USING STEREOCHEMISTRY MODELS IN TEACHING ORGANIC COMPOUNDS NOMENCLATURE: EFFECT ON SENIOR SECONDARY STUDENTS' PERFORMANCE IN RIVERS STATE OF NIGERIA

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ABSTRACT

The purpose of the study was to find out the effect of stereochemistry models on students' performance on organic compounds nomenclature. The study was a quasi-experimental design. The sample of the study was two hundred and sixty senior secondary 1 and 2 chemistry students in four intact classes of a University Demonstration School. The sample constituted 134 students in the experimental group and 126 students in the control group. Lesson plan of organic nomenclature using Stereochemistry Models, lesson plans using Chart Models and Organic Compound Nomenclature Test were the three instruments used in the study. Overall findings of the study showed among others that the control group (Chart Model) experienced more problems in organic nomenclature than the experimental group (Stereochemistry Model); the treatment had significant effect: students taught using Stereochemistry Models performed better than those taught using Chart Model; SS 2 students performed better than SS 3 students in the Organic Nomenclature Test. These findings were discussed in the study. *[AJCE, 3(2), June 2013]*

INTRODUCTION

Chemistry is a branch of science which deals with the composition, properties and uses of matter. It probes into the principles governing the changes that matter undergoes. According to West African Examinations Council (1), the sole organizer of Senior Secondary School Certificate Examinations for West African Countries, a chemistry curriculum should, amongst other objectives,

(i) facilitate a transition in the use of scientific concepts and techniques in integrated science;

(ii) provide the students with basic knowledge in chemical concepts and principles through efficient selection of content sequencing;

(iii) show chemistry in its inter-relationship with other subjects;

(iv) show chemistry and its link with industry, everyday life and benefits;

(v) provide a course which is complete for pupils not proceeding to higher education while it is at the same time a post-secondary chemistry course.

Knowledge of chemistry through its content and processes has enabled us to produce good water for drinking, food, improved health care delivery through the production of drugs, production of various materials for construction in industries, roads, automobiles and in our homes. Chemical knowledge is also useful in solving problems resulting from human interaction with the environment like water, air and land pollution.

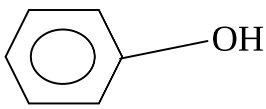
Despite the relevance of the knowledge of chemistry to the society, achievement of students in chemistry as measured by their scores in Senior Secondary School Certificate Examinations has been very poor (1-3) up to the present day.

Apart from the heavy conceptual demand on the memory capacity required of the students to study chemical content, one additional problem is that of naming chemical compounds especially in organic chemistry. Chief Examiners' Reports (1) have continuously indicated that candidates' poor performance in organic nomenclature has been their inability to write the correct names and structures of the organic compounds. The problem with chemical nomenclature has been reported with students elsewhere in the world (4).

PURPOSE AND BASIC QUESTIONS OF THE STUDY

The main purpose of this study is to find out how to help the students remedy the problem identified in the previous section.

Two major sources of the problems encountered by the students in learning nomenclature are from the chemistry textbooks and from the teachers. Some chemistry textbooks are not consistent with the names given to organic compounds. Some of these texts go with old names side-by-side with the IUPAC names (5). For instance, CH_3CH_2OH or C_2H_5OH stands for ethanol, ethan-l-ol and ethyl alcohol in some textbooks and they are the same. Why phenol C_6H_5OH or



and not benzene alcohol? These and lot more pose doubt in the memory of the students as they learn organic nomenclature.

Some chemistry teachers are not well grounded in naming organic compounds. They cannot give what they do not have. By implication, they cannot teach what they do not know. So where do the students go from here? They are left in their own imagination. However, good teachers have employed the use of models especially in teaching nomenclature in stereo chemical compounds. These are compounds whose molecules have three dimensional spatial configurations. Some stereochemistry models include ball-and-stick which are very useful in studying the stereochemistry or the spatial arrangement of carbon atoms of relatively complex organic molecules. These are commonly used in teaching nomenclature in our schools. Because of the nature of the organic content of general secondary school chemistry which is not too wide and detailed as undergraduate chemistry, the use of ball-and-stick model seem to suffix in demonstrating organic structures. This is why this model appealed to us for usage in this study.

