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Sequential Usage of Four Teaching Methods: Effects on Secondary School Chemistry Students'acquisition of Science Process Skill

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Abstract: *The study investigated the effect sequential usage of four teaching methods and its effects on secondary school chemistry students' acquisition of science process. Two research questions guided the study and three null hypotheses were tested at 0.05 level of significance. The pretest posttest non-equivalent control group quasi-experimental design was used in the study. The population of the study was 1, 440 SS2 chemistry in Uvwie local government area of Delta State. The sample size for the study was 216 senior secondary year two (SS 2) chemistry students. The instruments for data Science Process Skills Acquisition Test (SPSAT) 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 instrument was established using Kuder-Richardson Formula 20 to be 0.60. 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 science process skills scores of students taught using different sequence of four teaching methods in favour of the discussion-problem solving-lecture-laboratory sequence of methods. Also, gender had significant influence on the students' acquisition of science process skills. There was a significant ordinal interaction of sequences of teaching methods and gender on students' achievement. The study recommended that effort should be made by chemistry teachers to always conduct a laboratory verification of the chemistry contents taught at the end of the lesson to enable them acquire science process skills necessarily to conduct science experiments.*

Keywords: *Science process skills, sequential usage of teaching methods, chemistry, mass and volume, volumetric analysis*

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I. Introduction

The chemistry curriculum at the senior secondary level of education has been appropriately chosen to ensure proper learning/teaching experiences and development of the cognitive, psychomotor and affective skills. The syllabus emphasizes the use of international units for physical and applied chemistry (IUPAC) system nomenclature, correct use of chemical terminologies and equations. The general objectives of the chemistry curriculum according (National Education Research and Development Council, NERDC, 2019) are: To help students develop interest in the subject of chemistry; enable students acquire basic theoretical and practical knowledge and skills; allow learners acquire basic Science Mathematic and Technology (SMT) knowledge and skills; ensure the development of reasonable level of competence in ICT application that will engender entrepreneurial skills in students; provide learners the means to apply skills to meet social needs of creating employment and wealth; create a position for learners to take advantage of the numerous career opportunities offered by chemistry; and encourage the learners to adequately get prepared for further studies in chemistry. These objectives of teaching and learning chemistry communicate the importance of chemistry in the development of the Nigerian society.

Students by learning chemistry are expected to acquire knowledge about how matter reacts, can be produced and used and to acquire the necessary process skills required to continue the studies at higher levels of education. However, students' achievement in external examination show that students' achievement have remained poor over the years. The WAEC Chief Examiner's Reports show that students perform poorly in chemistry examination with the worst performance reported in the most recent times in 2018. A lot of factors have been implicated for the poor achievement in chemistry among which teaching methods is recurrent in literature.

The problem of teaching methods arises as teachers adopt teacher-centred method of instruction due to lack of facilities and necessary instructional materials for instruction. Although, teachers adopt a variety of teaching methods, students' knowledge and acquisition of science process skills in chemistry nevertheless, remains poor. It is thought that combining the available methods of instruction such as lecture, laboratory, discussion and problem solving methods of instruction in different sequence could improve students' achievement and science process skills acquisition.

A lecture is an oral presentation intended to present information or teaches people about a particular subject (Armstrong, 2012). Lecture method is the oldest method of teaching. It is based on the philosophy of idealism (Paul, 2015). This method refers to the explanation of the topic to the students. The emphasis is on the presentation of the content (Worthen, 2015). Lecture method has been criticized as being mainly a one-way method of communication that does not involve significant audience participation but relies upon passive learning. Therefore, lecturing is often contrasted to active learning. Lectures delivered by talented teachers however can be highly stimulating; at the very least, lectures have survived in schools as a quick, cheap, and efficient way of teaching large numbers of students to a particular field of study and covering large content areas (Armstrong, 2012). It does not involve the students so actively as is common is teaching methods such as discussion method.

