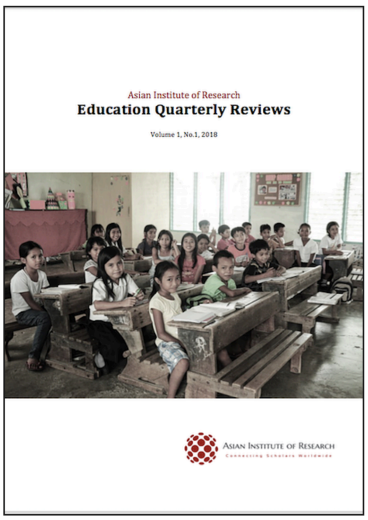

Education Quarterly Reviews

Ibrahim, Muhammad Shamsuddin, Abubakar, Mahmud Adamu, Adamu, Muhammad, and Ogabi, Raphael Oluwatoyin (2018), Influence of Using Ball-And-Stick Models in Teaching Nomenclature to SS 3 Chemistry Students in Sabon Gari Local Government Area of Kaduna State. In: *Education Quarterly Reviews*, Vol.1, No.1, 18-27.

ISSN 2621-5799

DOI: 10.31014/aior.1993.01.01.4

The online version of this article can be found at:
https://www.asianinstituteofresearch.org/

Published by:
The Asian Institute of Research

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The Asian Institute of Research
Education Quarterly Reviews
Vol.1, No.1, 2018: 18-27
ISSN 2621-5799

DOI: 10.31014/aior.1993.01.01.4

Influence of Using Ball-And-Stick Models in Teaching Nomenclature to SS 3 Chemistry Students in Sabon Gari Local Government Area of Kaduna State

Ibrahim M.S[1], Abubakar M.A[2], Adamu M.[3], Ogabi R.O[4]

[1] Department of Chemistry, Sa'adatu Rimi College of Education Kumbotso, Kano State (NYSC). Email: mshamsuddin68@yahoo.com
[2] Department of Chemistry, Federal College of Education, Zaria
[3] Department of Chemistry, Federal College of Education, Zaria
[4] Department of Polymer and Textile Science, Ahmadu Bello University, Zaria

Abstract
This research work investigates the influence of the use of Ball-and-Stick Models in teaching nomenclature to SS 3 chemistry students in Sabon Gari Local Government Area of Kaduna State. In this study, a Quasi-experimental research design was used with a nomenclature achievement test (NAT) as data collection instrument with two hundred and eighty five (285) respondents from six selected secondary schools with a total population of one thousand and ninety six (1096) students from Sabon Gari Local Government Area of Kaduna state chosen as sample using Sample Size Calculator with 5% confidence interval which is a public service of Creative Research Systems survey software. The analytical tools used for data analysis was the statistical package for social sciences (SPSS, Version 22). The result obtained shows that there is a significant difference between the performance of students taught naming organic compounds using ball-and-stick and that those taught with the chart, There is a significant difference in the performance of students taught naming organic compounds using ball-and-stick in respect to gender since the P value is of the alpha level of significance ≤0.05. The significant improvement in students' understanding can be attributed to their increased exposure to virtual and physical models and the active learning these students were engaged in. It is recommended that the government should inculcate incorporating a combination of virtual and physical models in chemistry teaching/learning as a means to foster meaningful learning and spatial understanding of molecular structure.

Key Words: Ball-and-Stick Model, Chemistry, Nomenclature, Teaching, Chemistry Students

Introduction

Chemistry can be described at three distinct levels; namely, a) the macroscopic level (visible/touchable phenomena), b) the microscopic level (atomic/molecular), and c) the symbolic level (representing matter in terms of formulae and equations) (Hinton & Nakhleh, 1999). Students who are studying chemistry are supposed to think at the microscopic levels and explain changes at the macroscopic levels (Chandrasegaran, Treagust & Mocerino, 2008). Students are supposed to link 2D and 3D structures of chemicals to their physical

properties [such as the physical state (gas, liquid, or solid), the appearance of the chemical, boiling & melting points, density, state at room temperature, and color] and chemical properties (Enthalpy of formation, Flammability, Preferred oxidation state, Coordination number, etc.). All of these think should be "cooked" in mind.

Nomenclature and molecular structure are most frequently the first topics students come across in organic chemistry. Students encounter problems in learning nomenclature from the chemistry textbooks and from the teachers (Obumnenye & Ahiakwo, 2013). Lecturers in most colleges of education still use textbooks and 2D pictures to illustrate molecules. Many researchers claim that the use of still pictures enables the building of a mental model of new concepts and phenomena, while others claim that still pictures are not adequate and utilizing animated pictures is MUST for promoting conceptual understanding (Barak & Hussein-Farraj, 2012). Chandrasegaran, Treagust & Mocerino (2008) claim that students' ability to use macroscopic, microscopic, and symbolic representations is necessary for understanding chemistry concepts and phenomena. Students who are studying chemistry are requested to think at the microscopic level (in terms of interactions between individual atoms and molecules) and explain phenomena at the macroscopic level (Dori & Hameiri, 2003).

