THE EFFECT OF LEARNING CYCLE MODELS ON NIGERIAN SENIOR SECONDARY STUDENTS' ACADEMIC ACHIEVEMENT IN CHEMISTRY

By

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Abstract

The method of teaching Chemistry in Nigerian classrooms has given it an image of being a subject with a body of abstract ideas, giving room for dwindling performances in the subject at the secondary school level. It is within this context that this study investigated the impact of 5E and PDEODE Learning Models on students' achievement in senior secondary Chemistry. The research design was a pre-test, post-test, control group quasi-experiment, involving a 3x2x2 factorial matrix. A total of 188 students drawn from three senior secondary schools in three Local Education Zones of Lagos Education District III of Lagos State, Nigeria formed the sample. Results revealed, among others, that there was significant difference ($F_{(2, 175)} = 3.660$, $P < 0.05$) in the post-test mean achievement scores of the students in Chemistry after exposure to the different instructional strategies. Also, the students' post-test mean achievement scores in Chemistry after exposure to the different instructional strategies varied significantly ($F_{(2, 175)} = 3.582$, $P < 0.05$), between the sampled male and female students. The independent and moderator variables jointly accounted for 36.9% of the variation in the students' achievement scores. This study concluded that exposing students to the PDEODE learning model led to higher mean achievement gains in Chemistry than the 5E learning model and the conventional method .It was therefore recommended that teachers be trained in the use of conceptual change model such as PDEODE learning model in the teaching and learning of Chemistry to enhance students' achievement.

Keywords: Cognitive- style; Gender; Learning cycle models; Students' achievement.

Introduction

The essence of science learning is to understand the characteristics and behaviour of the natural environment with a view to applying the knowledge so gathered to explain, predict, control and manipulate the forces and resources of nature for the betterment of human conditions in the environment, (Njoku, 2009). It is widely and generally acknowledged that the gateway to the survival of a nation scientifically and technologically is scientific literacy which can only be achieved through science education, (Bilesanmi-Awoderu & Oludipe, 2012). Science, Technology, Engineering and Mathematics (STEM) education is a concept among others, for

attaining true independence in this regard. Tsupros, Kohler & Hallinen, (2009) refer to STEM education as an interdisciplinary approach to learning where academic concepts are coupled with real-world lessons with a view to ensuring that students apply science, technology, engineering, and mathematics in contexts that make connections among school, community, work and the global enterprise. Science & Technology has long been recognised as the instruments per excellence for nation building, and every country today craves for its advancement (Nwagbo, 2000; Opara, 2004).

Among the subjects of Science, Technology, Engineering and Mathematics (STEM) Education, Chemistry is a subject that is central to the science and technology professions, natural and artificial phenomena (Mohammed, Bello & Gwandu, 2010). Chemistry is a branch of science that deals with the scientific study of the composition, properties and reactions of chemical elements and their compounds. Its importance in technological development cannot be over emphasised, and has continued to play an increasingly important role in the lives of all mankind, by helping to produce many of the technologies which we now enjoy ranging from life-saving pharmaceuticals specifically and to social, industrial, and economic life of the world in general. The revised edition of the Nigerian Senior Secondary School Chemistry curriculum is expected ,among other things after implementation, to enable students to: develop interest in the subject chemistry; acquire basic theoretical and practical knowledge and skills; develop interest in science, technology and mathematics; acquire basic STM knowledge and skills; develop reasonable level of competence in ICT applications that will give rise to entrepreneurial skills; apply skills to meet societal needs of creating employment and wealth; be positioned to take advantage of the numerous career opportunities offered by chemistry; be adequately prepared for further studies in chemistry. (Nigerian Educational Research & Development Council, NERDC, 2007: pg. IV).

Despite the relevance of knowledge of chemistry to the society, studies (Achor, Oghonogor&Daikwo, 2011; Avwiri, 2011) have shown that the method of teaching chemistry in Nigerian classrooms has given chemistry, as a subject, a reputation of being a subject with a body of abstract ideas. This is detrimental to the development of chemistry in Nigeria and has resulted in growing public anxiety about the dwindling nature of learning outcomes in secondary school science (Chemistry) subjects.