The discussion teaching method is a method designed to provide opportunity for interactive conversation between teacher and students, and students to students. It is a strategy that centres on shared conversations, discussions, and exchange of ideas in class. A classroom discussion according Cashin (2011) is a sustained exchange between and among teachers and their students with the purpose of developing students' capabilities or skills and expanding students' understanding (both shared and individual) of a specific concept or instructional goal. The goal of a discussion is to get students to practice thinking about the subject material (Abdu-Raheem, 2011). The role of the teacher becomes that of facilitator who designs and facilitates the discussion rather than convey information. It is characterized by probing questions from the teacher designed to elicit students interpretations, opinions, and questions (Wilkinson, 2009). Discussion method helps the students develop the science process skills of critical thinking which is needed during laboratory method of instruction.

Laboratory method of teaching is a planned learning activity dealing with original or raw data in the solution of problem (Umar, 2011). It is a procedure involving first-hand experience with materials or facts derived from investigations or experimentation (Jillian, 2012). This method is one of the important methods of teaching science and it forms an integral part of effective science teaching. In laboratory method, teacher encourages the students to derive various scientific laws and principles on their own by getting personally involved in the experiment work (Zodonu, 2013). The entire work by the students is being supervised and controlled by the teacher to reduce the risk of laboratory hazards. Laboratory method could be science process skill oriented in which case, the teacher develops the science process skills of various kinds in the students.

Pre-laboratory instructions are provided by the science teacher well in advance of time as through it students will get prepared for taking active part in laboratory activities (Zodonu & Nworgu, 2011). Through such kind of pre-laboratory instructions, students will become oriented to the objectives to be attained and the procedures or methods to be adopted. Necessary directions for actual laboratory work are also provided by the teacher to the students. Such directions highlight the necessary precautions to be taken in the laboratory during an experiment. Laboratory method follows similar approach in problem-solving method where the teacher gives students an example before they find the solution to similar problems themselves.

Problem solving method according to Adegoke (2017) generally involves defining a problem, collecting information related to the solution process, reasoning through the problem state to solution while checking and evaluating the solution. In a problem solving method, students learn by working on problems that are structure from the topic taught (Jonassen, 2010). Problem solving enables the students to learn new knowledge by facing the problems to be solved. The students are expected to observe, understand, analyze, interpret find solutions, perform applications that lead to a holistic understanding of the concept (Schoenfeld, 2013).

The discourse thus far shows that each method described has its own 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 fundamental question becomes: Which sequence of combination of these four teaching methods will be more effective in improving the students' science process skills acquisition in chemistry?

PURPOSE OF THE STUDY

The purpose of the study is to investigate the effects of sequential usage of four modes of teaching on secondary school chemistry students' acquisition of science process skills. Specifically, the study sought to examine the:

1. Difference in the pretest and posttest mean science process skills acquisition scores of students taught chemistry using lecture, laboratory, discussion and problem-solving methods of teaching presented in four different sequences.
2. Difference between the pretest and posttest mean achievement scores of male and female students.

3. Interaction effect of the sequential usage of teaching methods and gender on students' science process skills acquisition in chemistry.

RESEARCH QUESTIONS

The following research questions guided the study.

1. What is the difference between the pretest and posttest mean science process skills (SPS) acquisition scores of students taught chemistry using lecture, laboratory, discussion and problem-solving method methods of teaching presented in four different sequences?
2. What is the difference between the mean pretest and posttest mean science process skills acquisition scores of students taught chemistry.

HYPOTHESES

The following hypotheses were tested at 0.05 level of significance:

1. There is no significant difference between the pretest and posttest mean science process skills acquisition scores of students taught chemistry using lecture, laboratory, discussion and problem-solving methods of teaching presented in four different sequences.
2. There is no significant difference between the mean pretest and posttest science process skills acquisition scores of male and female students.
3. There is no significant interaction effect of the sequential usage of teaching methods and gender on students' science process skills acquisition in chemistry.

II. Method

Research design

The design adopted for the study is quasi-experimental. The pretest posttest non-equivalent group design was used. Quasi-experimental design according to Nworgu (2015) is one in which it is impossible to randomly assign subjects or study participants into groups, instead intact classes are used. The design is therefore, most appropriate for this study as students cannot be randomly assigned to the experimental and control groups owing to the administrative set up in schools.

