Assessing the Effectiveness of 3D Molecular Models for Drawing Structures of Aliphatic Hydrocarbons at Wiawso College of Education

Francis Abban – Acquah[1] & Joseph Coleman[2]
[1]*Science Department, Wiawso College of Education, Ghana*
[2]*Mathematics Department, Wiawso College of Education, Ghana*

Abstract:- **The study aimed at assessing the effectiveness of 3D molecular models for drawing structures of aliphatic hydrocarbons at Wiawso College of Education in the Western North Region of Ghana. The research design was Quasi experimental, Purposive sampling technique was used to select all the sixty-five(65) students in the second-year science class. The main instruments used in the collection of the data were tests and questionnaire. The scores obtained from the use ofchalk board illustrations and3D molecular modelswere analysed usinginferential statistics.The results obtained from the statistical analysis showed that there was significant difference instudents' performance in the use of chalk board illustrations and 3D molecular models.The analysis of the questionnaire showed that students generally appreciated the use of the 3D molecular models in the drawing structures of aliphatic hydrocarbons. Further research is also needed on the topic; specially to investigate the incorporation of computer-generated structures to enhance teaching and learning at Colleges of Education in Ghana**

Key words: **Aliphatic hydrocarbons, Tetravalent, Structure formular, condensed formular, molecular model**

I. INTRODUCTION

This study seeks to find out the effectiveness of molecular models in drawing structures and naming of aliphatic hydrocarbons at Wiawso College of Education. The importance of the research in this area is due to the fact that there is a strong link between the teachers' content knowledge, and the pedagogy they use to teach. Primarily, teachers' knowledge affects the teaching and learning process whiles the learner's knowledge is influenced by teacher experiences that reflects on such experiences (Caldderhead, 1996; Clark & Peterson, 1986). It is therefore reasonable to relate learning experiences of the learner to that of the influence of the teacher.

The number of candidates who fail in integrated science examinations, at both first and second cycle levels of education in Ghana has been of concern of late. As one of the important core subjects offered at these levels, a good pass in integrated science becomes one of the basic requirements for entry into the subsequent levels of the educational system. Evidently, the bulk of students who do remedial classes and resit for examinations after completion of first or second cycle are those who could not pass or had weak grades in science. National Urban League (1999) observed that although science seems to be one of the subjects which influence the lives of people in many ways, it is one of the academic subjects' students tend to dislike most. Literature shows that abstract teaching of scientific concepts among others contribute largely to lack of interest and poor performance of students in science. Many efforts have been made by the Government of Ghana, the Ministry of Education and Ghana Education Service as well as many other stakeholders to address science education issues in the educational system. However, limited resources in terms of models make the teaching and learning of some topics, like the structure and names of hydrocarbons, remain a problem.

Statement of the problem

Science students of Wiawso College of Education cannot write structural formulaeand give IUPAC names of Aliphatic hydrocarbons. Most of their wrong answers reveal specific misconceptions, which need to be corrected. Skelly and Hall (1993) defined a misconception as a mental representation of a concept, which does not conform to scientific theory, principle or the likes.

Purpose of the Study

The purpose of this study was to assess the effectiveness of 3D molecular models for drawing

Structures and naming of aliphatic hydrocarbons within the science course content at Wiawso Colleges of Education. It was also meant to find the level of students' appreciation of the use of the molecular models.

Theoretical framework of the study

The theoretical base of this research is embedded in the constructivists' theory of learning. Constructivism is an approach to teaching and learning based on the idea that learning is the result of mental construction. Students learn by fitting new information together with their past experience. Constructivists believe that learning is affected by the context in which an idea is presented as well as by the students' personal beliefs and attitudes.

Constructivists' theory deals with learning that "is a process of constructing meaning; it is how people make sense of their experiences" (Merriam, Caffarella, & Baumgartner, 2007, p. 291). Some leading developers of constructivist theory were, John Dewey, Lev Vygotsky, and Jean Piaget (Davis &Sumara, 2002; Henson, 2003; Merriam, Caffarella, & Baumgartner, 2007; Piaget,

1984, 2003; Proulx, 2006; Wilson & Lowry, 2000). Constructivism theory concerns learning basically and not teaching. The emphasis is therefore laid on the learning environment and it is learner centered rather than teacher centered (Proulx, 2006). The teacher's role is to ask "what should be taught" and "how can this be learned" (Proulx, 2006). Henson (2003) cites some of the benefits of learner-centered education put forward by Dewey as including students increased intellectual curiosity, creativity, drive, and leadership skills. Educators who are committed to learner-centered education do challenge students within their abilities while providing reinforcement and appropriate rewards for students' success.