Several studies had been carried out in order to popularize appropriate teaching strategy for teaching and learning science (Chemistry), they include; Computer Assisted Instruction (Bilesanmi-Awoderu, 2006; 2000), Hands-on Minds-on (Ibe, 2005), Concept Mapping (Danmole& Femi-Adeoye, (2004), Concept Mapping (Bilesanmi-Awoderu, 2002), Cooperative learning (Alebiosu, 2000; 1998), Questioning & Answering (Alebiosu, 1997) and Constructivism (Jonansen, 1994). However, the achievement of students in internal and external examinations is still poor. It then becomes clear that there is need to seek other approaches of teaching that will be student-centred, involving student-student interaction, and thus making learning more meaningful.

In an effort to promote conceptual understanding in chemistry classrooms leading to improved performance in chemistry, this study wishes to emphasise on this issue in teaching chemistry, by assessing the effectiveness of three types of classroom instructions, the Conceptual Understanding 5E (Engagement, Exploration, Explanation, Elaboration, Evaluation) learning model; the Conceptual Change PDEODE (Predict, Discuss, Explain, Observe, Discuss, Explain) learning model and Conventional instruction on students' achievement in chemistry.

The 5E Learning model is based on constructivism theory and Piaget's development theory (Intellectual development theory), enhancing learners' abilities to discover new knowledge by using inquiry approach. It is seen as an effective hands-on, minds-on, guided inquiry-based scientific pedagogy, especially for enhancing conceptual understanding (Bybee, Taylor, Gardner, Van Scotter, Powell, Westbrook & Landes, 2006). The 5E Learning model consists of five phases: Engagement, Exploration, Explanation, Elaboration and Evaluation (Eisenkraft, 2003). It is a teaching and learning procedure consistent with the privileged status of inquiry, deviating from the teacher centred approach to the student centred learning technique. It has been found to cause significantly better acquisition of scientific conceptions related to states of matter and solubility (Eren& Omer, 2009), acid-base (YelZKilavuz, 2005) and photosynthesis and respiration in plants (Balci, Cakiroglu &Tekkaya, 2006). It has also been found that having students exposed to learning activities in 5E model enhanced students' scientific performances and positive perceptions towards the learning activities (Liu, Peng, Wu & Lin, 2009).

The PDEODE strategy is a conceptual change model first proposed by Posner, Strike, Hewson & Gertzog (1982). According to Costu (2008), it is an important teaching strategy in which there is an atmosphere that supports discussion and diversity of views. It is believed that it can be used as a vehicle in helping students make sense of everyday situations. This consists of six steps: Prediction: P; Discuss: D; Explain: E; Observation: O; Discuss: D; Explain: E. Researchers have reported the positive impact of PDEODE learning model as a pedagogical strategy on learning outcomes within different learning context. It has been found to enhance better identification of students' preconceptions and conceptual change in students' understanding of the concept of evaporation and condensation, and also enable students to retain their new conceptions in their long-term memory (Costu, Ayas & Niaz, 2012; Costu, Ayas & Niaz, 2010). It has also been found that having students learn within PDEODE model make them have better results in physics achievement and scientific thinking skills (Mohammed Khair, 2012), enhanced mathematical thinking, understanding and retention of mathematical concepts (Al-Khateeb, 2012).

These research reports are mainly foreign based, it might therefore be necessary to test the efficacy of these models in an environment like Nigeria. Literature also shows that some of these previous studies investigated the efficacy of a model over the conventional method, but this study is aimed at testing the effects of these two models of learning over the conventional teaching method. This study investigated the effects of two learning models (5E and PDEODE) on senior secondary school students' achievement in chemistry. The moderating effects of gender and cognitive style on students' achievement in chemistry were also investigated.

Research Questions

i. Would there be any difference in the pre and post-test achievement scores of students taught within the different strategies (5E, PDEODE & CM)?
ii. Would there be any difference in the pre and post-test achievement scores of students taught within the different strategies (5E, PDEODE & CM) according to gender?
iii. Would there be any difference in the pre and post-test achievement scores of field dependent and field independent students taught within the different strategies (5E, PDEODE & CM)?