Area of the Study

The area for the study is Uvwie local government area (LGA) of Delta state. Uvwie is one of the 25 LGA in Delta state situated in the Delta South senatorial district with its headquarters in Effurun. The LGA shares borders with Okpe, Udu. Ughievwen, Okere, and Itsekiri. The area is primarily occupied by members of the Uvwie sub-dividion of the Urhobo ethnic group with Urhobo dialect. Uvwie has notable landmarks which include the Federal University of Petroleum Resource which is the first of its kind in the whole of Africa, and the Petroleum Training Institute (PIT). There are 16 public secondary schools in Uvwie.

Population of the Study

The population of the study consist of 1, 440 (812 males and 628 female) SS2 chemistry students from the 17 secondary schools in Uvwie.

Sample and sampling technique

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).

Instrument for Data Collection

The instrument for data collection was Science Process Skills Acquisition Test (SPSAT). SPSAT consisted of two sections namely: Section A and Section B (see Appendix E, p. 95). Section A is made up of titrations experiment with five questions. Section B is on preliminary and confirmatory test for salts using bench reagents. Students are expected in both sections to observe the reactions, record their observation and inference, and make certain calculations relation to concentration, volume and moles. SPSAT is designed specifically to measure students' acquisition of the science process skills of observing, recording, experimenting, calculating, communicating, measuring, inferring, and hypothesing. 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).

Validation of the instrument

The objectives of the study, research questions, hypotheses and the instrument were given to 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 teachers for validation. The validators were asked to vet the instrument based on plausibility of distractors, clarity of statement, and appropriateness for the level of students under study. The validators were requested to write R (retain), D (delete) and M (modify) against any questions they wish the researcher to retain, delete or modify. The correction by the validators was effected in the instrument.

Reliability of instrument

The reliability of the instrument was established using Kuder-Richardson 20 (KR-20). KR-20 was used because it is a suitable reliability estimate for objective test questions with heterogeneous level of difficulty and which are dichotomously scored. The instruments were administered once to twenty chemistry students in Abraka grammar school, not used involved in the study. The obtained scores were subjected to KR-20 computation. The coefficient of internal consistencies obtained was 0.60.

Experimental Procedure

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 activities in each contact are described as follows:

Contact 1: The researcher trained the teachers on the objectives of the study, show them the instrument and train them on how to administer and score them. The research also showed them the lesson plans and briefs them on the content, the timing for each method in the sequence. Together with the researcher, they look at the experimental set up, the role of the teacher, the students' activities and the evaluation as well as the assignment. The first contact came to a close with the researcher using one of the lessons to conduct a micro-teaching for the teachers, after which they went and practice the different sequence.

Contact 2: In the second contact, each teacher presented micro-teaching exercise for the researcher to assess their understanding and mastery of the lesson plans in view of the research objectives. The researcher gave further directive based on their performance and on how to administer the instruments.

In the second phase, the treatment and data collection was done. 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.

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.

Control of extraneous variables

1. Experimenter bias: The research used the regular classroom teachers to implement the lesson as contained in the lesson plans, making sure that all the contents are the same.

2. Teacher variable: The lesson plan used for the teaching was prepared by the researcher, and also the teachers were briefed on the use of the lesson packages. This helped take care of the teacher variables.

3. Hawthorne Effect: this is when the students become aware of the experiments and leads to noticeable differences. To control for Howthorne effect, the regular class teachers were used in the experiment.

4. Class interaction**:** to reduce every possibility of students of different experimental group interacting over the study, the research made sure the schools to be used in the study are situated miles apart.

5. Initial group difference: Since intact classes were used in the study which does not allow randomization, the initial group difference was eliminated through the use of analysis of covariance (ANCOVA).

Method of Data Collection

The instrument was administered as pretest before the treatment and as posttest after the treatment. The scored obtained were arranged according to the experimental groups' pretest and posttest indicating the gender. The researcher went through the records to make sure that students' scores in the pretest and posttest are well recorded before final collation for data analysis.

Method of data analysis

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 ($P > 0.05$).

