teaching methods and gender on students' academic achievement in chemistry

The plot of the interaction effect between sequential modes of teaching methods and gender on students' academic achievement in chemistry is significant and disordinal. This shows that the teaching strategies have different effects on achievement of students on different conditions, for example, the effect of the sequential modes of teaching on students' achievement changed when gender was consideration.

IV. DISCUSSION

The finding of the study showed there is a significant difference between the pretest and posttest mean achievement scores of students taught chemistry using lecture, laboratory, discussion and problem-solving methods of teaching presented in four different sequences. The most effective sequence was however, the sequence of lecture method, laboratory method, discussion method followed by problem-solving method. The observed result using lecture method first enables the teacher clarifies the content matter to the students by using gestures, simple devices, by changing voice, change in position and facial expressions. Through the use of lecture method, students get ordered presentation of information that enables them to grasp the topic from the known to the unknown. Because, they are accepting information from an authority figure the teacher, lecture method prepared the students and gave them to motivation to seek further verification of scientific facts presented through the lectures in the laboratory.

The teachers' adoption of the laboratory method enable students to translate what they have read in their lectures and texts to practical realities, thereby enhancing their understanding of the learnt concepts. When teachers begin the demonstration which is key in laboratory methods, students are given opportunity to witness at firsthand, the best connection between what is taught in class and how it is in reality. This learning experience helps the students to have a better understanding of the learning contents and materials. This could be the possible explanation for the improved achievement observed in the sequence.

The laboratory method also disposed students for discussion have had a realistic understanding of the concept. The laboratory method also prompts so many questions in the minds of the students which need immediate attention. Such questions may manifest as different academic or cognitive needs for the students for which they are better predisposed for discussion. The discussion method becomes a fertile ground for students to exchange learning experience and their understanding of the concept. It also afforded the students the opportunity to learn further the concepts they do not understand from their fellow students. Through the discussion also, the students cleared their misconception and had confusion settled. To ensure whether they have met the demands of the instructional objectives, the students try to solve related problems to the concepts learnt.

The problem-solving helped the students to consolidate their understanding of the learning materials by applying their understanding to the solution of related problems. Through the problem-solving approach, the students evaluate themselves and get feedback as to the extent they have understood the topic. The problem solving exposed the students' achievement strength and weaknesses affording them the opportunity to improve on their weaknesses. The sequence therefore, at different stage of the learning process facilitated the improvement of students' achievement in chemistry more than other sequence.

The finding of the study is in agreement with the finding of Esra, Ijlal and Gurbuz (2009) that students taught using different sequence of teaching methods starting with lecture method was significantly better than the group taught with the sequence starting with experiment before lecture method. The finding of the study however, contravened the findings of Mbaegbu (2017) that there is significant difference between the mean achievement and retention scores of students in the experimental groups, in favour the demonstration-laboratory students' experiment and lecture sequence (DEL).

V. CONCLUSION

The conclusion drawn from the study is that chemistry teachers need to employ a sequence of different teaching methods during chemistry classes in order to improve achievement and acquisition of science process skills. The most favourable sequence to improve students' chemistry achievement is lecture, laboratory method, discussion method and ending with problem-solving method.

VI. RECOMMENDATIONS

The following recommendations are made based on the findings of the study.

- ✓ Chemistry teachers should present their lesson first by giving students insight into what is to be learnt followed by a laboratory method leading to discussion, with the lesson ending with related problems for students to solve.
- ✓ Chemistry teachers should acquaint themselves with the knowledge and application of different teaching methods such as lecture, laboratory method, discussion and problem-solving methods and be able to employ them in different sequence in one lesson.

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