Hypotheses

Ho_1: There is no significant main effect of the use of 5E and PDEODE Learning Models and Conventional method on senior secondary school students' achievement in Chemistry.
Ho_2: There is no significant main effect of gender on senior secondary school students' achievement in Chemistry.
Ho_3: There is no significant main effect of cognitive style on senior secondary school students' achievement in Chemistry.
Ho_4: There is no significant interaction effect of the use of 5E and PDEODE Learning Models, conventional method and gender on senior secondary school students' achievement in Chemistry.
Ho_5: There is no significant interaction effect of the use of 5E and PDEODE Learning Models, conventional method and cognitive style on senior secondary school students' achievement in Chemistry.

Method

This study employed the 3 x 2x 2 quasi-experimental design. This implies that the design included three instructional groups: experimental groups; 5E and PDEODE Learning models and the conventional lecture method (control group); cognitive style at two levels – field dependent and field independent; and gender at two levels- male and female. The target population for this study was the Senior Secondary I (SSI) science students in Education District III area of Lagos State, South/West Nigeria. The sample for this study was one hundred and eighty eight SSS I science students from three coeducation senior secondary schools, selected from a total of twenty four senior secondary schools in Epe, Eredo and Ibeju-lekki Local Education Zones of Lagos State Education District III area of Lagos State, South/West Nigeria. Selection of the schools was depended on the availability of Chemistry teachers, the distance of the schools to one another in order to remove contamination effect and willingness of school principals and teachers to cooperate and

participate in the study. The chemistry topics used during classroom teaching, using any of the teaching methods, were three topics (Separation techniques, Acids, Bases and Salts, Water) in Chemistry selected from the second term scheme of work. This was necessary to make sure that students had not been exposed to those topics before the experiment. In order to collect data for the study, the following instruments were developed, validated and used:

1. Chemistry Achievement Test (CAT)
2. Group Embedded Figure Test (GEFT)

The Group Embedded Figure Test (GEFT)

GEFT was developed by Witkin, Oltman and Raskin in 1971 in America and it was found by the authors to have a reliability coefficient of 0.82 using Spearman Brown prophecy formula on a sample of 80 females and 97 males. (Achor: 2003).This was used in this study to determine the students' measure of field dependency and independency. Field dependency – independency refers to the extreme of the cognitive style continuum. Therefore, the higher the score on GEFT, the more field independent an individual is. Each respondent received this, containing 25 complex geometric designs and on the last page, the eight sample figures. There are 3 sections consisting of 7, 9, and 9 items respectively. The first section was for practice. The eight sample figures each to be identified by a letter cannot be viewed at the same time as the complex designs. The test score of individual sampled student represented the total number of figures correctly located. Thus, those that scored between 1 and 9 in this GEFT test were categorized as field dependent, while those that scored between 10 and 18 were categorized as field independent. This was administered on a sample of students, different from the schools selected for the study, to determine the reliability in Nigerian context; a Cronbach's alpha of 0.87 was obtained. This index showed an evidence of internal consistency.

The Chemistry Achievement Test (CAT)

CAT was a forty item multiple choice objective test with four options per item, meant to measure knowledge, comprehension and application. The objectives were limited to the three because of the level of exposure of the students to chemistry. It had an initial pool of 100 items constructed by the researcher, covering the SSS I topics that were taught within the study context. These were Separation techniques, Acids, Bases, Salts and Water. The face validity of the instrument were determined through expert opinion of six Senior Secondary One (SS 1) chemistry teachers ensuring that all question items were derived from the contents of the topics. It was trial tested on senior secondary one (SS 1) chemistry students, different from students of the study area. From the responses of the students, using difficulty level of 0.4-0.6 for the discrimination and difficulty indices of the items, forty (40) items survived the item analysis, and were finally selected for the CAT instrument. The forty (40) selected items for the purpose of this study were re-administered to another set of senior secondary one students to determine the reliability of the instrument. Using Kuder Richardson formula 21 (K-R 21) statistics, a reliability index of 0.73 was obtained.