Although this model is commonly being used in helping students learn organic compounds, we are not sure if the efficacy of this model in learning has been investigated. We are yet to sight such studies. This is why we thought it wise to carry out an investigation to find out how students will perform in naming organic compounds after being taught using the ball-and-stick model and compare such performance with mere teaching with sketches of structures on charts or chalkboard. We are also conscious of gender factors in our classrooms as pertaining to learning achievement and so we included it in our study. Specifically, the study attempted to provide answers to the following research questions, namely;

1. What difficulties do students have in naming organic compounds after they are taught using ball-and-stick model and chart?
2. What is the performance of the students in naming organic compounds after they are taught using ball-and-stick model and chart?
3. Considering class level, what is the performance of the students in naming organic compounds after they are taught using ball-and-stick and chart?
4. To what extent will gender influence the performance of the students in naming organic compounds after they are taught using ball-and-stick and chart?

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It was also hypothesized in the study that:

H_o1: There will be no significant difference between the mean performance of students taught naming organic compounds using ball-and-stick and that those taught with chart.

H_o2: There will be no significant difference between the mean performance of students taught naming organic compounds using ball-and-stick and that of those taught with chart with respect to class level.

H_o3: There will be no significant difference between the mean performance of students taught naming organic compounds using ball-and-stick and that of those taught with chart with respect to gender.

METHODOLOGY

The study is a quasi-experimental study of the type

$$\begin{matrix} O_1 & x\, O_2 \\ O_3 & \quad O_4 \end{matrix}$$

Involving an experimental group (teaching organic nomenclature using ball-and-stick) and a control group (using chart in teaching nomenclature). Independent variables of the study were the teaching methods while the dependent variable was the performance of the students in naming organic compounds. Two intervening variables namely, class level and gender were considered in the study. The variables of the study are schematically represented in Figure 1.

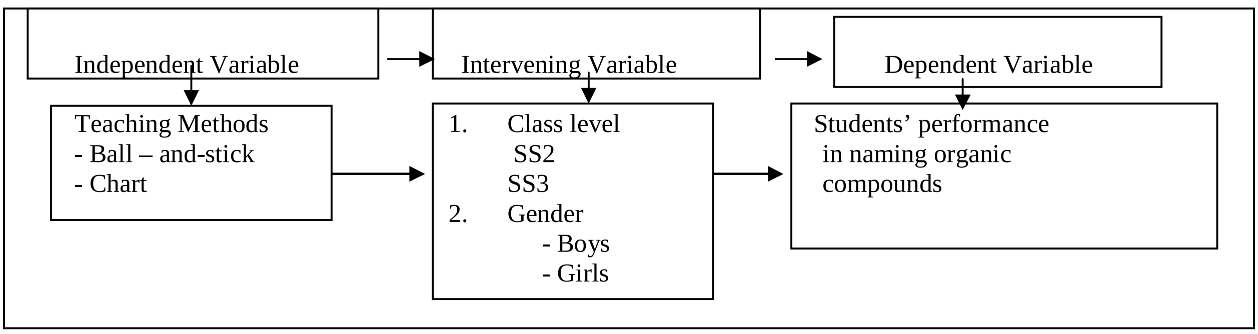


Fig.1: Schematic Representation of Variables (Arrows do not indicate causal relationship.)

Two hundred and sixty (260) year 2 and 3 Senior Secondary Chemistry students from four intact classes each of SS2 and SS3 from a University Demonstration School made up the sample of study. SS2 students were 140 while SS3 students constituted 120. Two classes each of SS2 and SS3 were randomly assigned to experimental and control groups. There were therefore two experimental groups and two control groups for SS2 and SS3 classes. Sample distribution according to class and gender is shown in table 1.