Models in Sciences

Models are very important in the teaching and learning of many scientific concepts. The use of models can be seen in the use of billiard ball model of a gas, the Bohr model of the atom, the Gaussian-chain model of a polymer, the double helix model of deoxyribonucleic acid (DNA), agent-based and evolutionary models in the social sciences, and others (Frigg & Hartmann 2006). Scientists spend a great deal of time building, testing, comparing and revising models, and much literature is dedicated to introducing, applying and interpreting models as valuable tools in modern science.

Idealised models

An idealisation is an intentional simplification of something complicated with the mind of making it more meaningful. Some well-known examples include frictionless planes, point masses, infinite velocities, isolated systems, and markets in perfect equilibrium. Thoughtful arguments over idealisation have focused on two general kinds of idealisations: the Aristotelian and Galilean idealisations (Reiss, 2003). The Aristotelian idealization puts away, all properties of a concrete object that is believed not relevant to the problem at hand. This allows attention to be paid to a limited set of characteristics of interest

Analogical models

Standard examples of analogical models in science include the billiard ball model of a gas, the computer model of the mind or the liquid drop model of the nucleus. At the most basic level, two or more things are analogous if they share certain relevant similarities. Hesse (1963) differentiated between different types of analogies according to the kinds of similarity relations in which two objects enter. A simple type of analogy is one that is based on shared properties. The earth and the moon are analogous because of the fact that both are large, solid, opaque, spherical bodies, receiving heat and light from the sun, revolving around their axes, and gravitating towards other bodies. It is not always that sameness of properties is a necessary condition for analogical models. An analogy between two objects can also be based on relevant similarities between their properties. In this more liberal sense, there is an analogy between sound and light because echoes are similar to reflections, loudness to brightness, pitch to colour, detectability by the ear to detectability by the eye.

Phenomenological models

Phenomenological models have been explained in different though related, ways. Traditionally they refer to models that only represent observable properties of their throats and refrain from postulating hidden mechanisms arid the like in another development, McMullin (1968) explains phenomenological models as models that are independent of theories. This however, seems to be too strong. Though many phenomenological models, fail to he obtained from a theory, incorporate principles and laws associated with theories. The liquid drop model of the atomic nucleus, for instance, portrays the nucleus as a liquid drop and describes it as having several properties; surface tension and charge, among others originating in different theories like hydrodynamics and electrodynamics, respectively. Certain aspects of these theories are partially used to determine both the static and dynamic properties of the nucleus.

II. METHODOLOGY

Population and Sample Selection procedure

The target population consists of students, chemistry tutors of Wiawso College of Education. Much attention was focused on sixty-five (65) students after which information was elicited from this structure was to collect detailed and objective information as much as possible from students.Mokhado (2002) stressed that it is important to select information rich cases because it helps to address the purpose of the research. McMillan and Schumacher (2001) further recommended purposive sample because the sample that are chosen are likely to be knowledgeable and informative about the phenomenon being investigated.Due to resources and time constraint,purposive sampling technique was used in selecting the participants for the study.

Research Instruments

The instruments used for the study were tests and questionnaire to determine the effectiveness of the intervention on students' performance. The researcher also used interview to find more about the sample at hand. The chemistry tutors were interviewed by the researcher to give his general perception about the problem.

Test

The test items for the pre and post-tests hundred content questions which were later put into two sets of fifty questions each. Most of the items were selected from the foundation studies course FDC 224 C examination past set by the institute of Education, Cape Coast University for the past five years (2015 – 2020), and parallel sample questions were also set by the researcher. The fifty test items were content validated based on the existing course content on aliphatic hydrocarbons. The fifty (50) items comprising twenty (20) items on naming, twenty (20) on structural formulae and ten (10) on writing of condensed formula were developed.