There were three phases of data collection. These were the pre-test – first one week, treatment – eight weeks, the post-test – one week. Three periods of 40 minutes each were spent each week for the six weeks. There was no alteration on the time-table allocated for chemistry by the school, i.e. the periods were in line with the schools' time-tables. During the lessons, the teacher presented the topic and the instructional materials required. He listed the instructional objectives and further linked previous knowledge with the new material explicitly explaining new concepts. At the implementation stage, teacher did the following:

i. They had their students seated and asked them to keep quiet as they moved into groups.

ii. Teachers generated interest and curiosity by asking thought provoking questions to lead the students into the activities.

The data collected from the administration of the instruments were analysed using the following statistical techniques:

i. Descriptive statistics, which involved the computation of the pre-tests, post-tests mean scores, standard deviation, and variance for each of the dependent variables.

ii. Analysis of Covariance (ANCOVA) computed for each dependent variable for the three instructional groups in order to test for possible post experimental differences in the dependent variables with respect to methods and anxiety. Multiple Classification Analysis (MCA) was used to determine the direction of the differences among the groups.

Computations for the afore-mentioned methods of data analysis were done using SPSS 15.00 statistical package.

Results and Discussion

Research Question One: Would there be any difference in the pre and post-test achievement scores of students taught within the different strategies (5E, PDEODE & CM)?

In Table 1, it was revealed that the students' achievement mean scores in Chemistry before and after exposure to the instructional strategies used in the study. The table showed that the 61 students exposed to '5E' strategy recorded post-test achievement mean score of 21.02 (S.D. = 5.04); the 54 students exposed to PDEODE strategy recorded the highest post-test achievement mean score of 23.15 (S.D. = 5.34), while the 73 students exposed to conventional method recorded post-test achievement mean score of 22.42 (S.D. = 6.25). Table 1 also revealed that the highest post-test achievement score of 35 was scored by a student taught using the conventional method while another student exposed to the same method recorded the least post-test achievement score of 5. The table further revealed positive mean gains across the three groups when the pre-test and post-test scores are compared, with the PDEODE strategy recording the highest mean achievement gain of +2.61, followed by the conventional method with mean achievement gain of +0.89 and 5E strategy with the least mean achievement gain of +0.09. This outcome thus revealed that exposing students to the PDEODE strategy lead to the highest achievement gains in Chemistry when compared with the '5E' strategy and conventional method.

Table 1: Students' Pre & Post-test Achievement Scores According to Strategy

Instructional Strategy		*N*	*Mean*	*Mean Gain*	*S.D.*	*Minimum*	*Maximum*
'5E' Strategy	Pre-test	61	20.95	0.09	4.54	8	31
	Post-test		21.02		5.04	10	31
PDEODE Strategy	Pre-test	54	20.54	2.61	4.94	10	31
	Post-test		23.15		5.34	11	33
Convent. Method	Pre-test	73	21.53	0.89	5.74	10	32
	Post-test		22.42		6.25	5	35
Total	Pre-test	188	21.06		5.14	8	32
	Post-test		22.18		5.66	5	35

Research Question Two: Would there be any difference in the pre and post-test achievement scores of students taught within the different strategies (5E, PDEODE & CM) according to gender?

In Table 2, it was revealed that the mean achievement scores in Chemistry of the sampled male and female students before and after exposure to the instructional strategies. The table showed that the 113 male students recorded higher post-test achievement mean score of 22.30 (S.D. = 5.95) than the 75 female students who recorded post-test achievement mean score of 21.99 (S.D. = 5.22). The table also revealed that the highest post-test achievement score of 35 was obtained by a male student while the least post-test achievement score of 5 was obtained by another male student. It further revealed positive mean gains across the levels of gender when the pre-test and post-test scores are compared, with the male students recording higher mean achievement gain of +1.20.

Table 2: Students' Pre & Post-test Achievement Scores According to Gender

Gender		N	Mean	Mean Gain	S.D.	Minimum	Maximum
Female	Pre-test	75	21.00	0.99	4.81	11	31
	Post-test		21.99		5.22	10	33
Male	Pre-test	113	21.10	1.20	5.36	8	32
	Post-test		22.30		5.95	5	35
Total	Pre-test	188	21.06		5.14	8	32
	Post-test		22.18		5.66	5	35

Research Question Three: Would there be any difference in the pre and post-test achievement scores of field dependent and field independent students taught within the different strategies (5E, PDEODE & CM)?