Table 1: Study Sample Distribution

Group	**Class**				
	SS2		**SS3**		
	Boys	Girls	Boys	Girls	Total
Experimental	40	30	30	34	134
Control	37	33	31	25	126
Total	**77**	**63**	**61**	**59**	**260**

Three sets of research instruments were used in the study. They were (a) Lesson Plans of Organic Nomenclature using Stereochemistry Models (LPSM), (b) Lesson Plans of Organic Nomenclature using Chart Models (LPCM) and (c) Organic Compounds Nomenclature Test (OCNT).

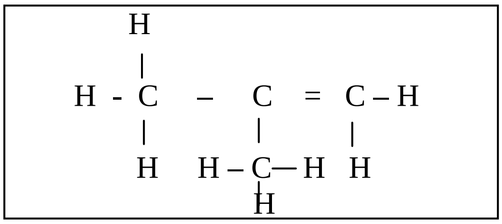
In both LPSM and LPCM, students were taught the IUPAC rules (6-9) for naming organic compounds. Students were also taught the structures of the organic compounds to be named. Altogether ten lessons involving nomenclature of simple alkanes, alkenes and alkynes and derivatives were taught each for LPSM and LPCM. The difference between LPSM and LPCM was that in LPSM further illustration was done using the stereochemistry model to explain the spread of the atoms in space and the attempt to present what seem to be the real pictures of the molecules between atoms through the bonds.

OCNT was made up of forty test items requiring the students to provide the names of the organic compounds following the IUPAC rules. Three samples of the test items are given below.

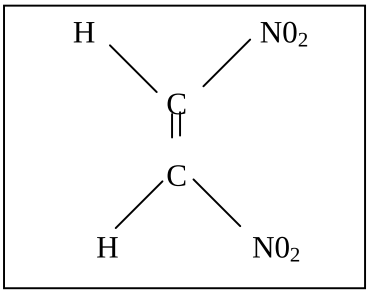
1. Write down the name of the compound with the formula:

$$ClH_2\ CCH_2\ CH_2\ OH$$

2. What is the IUPAC name of the compound?



3. Give the name for the structure



OCNT is a paper-and-pencil test and was timed to last for forty minutes. In scoring of OCNT each correct naming of the organic compounds in the test item was scored 2 marks while incorrect answer was scored O. Maximum score was 80 marks while minimum score was 0 mark.

The instruments for the study were subjected to adequate scrutiny by three chemical educators who were already working on some aspects of organic compound nomenclatures. They provided some advice concerning the procedure for teaching the nomenclatures with or without the stereochemistry models. They also suggested that two research assistants should be trained to handle the teaching using the two sets of lesson plans. These suggestions were very useful in making amendments for the design of the study. The three chemical educators also observed that the test items were within the reach of senior secondary students considering the content of their syllabus.

On this note, the test (OCNT) was administered on 20 SS2 chemistry students chosen from a Secondary School in a Local Government different from that of the school used for the study. The test was given to the students on two different occasions spaced by two weeks. The two sets of scores obtained were collated and Pearson's Product Moment Correlation Coefficient formula applied to determine the reliability (r) of the OCNT. An r of 0.73 was obtained. Based on this coefficient, the test was considered to be reliable for use in the study.

The study was carried out in the students' school. The authorities of the school were consulted and permission sought. The lessons were taught during the periods for chemistry in the timetable. Altogether ten weeks were used by the research assistants for both the experimental group and the control group. Before the teachings started, the students were pretested. After the teaching, testing also took place.

RESULTS

Data were analyzed and presented according to the research questions and hypotheses set for the study.

1. Difficulties encountered by the students in naming organic compounds

Nine observable difficulties were noted for both students taught with stereochemistry models and those taught with chart (see Table 2)

Table 2: Difficulties associated with naming Organic Compounds by students after teaching