In the early practice of chemistry, the chemical name of a compound and its chemical formula had little or no relationship to one another. For example, the compound $(CH_3)_2CO$ was called Acetone. The name “Acetone" contains no information about the type or number of elements in the compound. Modern naming methods have corrected this lack of connection. Today's rules for naming chemical compounds are set by the Nomenclature Committee of the International Union of Pure and Applied Chemistry (IUPAC). Older names, such as acetone, are now generally referred to as common names. The correct IUPAC name for $(CH_3)_2CO$ or Acetone is Propanone.

Students' ability to write correct IUPAC names is central to learning and understanding chemistry. The West African Examination Council (WAEC), the body responsible for organizing examinations in West Africa, has for some time been concerned about students' inability to name inorganic compounds correctly systematically. The 2006 WAEC Chemistry Chief Examiner (CE) report stated that many candidates had problems with the systematic naming of inorganic compounds. Student difficulties with naming inorganic

compounds have resulted in their inability to write correct chemical formulae (CE report for 2001, 2004 and 2005).

Experimental students gained a better understanding of the model concept and were more capable of defining and implementing new concepts, such as isomerism and functional group. They were better capable of mentally traversing across four understanding levels in chemistry: symbol, macroscopic, microscopic and process. Experimental group students were more capable of applying a transformation from two-dimensional representations of molecules, provided by either a symbolic or a structural formula, to three-dimensional representations – a drawing of a model, and vice versa. Based on the research findings, it is recommended that incorporating both virtual and physical models in chemistry teaching/learning serve as a means to foster model perception and spatial understanding of molecular structure. Dori and Barak, (1999)

Raiyn & Rayan (2015) Research on How Chemicals' Drawing and Modeling Improve Chemistry Teaching in Colleges of Education they concluded that integrating modeling tools such as CHEMDRAW software in chemistry education is helpful. The improvement in the average score from 5.7 (prior CHEMDRAW incorporation) to 7.3 (post CHEMDRAW incorporation) is very impressive. The students' feedback following the initiative was positive and very supportive. Most students stated that with CHEMDRAW they experienced a challenging learning environment engaged with dynamic illustration & interactive visual and would like to see such software integrated in their chemistry studies from day one. Other parameters could be tested in the future, e.g., Students' attitude toward learning chemistry as well as in more depth students' conceptual understanding of chemicals.

Hence the present study, which sets out to investigate the problems students have with understanding the systematic naming of inorganic compounds, is an important one. The fact that little academic research appears to have been done in this area, also makes this study a valuable one.

Statement of the Problem

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 the West African Examinations Council, 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 of chemical concepts and principles through an 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 healthcare 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 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 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.

Objectives of the study

The research objective was to investigate the impact of using physical types and virtual models on student understanding of new concepts and the spatial structure of molecules and to investigate the influence of gender on their performance in nomenclature achievement test (NAT).

Purpose of the Study

The main purpose of this study is to find out how to help the students remedy the problem identified in the nomenclature of organic compounds. 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. 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 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 stereochemical compounds. These are compounds whose molecules have three-dimensional spatial configurations. Some stereochemistry models include ball-and-stick which are very useful in studying 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 the ball-and-stick model seems to suffix in demonstrating organic structures. This is why this model appealed to me for usage in this study.

Research Hypotheses

It was also hypothesized in the study that:

HO_1: There is no significant difference between the mean performance of students taught naming organic compounds using ball-and-stick and with those taught with the chart.

HO_2: There is no significant difference between the mean performance of students taught naming organic compounds using ball-and-stick and that of those taught with the chart with respect to gender. The hypotheses were accepted or rejected at an alpha level of significance of $P \leq 0.05$.

Methodology

The research design adopted for this study is quasi-experimental design. Quasi-experimental design is considered appropriate for the study because intact classes were used to avoid disruption of normal class lessons, intact classes were used because some of the selected schools were privately owned schools, with thus, small population size. A total of 285 respondents from all the six (6) selected senior secondary schools with a total population of one thousand and ninety-six (1096) students in Sabon Gari Local Government Area constituted the study. The sample size was chosen in line with Sample Size Calculator with 5% confidence interval which is a public service of Creative Research Systems survey software. This was to ensure that all students were duly represented in the study. Simple random sampling was used in selecting the targeted number of respondents from all schools to represent the sample for the study. The main instrument for data collection in this study is a researcher designed assessment test titled Nomenclature Achievement Test (NAT). The test was administered to students from the various selected schools within a period of ten (10) weeks. Data analysis is the process of systematically applying statistical and/or logical techniques to describe, illustrate, condense, recap, and evaluate data. Therefore, in this research work, the researcher used the statistical package for Social Science (SPSS, version 22) as a statistical tool for data analysis.