In Table 3, it was revealed that the students' achievement mean scores in Chemistry according to cognitive style (i.e. field dependent and field independent) before and after exposure to the instructional strategies. The table showed that the 102 field independent students recorded higher post-test achievement mean score of 22.73 (S.D. = 5.80) than the 86 field dependent students whose post-test mean achievement score was 21.52 (S.D. = 5.45). The table also revealed that the highest post-test achievement score of 35 was obtained by a field independent learner while the least post-test achievement score of 5 was recorded by another field independent learner. It further revealed positive achievement mean gains across the students' levels of cognitive style when the pre-test and post-test scores are compared, with the field dependent learners recording the higher mean achievement gain of +1.39.

Table 3: Students' Pre & Post-test Achievement Scores According to Cognitive Style

Cognitive Style		*N*	*Mean*	*Mean Gain*	*S.D.*	*Minimum*	*Maximum*
Field	Pre-test	86	20.13	1.39	4.86	10	29
Dependent	Post-test		21.52		5.45	10	34
Field	Pre-test	102	21.84	0.89	5.26	8	32
Independent	Post-test		22.73		5.80	5	35
Total	Pre-test	188	21.06		5.14	8	32
	Post-test		22.18		5.66	5	35

Hypothesis 1: There is no significant main effect of instructional strategy (treatment) on senior secondary school students' achievement in Chemistry.

As presented in Table 4. The result revealed significant difference ($F_{(2, 175)} = 3.660$, $P < 0.05$) in the post-test mean achievement scores of the students in Chemistry after exposure to the different levels of instructional strategies (5Es, PDEODE and conventional method). Hence, the null hypothesis (Ho1) was rejected. The Multiple Classification Analysis in Table 5 revealed that with a grand mean of 22.21, the students exposed to PDEODE strategy recorded the highest post-test mean achievement score of 24.73. Those exposed to conventional method recorded the next higher post-test mean achievement score of 23.86 while the students exposed to "5Es" strategy recorded the least post-test mean achievement score of 22.18. This outcome thus revealed that the PDEODE instructional strategy with the highest post-test mean achievement score could enhance students' achievement in Chemistry than "5Es" instructional strategy and conventional method.

Table 5 further revealed that while instructional strategy alone contributed 16% of the variance in the students' achievement scores, the independent and moderator variables jointly accounted for 36.9% of the variance in the students' achievement in Chemistry.

Table 4: Summary of Analysis of Covariance of SSS Students' Achievement Scores According to Treatment, Gender and Cognitive Style

Source of Variation	*Sum of Squares*	*df*	*Mean Square*	*F*	*Sig. of F*
1 Main Effects	**943.581**	**1**	**943.581**	**43.696**	**.000**
Covariates (pre-test)	1583.404	1	1583.404	73.326	.000
Treatment (Strategy)	158.075	2	79.038	3.660	.028*

Gender	3.143	1	3.143	.146	.703
Cognitive Style	13.603	1	13.603	.630	.428
2 Way Interactions					
Treatment * Gender	154.697	2	77.348	3.582	.030*
Treatment * Cognitive Style	34.080	2	17.040	.789	.456
Gender * Cognitive Style	1.906	1	1.906	.088	.767
3 Way Interactions					
Treatmt * Gender * C. Style	17.436	2	8.718	.404	.668
Explained	**2210.247**	**12**	**184.187**	**8.530**	**.000**
Residual	**3778.960**	**175**	**21.594**		
Corrected Total	**5989.207**	**187**			

*** indicate significant F at 0.05 level** **R Squared = .369**
(Adjusted R Squared = .326)

Table 5: Multiple Classification Analysis of Students' Achievement Scores According to Instructional Strategy (Treatment), Gender and Cognitive Style