Difficulties	**Experimental Group (use of stereochemistry Model) n = 134**		**Control Group (Use of Chart) n = 126**	
	f	(%)	f	(%)
1 Inability to recognize the longest chain	37	(27.6)	48	(38.1)
2. Confusion arising from representation of straight carbon chains  Confused with	25	(18.7)	20	(15.9)
3. Inability to identify bonds when not inserted, for eg. CH_3 $CHOHCH_3$	31	(23.1)	36	(28.6)
4. Inability to distinguish between functional groups for eg – CHO, COR	32	(23 .9)	34	(26.9)
5. Difficulty in numbering of carbon atoms considering functional groups	37	(27.6)	37	(29.4)
6. Inability to number carbon atoms in a chain containing double and triple bonds	16	(11.9)	21	(16.7)
7. Inability to distinguish main compounds from derivatives	19	(14.2)	30	(23.8)
8. Not attaching importance to the use of hyphens and commas in names eg 2–methyprop-2-ene or 1,2-chloroethane	30	(22.4)	30	(23.8)
9. Inability to name compounds according to cis-,trans-isomeric transformations	27	(20.1)	32	(25.4)

f means frequency

Information in Table 2 revealed that apart from 'confusion arising from representation of straight carbon chains' where control group had lesser percentage (15.9%) than experimental group (18.7%), in the rest of the eight identified difficulties, more students in the control group (use of chart) experienced difficulties than those in the experimental group where stereo-chemical models were used in teaching them.

2. Students' Performance in Organic Compounds Nomenclature

Analysis of Covariance (ANCOVA) was carried out using pretest and post test scores of both the experimental and the control groups. The results of are displayed on table 3.

Table 3: ANCOVA of Pre-test and Post-test Scores of Experimental and Control Groups

source	**Sum of squares**	**df**	**Mean**	**F**	**Significance**
Corrected mode	4669.717	2	2334.858	59.051	.000*
Intercept	6621.445	1	6621.445	167.464	.000*
Pretest	1.291	1	1.291	.033	.857ns
Treatment	4666.281	1	4666.281	118.015	.000*
Error	10161.683	257	39.540		
Total	804194.000	260			
Corrected total	14831.400	259			

* Significant beyond 5% level, ns = not significant

`It is worth noting that comparison of the pretest scores of the experimental and control groups did not yield a significant difference, but the effect of the treatment was highly significant, F=118.015, df=1/259, p<.05.

Performance of the students in Experimental and Control Groups:

Post test scores of both the experimental and the control groups were compared and H_o1 tested. The findings are presented in Table 4.

Table 4: Performance of Experimental and control groups in Naming organic compounds

Group	N	$\bar{X}$	SD	t-value	df	Decision
Experimental	134	59.21	7.98	11.01	258	Significant at P <.05
Control	126	50.73	3.68			

Results in Table 4 show that students taught using the stereochemistry models performed better than those taught using the chart. The difference in performance was significant at p<.05, t=11.01, df=258 (see H_o1).

Class Level and the Performance of the students in Naming Organic Compounds

Performance of the students according to the mode of instruction with respect to class level is shown in Table 5. Related hypothesis (H_o2) was also tested.

Table 5: Performance of Experimental and control groups with respect to class level

Group	Class	N	$\bar{X}$	SD	t-value	df	Decision
Experimental	SS2 SS3	70 64	59.71 58.66	8.65 7.20	0.76	132	ns
Control	SS2 SS3	70 56	50.63 50.86	3.48 3.95	- 0.34	124	ns
Experimental	SS2	70	59.71	8.65	8.18	138	*Significant at p < .05
Control	SS2	70	50.63	3.48			
Experimental	SS3	64	58.66	7.20	7.22	118	*Significant at p < .05
Control	SS3	56	50.86	3.95			

Results in Table 5 show that for experimental SS2 and SS3, and control SS2 and SS3, there are no significant differences in the performance of the students. But for experimental SS2 and control SS2, and experimental SS3 and control SS3 significant differences in the performance of the students exist. These are t=8.18, df=138 and t = 7.22, df = 118 respectively.

Gender and the Performance of the Students in Naming Organic Compounds

Performance of the students according to the mode of instruction with respect to gender is displayed in Table 6. Related hypothesis (H_o3) was also tested.