III. Results

Research Question 1: What is the difference between the pretest and posttest mean science process skills (SPS) acquisition scores of students taught chemistry using lecture, laboratory, discussion and problem-solving method methods of teaching presented in four different sequences?

Table 1: Mean Pre-test and Posttest Mean SPS Acquisition 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	17.84	5.04	52.67	4.09	34.83
LaDiPsLe	59	20.61	6.38	63.39	5.80	42.78
DiPsLeLa	63	25.11	4.55	75.86	6.39	50.75
PsLeLaDi	43	24.00	3.46	66.05	6.73	42.05

Table 1 shows that the group taught chemistry using LeLaDiPs sequence has mean gain science process skills acquisition score of 34.83, those taught using LaDiPsLe sequence has mean gain score of 42.78, those in DiPsLeLa group has mean gain score of 50.75 while those taught using PsLeLaDi sequence has mean gain SPS score of 42.05. The spread of score was greatest in the posttest mean of those taught using PsLeLaDi sequence and least among those taught using LeLaDiPs sequence.

Research Question 2: What is the difference between the mean pretest and posttest mean science process skills acquisition scores of students taught chemistry.

Table 2: Mean Pre-test and Posttest Science Process Skills Acquisition Scores of Male and Female Students taught

Sequence	Gender	N	Pretest Mean	Pretest SD	Posttest Mean	Posttest SD	Mean Gain
PsLeLaDi	Male	29	30.21	3.64	56.45	9.64	26.24
	Female	14	36.71	5.36	54.43	10.29	17.72
LeLaDiPs	Male	28	17.00	5.18	53.50	5.07	36.50
	Female	23	18.70	4.85	51.65	2.15	32.95
LaDiPsLe	Male	27	18.44	7.32	63.56	6.110	45.12
	Female	32	22.44	4.87	63.25	5.628	40.81
DiPsLeLa	Male	37	25.19	5.63	76.35	7.33	51.16
	Female	26	25.00	2.42	75.15	4.81	50.15

Table 2 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. Male students taught chemistry using the teaching sequence of Lecture-Laboratory-Discussion- problem-solving method (LeLaDiPs) has mean gain SPS acquisition score of 36.50 while the females has mean gain SPS acquisition score of 32.95. Male students taught chemistry using the teaching sequence of Laboratory-Discussion-Problem-solving-Lecture method (LaDiPsLe) has mean gain SPS acquisition score of 45.12 while the females has mean gain SPS acquisition score of 40.81. Male students taught chemistry using the teaching sequence of Discussion-Problem-solving-Lecture-Laboratory method (DiPsLeLa) has mean gain SPS acquisition score of 51.16 while the females has mean gain achievement score of 50.15

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

Table 3: ANCOVA on Difference between the Mean Science Process Skills Scores of Students taught using Lecture, Laboratory, Discussion and Problem-solving Methods of Teaching presented in four different Sequences

Source	SS	df	Mean Square	F	Sig.	Decision
Corrected Model	16018.206[a]	8	2002.276	62.907	.000	
Intercept	37416.076	1	37416.076	1175.521	.000	
Pretest	152.210	1	152.210	4.782	.030	
Gender	10524.226	3	3508.075	110.215	.000	S
Method	350.621	1	350.621	11.016	.001	S
Method * Gender	195.786	3	65.262	2.050	.108	NS
Error	6588.678	207	31.829			
Total	935857.000	216				
Corrected Total	22606.884	215				

Table 3 shows that at 0.05 level of significance, 1df numerator and 215 df denominator, the calculated F is 11.016 with Pvalue of .001 which is less than 0.05. Thus, the null hypothesis was rejected. Therefore, there is a significant difference between the pretest and posttest mean science process skills acquisition scores of students taught chemistry using lecture, laboratory, discussion and problem-solving methods of teaching presented in four different sequences.