Grand Mean = 22.21

Variable + Category Instructional Strategy	*N*	*Unadjusted Deviation*	*Eta*	*Adjusted for Independent + Covariates*	*Beta*
1. "5Es" Strategy	61	-2.74		-0.03	
1. PDEODE Strategy	54	-0.13		2.52	
2. Conventional Method	73	-1.26	**.03**	1.65	**.16**
Gender					
1. Female	75	-1.38		1.07	
2. Male	113	-0.86	**.01**	1.17	**.02**
Cognitive Style					
1. Field Dependent	86	-1.39		0.74	
2. Field Independent	102	-0.87	**.02**	1.52	**.04**
Multiple R Squared					**.369**
Multiple R					**.607**

To trace the source of the obtained significant difference, with respect to the null hypothesis (1), in Table 4, the Scheffe post-hoc analysis was computed and presented in Table 6.

Table 6: Scheffe Pair-wise Comparisons of Achievement Scores on Treatment

Mean	*Instructional Strategies*	*"5Es"*	*PDEODE*	*CM*
21.02	'5Es' Strategy		*	
23.15	PDEODE Strategy	*		
22.42	Conventional Method			

* denotes pairs of groups that are significantly different at $P < 0.05$

Table 6 revealed the pair-wise comparison of the students' post-test achievement scores in Chemistry on strategy using Scheffe test. The result revealed that the obtained significant difference was due to the significant difference in the post-test mean achievement scores of the students exposed to the pair of PDEODE and "5Es" strategy only.

Hypothesis 2: There is no significant main effect of gender on senior secondary school students' achievement in Chemistry.

The result of the main effect of gender on the SSS students' achievement in Chemistry in Table 4 revealed no significant gender difference ($F_{(1, 175)} = 0.146$, $P > 0.05$). As a result, the null hypothesis (2) is not rejected. The result of the Multiple Classification Analysis (MCA) on gender in Table 5 showed that with a grand mean of 22.21, the male students with post-test mean achievement score of 23.38 recorded higher achievement score than the female students who recorded post-test mean achievement score of 23.28 after treatment. This outcome revealed that the male students with higher post-test mean achievement score recorded better achievement in Chemistry than the female students but the difference in the mean scores is not statistically significant.

Table 5 further revealed that gender alone accounted for 2% of the variance in the students' achievement scores in Chemistry.

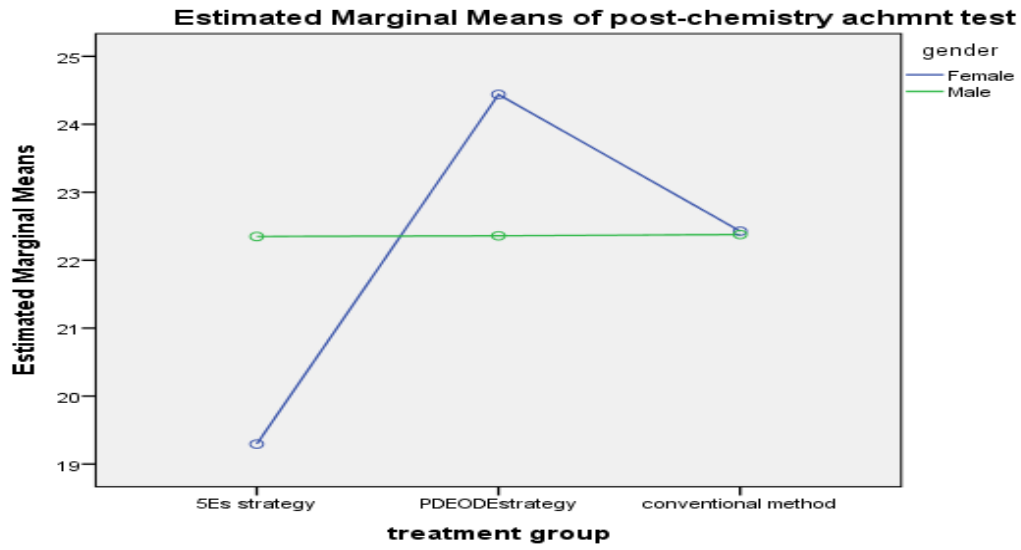
Hypothesis 3: There is no significant main effect of cognitive style on senior secondary school students' achievement in Chemistry.