Table 6: Performance of Experimental and control Groups with respect to gender

Groups	**Gender**	**N**	$\bar{X}$	**SD**	**t-value**	**df**	**Decision**
Experimental	Boys	70	59.71	8.65	0.76	132	ns
	Girls	64	58.66	7.20			
Control	Boys	68	50.58	3.51	-0.49	124	ns
	Girls	58	50.90	3.89			
Experimental	Boys	70	59.71	8.65	7.13	136	Significant at P < .05
Control	Boys	68	50.58	3.51			
Experimental	Girls	64	58.66	7.20			
Control	Girls	58	50.90	3.89	6.87	120	Significant at p < .05

Results in Table 6 show that experimental boys and girls performed better than the control boys and girls. The difference between the mean scores ($\bar{X}$) are significant at 5% level as observed in t=7.13, df=136 and t=6.87, df=120 respectively.

DISCUSSION OF FINDINGS

The findings of this study seem to be revealing how we teach organic compound nomenclature and how students learn. It appears that teachers do not emphasize the IUPAC rules guiding naming organic compounds. How else would one explain the difficulties students encounter in naming organic compounds, knowing well that these names connote the structures of such compounds. In turn, structures determine the type of reactions such compounds undergo. It is shown in Table 2 that students encountered a number of difficulties while attempting to name organic compounds even when the teachers employed some instructional strategies to help them. Experimental group students were taught using the stereochemistry models in addition to chart while the control group was taught with only the chart yet the difficulties were observed. Lesser percentage of the students taught using stereochemistry model than those taught using chart had difficulties. This seems to be encouraging the teachers to continue using model in teaching organic nomenclature.

One observation needs to be contemplated on. This is the "confusion arising from representation of straight carbon chains" where 18.7% of the experimental group encountered more difficulties as against 15.9% of the control group. It could be that straight chain of carbon atoms is better learnt when represented on the chart than when stereochemistry model is used. Obviously, ball-and-stick model arrangement of a C-C bond does not look like a straight line as indicated on a chart or on the chalkboard. The model arrangement is three-dimensional while the chart is one-dimensional. It would be wise for the teachers to improve on the combination of both the model and the chart in helping the students learn organic compound nomenclature. This perhaps assisted in the performance of the students in the experimental group and the control group because the treatments were significant beyond 5% level of significance, F=118.015, DF,1/257 (cf Table 3).

However, experimental group students performed significantly better than the control group students (cf Table 4). This finding seem to be pointing to the direction that teaching organic compound nomenclature is fruitful using stereochemistry model such as ball-and-stick. One good thing about ball-and-stick is that the atoms and functional groups are represented in colors and sizes compared with the sketches on the chart that appear to be mock forms of the compounds. Models are concrete and easily attract the attention of the learner to conceptualize the structure of the compound through the models. Students can be encouraged to acquire a model box for their own which will enable them practice naming of organic compounds on their own. Besides, it is easy to improvise organic compound models using local materials in our environment, for example, clay, wax, starch and gum.

The useful role of using stereochemistry model in learning nomenclature of organic compounds is also observed when students' class and gender variables were considered. In terms of the class, experimental S22 and SS3 students performed significantly better than the control SS2 and SS3 students (See Table 5). Use of the model was very important, but it was also found that experimental SS2 students had higher mean score (X=59.71) than the SS3 students (X=58.66) in naming the organic compounds. This was surprising. However, when the school's subject diary was checked, it was found that SS3 students studied major part of nomenclature in SS2. They (SS3 students) seem to have forgotten the IUPAC rules for naming organic compounds. The SS2 students were currently studying the IUPAC rules of naming the compounds, so it was fresh in their memory when the study was carried out.

It was also revealed in the study that experimental boys and girls were significantly better than control boys and girls in naming organic compounds (see Table 6). Mean difference between the performance of the boys and that of the girls was not significant. Again, the use of stereo-chemical models in teaching nomenclature of organic compound proved very useful in learning the names and structure.

In conclusion, it is important to note that teachers make various attempts using different strategies in teaching chemical concepts including teaching organic compound nomenclature. Studies have also been conducted to show how such strategies and methods are paying-off in learning. It was not to our knowledge that a study like this present one has been conducted elsewhere. We are happy as chemistry teachers to have been involved in the study and to encourage other chemistry teachers to use both the stereochemical model and the chart in teaching students names of organic compounds.

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