Table 4: Scheffe PostHoc

(I) Method	(J) Method	Mean Difference (I-J)	Std. Error	Sig.[b]	95% Confidence Interval for Difference[b]	
					Lower Bound	Upper Bound
LeLaDiPs	LaDiPsLe	-10.244*	1.127	.000	-12.466	-8.022
	DiPsLeLa	-21.932*	1.230	.000	-24.356	-19.507
	PsLeLaDi	-12.313*	1.292	.000	-14.859	-9.767
LaDiPsLe	LeLaDiPs	10.244*	1.127	.000	8.022	12.466
	DiPsLeLa	-11.688*	1.106	.000	-13.868	-9.507
	PsLeLaDi	-2.070	1.190	.083	-4.415	.276
DiPsLeLa	LeLaDiPs	21.932*	1.230	.000	19.507	24.356
	LaDiPsLe	11.688*	1.106	.000	9.507	13.868
	PsLeLaDi	9.618*	1.148	.000	7.356	11.880
PsLeLaDi	LeLaDiPs	12.313*	1.292	.000	9.767	14.859
	LaDiPsLe	2.070	1.190	.083	-.276	4.415
	DiPsLeLa	-9.618*	1.148	.000	-11.880	-7.356

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 4 reveals that significant difference exists between the mean science process skills (SPS) scores of students taught using DiPsLeLa sequence and LeLaDiPs in favour of DiPsLeLa sequence. Table 4 also reveals that a significant difference exists between the mean SPS scores of students taught using DiPsLeLa sequence and LaDiPsLe in favour of DiPsLeLa sequence. Table 4 further shows that there is significant difference between the mean SPS scores of students taught using using DiPsLeLa sequence and PsLeLaDi in favour of DiPsLeLa sequence. There is significant difference between the mean achievement scores of students taught using PsLeLaDi sequence and LeLaDiPs in favour of PsLeLaDi sequence. There is significant difference between the mean achievement scores of students taught using PsLeLaDi sequence and LaDiPsLe in favour of PsLeLaDi sequence. There is significant difference between the mean achievement scores of students taught using LaDiPsLe sequence and LeLaDiPs in favour of LaDiPsLe sequence. This shows that the direction of significance moves from DiPsLeLa, PsLeLaDi and LaDiPsLe sequence.

Hypothesis 2: There is no significant difference between the pretest and posttest mean science process skills acquisition scores of male and female students taught chemistry.

Table 3 also shows that at 0.05 level of significance, 1df numerator and 215 df denominator, the calculated F is 110.215 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 science process skills acquisition scores of male and female students taught chemistry.

Hypothesis 3: There is no interaction effect of the sequential modes of teaching methods and gender on students' science process skills acquisition in chemistry.

Table 3 further shows that at 0.05 level of significance, 1df numerator and 215 df denominator, the calculated F is 2.050 with Pvalue of 0.108 which is greater than 0.05. Thus, the null hypothesis was not rejected. Therefore, there is no interaction effect of the sequential modes of teaching methods and gender on students' science process skills acquisition in chemistry.