The result of the main effect of cognitive style on the SSS students' achievement in Chemistry in Table 4 revealed no significant difference ($F_{(1, 175)} = 0.630$, $P < 0.05$). As a result, the null hypothesis (3) is not rejected. The result of the Multiple Classification Analysis (MCA) on cognitive style in Table 5 showed that with a grand mean of 22.21, the field independent students with post-test mean achievement score of 23.73 recorded higher achievement in Chemistry than the field dependent students who recorded post-test mean achievement score of 22.95. This outcome revealed that although, the magnitude of the post-test mean achievement score of the field independent students was higher than that of the field dependent students, the difference in the mean scores of the two categories of the students in terms of cognitive style is not statistically significant.

Table 5 further revealed that cognitive style alone accounted for 4% of the variance in the students' achievement scores in Chemistry.

Hypothesis 4: There is no significant interaction effect of treatment (instructional strategy) and gender on senior secondary school students' achievement in Chemistry.

The result of the 2-way interaction effect in Table 4 revealed significant interaction effect of treatment (instructional strategy) and gender on the students' achievement scores in Chemistry ($F_{(2, 175)} = 3.582$, $P < 0.05$). Therefore, the null hypothesis (4) is rejected. This outcome of significant 2-way interaction effect of treatment (instructional strategy) and gender on the students' achievement in Chemistry, is further explained graphically using figure 1 to dis-entangle the source of the obtained significant interaction effect. The figure is necessary to pictorially depict which level of instructional strategy ('5Es', PDEODE and conventional method) varies consistently or inconsistently with which level of gender (male and female).



Covariates appearing in the model are evaluated at the following values: pre-chemistry achievement = 21.06

Fig 1: Graphical Illustration showing 2-way Interaction Effect of Treatment (Instructional Strategy) and Gender on Students' Achievement Scores in Chemistry

The graph in figure 1 shows that while the sampled male students exposed to '5Es' strategy recorded higher post-test mean achievement scores in Chemistry than the female students exposed to that strategy, the female students exposed to PDEODE strategy recorded higher post-test mean achievement scores in Chemistry than the male students exposed to the strategy. Whereas there seems to be no difference between post-test mean achievement scores in Chemistry of the sampled male and female students exposed to conventional method.

Hypothesis 5: There is no significant interaction effect of treatment (instructional strategy) and cognitive style on senior secondary school students' achievement in Chemistry.

The result of the 2-way interaction effect in Table 4 revealed no significant interaction effect of treatment (instructional strategy) and cognitive style (field dependent and field independent) on the students' achievement scores in Chemistry ($F_{(2, 175)} = .789$, $P > 0.05$). Therefore, the null hypothesis (5) is not rejected.

Discussion of Findings

Results from the aforementioned Tables 1 to 3 indicated that the three teaching methods used had effects on the academic achievement of students in their groups at the post test level.

This implies that the PDEODE and the 5E strategies have the tendency to improve achievement in chemistry instructions, corroborating the findings of Balci, Cakiroglu&Tekkaya, (2006); Eren& Omer, (2009); Liu, Peng, Wu& Lin, (2009) and Yel_ZKilavuz (2005) in the effectiveness of 5E strategy as against conventional method on students' achievement. Al-Khateeb, (2012); Costu, Ayas & Niaz, (2012); Costu, Ayas & Niaz, (2010); Costu, (2008) and Mohammad Khair, (2012) in their various studies also revealed the effectiveness of PDEODE strategy in producing significant learning outcomes.

The finding of the present study indicated that both the 5E and PDEODE learning models caused a significantly better acquisition of scientific conceptions related to separation technique, acids, bases, salt and water, than the conventional method. In the experimental groups (5E and PDEODE), emphasis was given to students' preconceptions and misconceptions. Students were involved in activities that helped them activate their prior knowledge and struggle with their misconceptions. These activities also provide evidence that students' initial conceptions are insufficient and support only partial understanding of these concepts. To deal with these misconceptions, for instance; in the PDEODE model, students became dissatisfied with their existing conceptions. This dissatisfaction made them accept better explanations from their friends to the phenomenon that were introduced. In this way, students were allowed to think about their prior knowledge and reflect on it. The important part in the implementation of these study models was the intensive teacher-student interaction. Such a discussion environment provides opportunities for greater involvement, thereby giving students more opportunities to gain insights, intrinsic interest, and self-efficacy; and students are allowed to focus on learning, understanding, and mastering the task.