Administration of Questionnaire

Questionnaire was used to collect information from the sample to assess the effectiveness of the used of the molecular models. Research questions were used as the basis to design a questionnaire to seek the views of the students' appreciation on the use of models and their suitability as a pedagogical tool in the teaching and learning process. The questionnaire had eleven closed and one opened ended questions item.

Validity of the main Instrument

To validate the test instruments some of the test items and questionnaire were given to other colleague researchers with considerable knowledge in the concept area to review. Their comments were used to redefine the test items before they were administered. Joppe (2000) explains validity as: whether a research truly measures that what it is intended to measure or how truthful the research results are. In order words, does the research instrument allow you to hit "the bull's eye" of you research object?

Reliability of the main instrument

Charles (1995) noted that the consistency at which answered questionnaire or test items or individual scores could remain relatively the same can be determined through the use of the test -retest method at two different times. A reliability test was conducted by determining the Cronbach's alpha. Cronbach alpha was then used to calculate the coefficient of reliability, which was found to be 0.825. This was then compared with the tabulated coefficient of reliability which according to Cramer and Bryman (2001) is acceptable at 0.8, thus the internal consistency (reliability) of the instrument was calculated.

Treatment Process

The researcher used 3D molecular models to draw structures of aliphatic hydrocarbons these were alkanes**,** alkenes alkynes. The structures were limited to compounds having not more than ten carbon atoms. The IUPAC naming and the writing of structural formulae were integrated into the teaching and learning process to facilitate the students understanding.The test items were administered to the whole second year science students which were sixty-five (65) in number. The tests were conducted in line with the laid down regulations of the institute of education, University of cape Coast.

Data Analysis

Analysis of data involves the process of editing, cleaning, transforming, and modelling data with the goal of highlighting useful information to make suggestion, drawconclusion and support decision (Ader, 2008). All data were screened to check for errors, missing responses and ensure accuracy.Inferentialstatistical were adopted in analysing data.

III. SIGNIFICANT FINDINGS

Research question one

What difficulties do students encounter when asked to draw structures and name aliphatic hydrocarbons?

It was clear from the selected sampled answers given by the students that, they have various misconceptions which were listed below.

1. Fluorine as f instead of F,
2. Chlorine as cl and CL, instead of Cl
3. Bromine as br instead of Br
4. Carbon as small c which in many cases were too small to be considered as C.
5. Incorrect writing of chemical symbols.
6. The use of wrong prefix like meth-, eth-, prop-, but-, likewise methyl-, ethyl and propyl to indicate the number of carbon atoms in the given compounds.
7. Inability to identify the functional groups like alkane, alkene, alkyne present in the given compound and naming each accordingly.
8. Inappropriate selection of the parent chain and – or the selection of the longest continuous chain.
9. Lake or inadequate skills in numbering the carbon atoms, especially with respect to the functional group present and other substituents present and on the lesser side.
10. lacks or inadequate knowledge in separating numerals and letters, for example, 1,2,3 as in1 2 3trichlorobutane.
11. Inability to identify the tetravalent nature of carbon

Research question two

There is no significant difference in student's performance in the use of chalk board illustrations and 3D molecular models

Table 1. Analysis of students' performance in the use of chalk board illustration and 3D molecular models

t-Test: Paired Two Sample for Means		
	CHALKBOARD ILLUSTRATIONS	3D MOLECUAL MODELS
Mean	19.28125	62.15625
Variance	78.55456349	75.53075397
Observations	64	64
Pearson Correlation	0.068659483	
Hypothesized Mean Difference	0	
df	63	
t Stat	-28.63229501	
P(T<=t) one-tail	3.97664E-38	

t Critical one-tail	1.669402222	
P(T<=t) two-tail	7.95329E-38	
t Critical two-tail	1.998340543	

IV. CONCLUSION

Test statistics value is greater than the critical or the probability value. There is significant difference,the null hypothesis is rejected. Therefore, there is significant difference in student's performance in the use of chalk board illustrations and 3D molecular models.

The feedback obtained from the tutor's questionnaire showed that students' appreciation level of making use of the IUPAC rules governing naming of chemical compounds was rather the lowest scored item.

Limitation of the study

The main limitation of the study is that the result cannot be generalized because the population was from a single college.

REFERENCES

[1]. Calderhead, J. (1996). Teachers; Beliefs and knowledge. In D. C. Berliner & R. C. Calfee (Eds.), *Hand book of educational psychology* (pp. 709-725). New York: Macmillan.