Results

Performance of students in Naming Organic Compounds Using Ball-and-stick Model and a Chart

Descriptive statistics is showing the performance of students exposed to teaching with chart and ball-and-stick model**.**

Table 1: descriptive statistics of students when exposed to both teaching methods

Variable	N	Mean	Std. Deviation	Std. Error Mean
Chart	285	5.06	1.179	0.070
Ball-and-Stick	285	8.43	1.340	0.079

In respect to the performance of students in naming and drawing up the structure of organic compounds, it was evident that majority of the students had difficulties in drawing the structure of the organic compounds especially when they were exposed to the concept using chart, majority of the students' in their performance had an average score of 5.06 out of 15, their performance, when taught the same concept using the ball-and-stick model, was more encouraging they had an average score of 8.43 out of 15 as indicated in the descriptive statistics above. This shows that the use of concrete materials which is a theoretically based

simulation of reality will affect the performance of students when it comes to organic chemistry concepts, thus this research recommends the use of concrete materials in teaching organic chemistry nomenclature in secondary schools.

Test of Hypotheses

In order to test the null hypothesis which states that "there is no significant difference between performance of students taught naming organic compounds using the ball-and-stick model and those taught with chart" for Senior Secondary School chemistry students in Sabon Gari Local Government area, the collected data was subjected to t-test using Statistical Package for social science version 22 (SPSS, 22), The result is presented in the table below.

HO_1: There is no significant difference between the mean performance of students taught naming organic compounds using ball-and-stick and those taught with the chart.

Table 2: T-test Analysis of the Test Mean Scores (performance) of the Students Taught Chart and those using Ball-and-stick

Variable	N	X	S.D	S.E	Df	t- value	P	Remarks
Chart	285	5.06	1.179	0.070	284	72.368	0.034	Rejected
Ball-and-stick	285	8.43	1.340	0.079	284	106.199		

Significant @ P≤ 0.05

HO_2: there is no significant difference between the mean performance of students taught naming organic compounds using ball-and-stick and that of those taught with the chart with respect to gender.

Table 3: T-test Analysis of the Test Mean Scores (performance) of the Students Taught using Ball-and-stick Model in respect to Gender

Variable	N	X	S.D	S.E	Df	t- value	P	Remarks
Male	150	9.57	1.640	0.134	149	71.436	0.045	Rejected
Female	135	6.95	2.558	0.220	134	31.563		

Significant @ P≤ 0.05

Discussion of Results

Descriptive statistics in table 1 showed the performance of students in naming and drawing up the structure of organic compounds, it is evident that majority of the students find difficulties in drawing the structure of the organic compounds especially when they were exposed to the

concept using chart since majority of the students' performance is an average score of 5.06 out of 15, their performance when taught the same concept using the ball-and-stick model is more encouraging since their performance is an average score of 8.43 out of 15 as indicated by the descriptive statistics above. This shows that use of concrete materials which is a theoretically based simulation of reality will affect the performance of students when it comes to organic chemistry concepts. Thus this research recommends the use of concrete materials in teaching organic chemistry nomenclature in secondary schools.

The data obtained in Table 2 above shows that there is a significant difference in the performance of students taught using Chart and the same set of students using Ball-and-stick. Since an alpha level significance of 0.034 was found, thus the Null hypothesis which states; there is no significant difference between the mean performance of students taught naming organic compounds using ball-and-stick and that those taught with the chart.is thereby rejected and the alternative hypothesis which states; there is a significant difference between the performance of students taught naming organic compounds using ball-and-stick and those taught with the chart is therefore retained. This finding seems 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 on their own which will enable them to practice naming of organic compounds on their own.

The data obtained shows that there is a significant difference in the performance of male and female students taught Ball-and-stick. Since an alpha level of significance of 0.45 was found, thus the null hypothesis which states; there is no significant difference between the mean performance of students taught naming organic compounds using ball-and-stick in respect to gender is thereby rejected and the alternative hypothesis which states; there is significant difference between the mean performance of students taught naming organic compounds using ball-and-stick in respect to gender is therefore retained. It was revealed above that boys were significantly better than girls in naming organic compounds (see Table 3). Thus, the use of stereo-chemical models in teaching nomenclature of organic compound proved very useful

in learning the names and structure. These results are in accord with the findings of Barnea & Dori (2000).

Summary of Findings

i. There is a significant difference between the performance of students taught naming organic compounds using ball-and-stick and those taught with chart

ii. There is a significant difference between the mean performance of students taught naming organic compounds using ball-and-stick in respect to gender

Conclusion

In chemistry, physical ball-and-stick models derived from polystyrene spheres and plastic straws were not merely enlargements of the molecules that they are intended to represent. For example, the relative diameter of the spheres represents the size of the different atoms, or all the sticks (straws) are of equal length, while "real" molecular bond lengths were not. Space-filling models focus on different properties of the molecule. While the experimental students used various model types that they were able to construct, multiple representation modes for the same molecule mentally. The teacher used just one type of physical model, limiting students' experience with models and causing their model perceptions to be partially adequate.

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