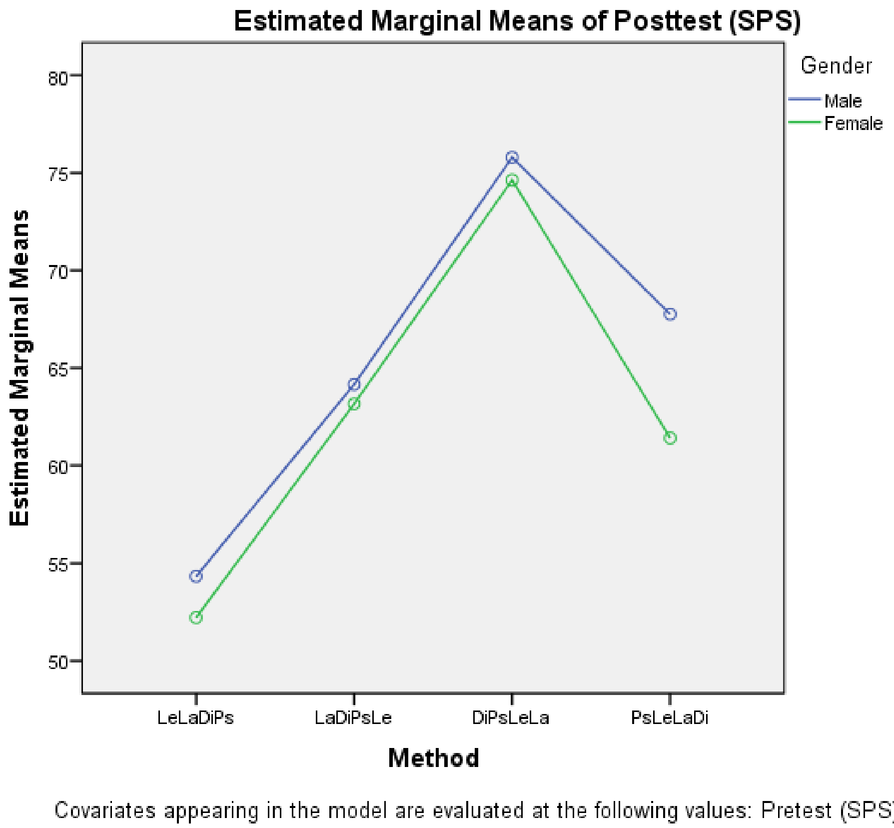

Figure 1: Plot of significant Interaction between sequential modes of teaching methods and gender on students' science process skills acquisition in chemistry

The plot of the interaction effect between the sequential modes of teaching methods and gender on students' science process skills acquisition in chemistry is significant and ordinal. Thus, the effect of the sequential mode of teaching methods on students' science process skills did not change when gender was put into consideration.

IV. Discussion

The findings of the study also showed that there is a significant difference between the mean science process skills acquisition scores of students taught chemistry using lecture, laboratory, discussion and problem-solving methods of teaching presented in four different sequences in favour of the sequence discussion, problem-solving, lecture and laboratory methods (DiPsLeLa). The observed result is attributable to the fact that the science process skills requires first an understanding into the concepts and the skills necessary to conduct a verification of that concept. The concepts of mass and volume relationship, volumetric analysis and qualitative analysis which were used in the study have continued to pose some difficulty to students both in internal and external examinations. The science process skills required by students to do these experiments are also not easily acquired. Thus, the use of discussion method first in the instructional sequence must have given the students better insight into the proper understanding of the concepts and what was required in the step by step procedure for the experiments.

The students' understanding into the concepts was further made clearer by the students' and teacher's evaluation through a problem-solving method. In the problem-solving method, students apply their knowledge and understanding of the concepts into the solution to real problems that are related to the concepts. Attempts to provide solutions to such problems expose the students' weaknesses and strength and the extent to which the required science process skills have been mastered. The students trying the questions over and having the teacher revised such problems and their solution makes their understanding clearer and results in better application of the requisite science process skills.

The introduction of lecture after the problem solving approach was quite appropriate. This is because the discussion and problem solving approach must have revealed the variety of students' needs in terms weaknesses and strength gotten through feedbacks. These feedbacks enabled the teacher to highlight the grey areas that students need further clarification. The highlights by the teacher was followed by questions from the students which augments their already acquired science process skills and knowledge preparing them adequately for laboratory experiments.

The teacher's adoption of the laboratory method at the end of the sequence was more like leading the students to verify what they already understood and for which they have the appropriate skills to do. This explanation suffices for the observed effectiveness of the sequence of instruction compared to other sequences. Trying the whole concept all over in a laboratory showed complete mastery of science process skills practiced all through the sequence. The finding of the study is in line with the findings of Elvan, Ezgi and Mustafa (2010) and Saputro, Irwanto, Atun and Wilujeng (2019) that problem-solving approach enabled students to acquire science process skills more than those in the control group.

V. Conclusion

The conclusion drawn from the study is that chemistry teachers need to employ a sequence of different teaching methods especially the discussion-problem solving-lecture-laboratory sequence of methods during chemistry classes in order to improve acquisition of science process skills.

VI. Recommendations

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

1. Effort should be made by chemistry teachers to always conduct a laboratory verification of the chemistry contents taught at the end of the lesson to enable them acquire science process skills necessarily to conduct science experiments.
2. Chemistry teachers should acquaint themselves with the knowledge and application of different teaching methods

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