[2]. Davis, B., &Sumara, D. (2002). Constructivist discourses and the field of education: Problems and possibilities. *Educational Theory,* 52(4), 409-428.

[3]. Frigg, R., & Hartmann, S. (2006). Models in Science, Retrieved January 25, 2010, from the website: http://plato.Stanford.edu/entries/models-science/#RepModIModPhe

[4]. Government of Ghana, (2004). *Report of the Education Reform Review Committee.* Accra: Government of Ghana.

[5]. Henson, K. T. (2003). Foundations for learner-centered education: A knowledge base. *Education, 124(1),* 5-16

[6]. *Hesse, M. (1963).* Models and analogies in science. *London: Macmillan.*

[7]. Institute of Education (2003-2008). *The chief examiners' report for FDC114.* Cape Coast: University of Cape coast.

[8]. Joppe, M. (2000). *The research processes.* Retrieved December 17, 2009 from the website: http://www.ryerson.ca/~mjoppe/rp.htm.

[9]. *McMillan J. H., & Schumacher S. (2001).* Research in education; A conceptual introduction (5th ed.). *New York: Longman.*

[10]. McMullin, E. (1968). What do physical models tell us. In B. van Rootselaar& J. F. Staal (Eds.). *Logic, methodology and science III.* Amsterdam: North Holland.

[11]. Merriam, S. B. Caffarella, R. S., & Baumgartner, L. M. (2007). *Learning in adulthood: A comprehensive guide* (3rd ed.). San Francisco, CA: Jossey-Bass.

[12]. Ministry of Education, Youth and Sports [MESS] (2004). *White paper on report of the educational reform review committee.* Accra: Ministry of Education, Youth and Sports.

[13]. *Mokhado, N. D. (2002).* Challenges educators experience in the provision of environmental education at schools in curriculum 2005. *Johannesburg: Rand Afrikaans University.*

[14]. National Urban League, (1999). *Science opens doors and its fun too: Who needs science;* retrieved on 20th September 2009 from the website: http//eripts.cr5c.uiuc.edu/npin/respar/texts/parschoo/sciencedoor.htinl.

[15]. Piaget, J. (1984). The attainment of invariants and reversible operations in the development of thinking. *Social Research, 51,* 167-184.

[16]. Piaget, J. (2003). Development and learning. *Journal of Research in Science Teaching, 40,* 8-18.

[17]. *Politzer, P., &Truhlar, D. G. (1981)* Chemical applications of atomic and molecular electrostatic potentials *(Eds). New York: Plenum.*

[18]. Proulx, J. (2006). Constructivism: A re-equilibration and clarification of the concepts, and some potential implications for teaching and pedagogy. *Radical Pedagogy,* 5(1). Retrieved January 25, 2010, from the website: http://radicalpedagogy.icaap.org/content/issue8_l/proulx.html.

[19]. *Reiss, J. (2003).* Causal inference in the abstract or seven myths about thought experiments, in Causality: Metaphysics and Methods Research Project. *Technical Report 03/02. LSE.*

[20]. Shulman, L., & Grossman, P. (1988). *The intern teacher casebook.* San Francisco, C. A: Far Wets Laboratory for Educational Research and Development.

[21]. *Skelly, K. M., & Hall, D. (1993).* The development and validation of a categorization of sources of misconceptions in chemistry. Paper presented at the Third International Seminar on Misconceptions and Educational Strategies in science and Mathematics. *Ithaca: August. 2008.*

[22]. Spigner-Littles, D., & Anderson, C. E. (1999). Constructivism: A paradigm for older learners. *Educational Gerontology, 25(3),* 203-209.

[23]. Tasker, R., & Dalton, R. (2006). Research into practice: visualisation of the molecular world using animations, *Chemistry Education Research and Practice,* 7, 141-159.

[24]. Treagust, D. F., Chittleborough, G., &Mamiala, T. L. (nd). Students' understanding of the role of scientific models in learning science. *International Journal of Science Education 15(2),* 4-14.

[25]. Van Fraassen. & Bas C. (1980). *The scientific image.* Oxford: Oxford University Press.

[26]. Woodward, J. (2003). *Making things happen: A theory of causal explanation.* New York: Oxford University Press.