Similarly, the use of the 5E learning model clarified students' thought processes and corrected their misconceptions. When students explored new concepts through exploration, their new experiences caused them to re-evaluate their past experiences. This produces disequilibrium in the students; and, subsequently, they need to accommodate the concept to reach a balance. The students in the 5E learning model group have the opportunity to explain, to argue, and to debate their ideas, which allows them to accommodate the concept. In the elaboration phase, students gain familiarity with the introduced concept and either assimilate or accommodate the new concept into their schemata. To promote meaningful learning, it is necessary to overcome misconceptions with the help of different contemporary methods like these study models rather than the conventional method. The present study suggests the use of the 5E learning model and PDEODE learning model as an alternative method to conventional instruction. However, successful implementation of these models requires that teachers are aware of students' prior knowledge and their possible misconceptions to be able to direct the classroom activities accordingly.

The findings in hypotheses 3revealed no significant main effect of cognitive style on Senior Secondary School students' achievement in chemistry. The result implied that the post-test mean achievement scores of the field dependent and field independent learners were not significantly different after exposure to the different instructional strategies. Literatures on the influence of cognitive style on Senior Secondary School students' learning outcomes contain contradictory results. While studies (Umaru, &Tukur, 2013; Sharma & Gupta, 2012) showed that field independent learners are generally superior to their field dependent counterparts in academic achievement; other studies (Altun & Cakan, 2006;Bahar, 2003), including this present study, did not find either style performing better than the other. These inconsistencies arose probably because these studies were conducted with students of different classes on different science content areas and under different testing formats. Also, the design of these studies, as experimental, quazi-experimental or causal- comparative and the use of immediate post-test or retention test may be a contributing factor to this state of affairs. The group work in this study - experimental groups (5E and PDEODE) favoured both Field-Dependent and Field-Independent students, seeing that the nature of the

topics (separation techniques, acids, bases, salt and water) covered within this study did not really require higher skill of numerical ability, cognitive restructuring and problem-solving on the part of the learners.

The result of the main effect of gender revealed no significant main effect of gender on the students' achievement scores in chemistry This corroborated the findings of Achor, Kurumeh & Orokpo, (2012); Ejimaji & Emekere, (2012), Oludipe, (2012), Orimogunje, (2013), that there are no longer distinguishing differences in science learning outcomes of students in respect of gender.

The result of the 2-way interaction effect of treatment and gender revealed a significant interaction effect of treatment and gender on the students' achievement scores in chemistry (hypotheses 4). This outcome implied that students' post-test mean achievement scores in chemistry under the various treatment varied significantly between the sampled male and female students. Treatment (PDEODE, 5E and CM) interacted with gender in determining students' achievement in chemistry, meaning that the effective use of PDEODE and 5E strategies was associated with gender. PDEODE strategy was found to be effective for female students' achievement in chemistry, while 5E strategy was found to be effective for male students' achievement in chemistry. The reason why this is so within the groups study might be due to partial existence of environmental and situational differences based on the unequal composition of sample with respect to gender within the two models, as a result of the quazi design of the study.

Conclusion

This study has very important contributions and high implication for the educational practices in Nigeria. The result of this study have indicated that the PDEODE model have significantly higher tendency of enhancing students' achievement in chemistry than the 5E model and the Conventional Method (CM). This implies that the two Learning Models (PDEODE and 5E) have been effective and can be recommended for use in the teaching and learning of chemistry concepts.

Recommendations

Based on these findings, the following recommendations are made:

i. The Science Teachers' Association of Nigeria (STAN), Chemistry Teacher Association and other relevant academic societies responsible for teaching of chemistry should endeavour to popularize the adoption of 5E and PDEODE strategies in their teaching.
ii. At the pre-service level, the use and implementation of these learning models in the classrooms should be emphasized in the methodology courses being offered by the Student-teachers.

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