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STUDENTS' UNDERSTANDING OF PRE-ORGANIC CHEMISTRY CONCEPTS: CHEMICAL BONDING

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Abstract. *Chemical bonding is a basic chemical principle that has applications in many areas of Chemistry. Students of Chemistry need to be able to analyze situations where Chemical bonding occurs in order to understand reaction mechanisms, many physical properties, solubility, molecular interactions and some spectroscopic information. The study investigated the students' conceptual understanding of pre-organic chemistry concepts in chemical bonding. This used descriptive research design which investigated how the students, after completing General College Chemistry, understand, explain and apply chemical bonding to determine physical attributes of organic molecules. There were 28 BSE Biological Science majors who participated in the study after having completed the 5-units General College Chemistry course with laboratory component. They took the two-tiered conceptual understanding test. The findings show that, generally, the students had functional misconception of Chemical bonding. This manifests that the students had vigorous misconceptions in which they were holding on to their initial beliefs which had enabled them to answer questions correctly, but for wrong reasons. This situation most often goes undetected because usually tests do not probe into the reasons supporting initial students' response.*

Key words: Conceptual understanding, two-tiered Test, Misconception

INTRODUCTION

Chemistry is a world filled with predominant events, interesting experimental activities and flourishing knowledge for understanding the natural and man-made worlds. However, students face problems in understanding the subject despite its association with daily life's experiences. Students' difficulty in understanding the subject is to some extent contributed by the abstract nature of the concepts involved in the subject. The students need not to understand only the symbols, terminologies and theories used in learning Chemistry concepts. They need to transform instructional language or materials which the teachers use in the Chemistry classroom into meaningful representations.

Chemical bonding is one of the key concepts in Chemistry, particularly in the study of Organic Chemistry. The learning of the many concepts taught in Organic Chemistry, is dependent upon the understanding of the fundamental ideas in Chemical bonding. Most of the teachers and students as well, perceive the concept as difficult, with teaching commonly leading to students developing misconceptions. Many of these misconceptions could be results from oversimplified models used in the textbooks, the use of traditional pedagogy that present a rather limited and sometimes incorrect pictures of the issues related to Chemical bonding (in Nahum, et al, 2010).

Success in studying Chemistry requires students' sound reasoning skills, fundamental scientific knowledge, ability to work with scientific knowledge and excellent problem solving skills (Johnstone, 2000). However, lessons in Organic chemistry, such as Hydrocarbons and their Derivatives, had become hindrance to students' understanding since these lessons requires lots of imaginary and abstract processes which are non-tangible and non-visual in context. Students often struggle with the abstract concepts in Organic chemistry. Pedagogy in Organic Chemistry class have to address the students' need to develop appropriate mental models of abstract concepts.

In addition, the difficulties in defining effective science teaching are embedded in the numerous characteristics and roles of the classroom teacher. Hudson (2007) alleged earlier that effective science teaching requires an understanding of the subject matter which need to be taught in several engaging ways. Research in science teaching cited theories to support teaching approach for what constitute effective science teaching. Such teaching approach may include authentic learning, problem-based learning, constructivism, cooperative learning, and social cognitive approach, among others.

Chemical bonding is a basic Chemical principle that has application in all areas of Chemistry (Chang, 2011). Students in Chemistry need to be able to analyze situations where Chemical bonding, as a pre-Organic Chemistry concept, can occur in order to understand reaction mechanisms, many physical properties, solubility, molecular interactions and some spectroscopic information. This assessment examines how the students after completing General College Chemistry course understand, explain, and apply Chemical bonding to determine physical attributes of organic molecules as well as biomolecules in advanced Chemistry studies.

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Determination and investigation of students' understanding in chemistry education has been very important for the last decades. Science educators have generally agreed that chemistry understanding and misconceptions should be investigated. Understanding concept of the atom and molecule is basic in chemistry education because the learning of concepts like chemical bonding, particulate nature of the atom, reaction rates, chemical equilibrium and solution chemistry are possible only with the comprehension of atom and molecule concept.

Furthermore, research on the students' conceptions in chemistry has been developed to improve the teaching and learning chemistry. The investigations show that the chemistry educators realized that students' misconceptions as well as alternative conceptions are important within the process of understanding the concepts in chemistry. Mulford and Robinson (2002) cited that the alternative conceptions play an important role in learning chemistry than simply producing inadequate explanations to questions. Therefore, as a chemistry teacher, it is important to understand the role of students' alternative conceptions in learning chemistry.

REVIEW OF LITERATURE

According to Duit and Treagust (2012), students may undergo instruction in a particular science topic, do reasonably well in a test, and yet, do not change their original ideas pertaining to the topic even if these ideas are in conflict with the scientific knowledge they were taught. Likewise, earlier research (Driver, 2013) show that even students who are been well trained and exhibit all the overt signs of success, faithful attendance at good schools, with high grades and test scores, typically do not display as adequate understanding of material and concepts with which they have been working.

Conceptual understanding goes beyond knowing facts and labels. Reasonably, conceptual understanding becomes meaningful only when it can be used to explain or to explore new situations. Learning theory posit that learning is an active process in which the learner takes information from the environment and constructs personal interpretation and meanings. The learner's interpretations are influenced not only by the external environment. They are also shaped by the learner's prior knowledge and experiences.

Students demonstrate conceptual understanding when they provide evidence that they can recognize, label, and generate examples of concepts. They could also use

and interrelate models, diagrams, manipulatives and varied representations of concepts. The student could also identify and apply principles, know and apply facts and definitions. They could compare, contrast, and integrate related concepts and principles; recognize, interpret and apply the signs, symbols, and terms used to represent the concepts. Conceptual understanding reflects a student's ability to reason in settings involving the careful application of concept definitions, relations, or representations (Balka, Hull, and Harbin, 2000).

If students are introduced to abstract concepts before they have a solid basis for understanding those concepts, they tend to resort to memorization and rote learning. It may not count as meaningful learning or a change in understanding which is not a solid foundation for further learning. Such changes in knowledge that constitute rote memorization nor an ability to regurgitate proposition verbatim, do not exemplify learning or understanding.

Balka et al. (2000) alleged that for many years, major emphasis in school was on procedural knowledge or what is referred to as procedural fluency. It gave emphasis on rote learning with little attention paid to understanding of concepts. In recent years, major efforts have been made to focus on what is necessary for students to learn. To be proficient, a student must have conceptual understanding which allows the student to apply and possibly adapt some acquired concepts to new situations.

METHODOLOGY

The study assessed the students' conceptual understanding of pre-organic chemistry concepts, specifically in Chemical bonding. The study was conducted with the third year BSE- Biology Science majors during the Second semester of School Year 2016 – 2017. Twenty eight third year BSE-Biology Science majors participated in the study.

The data on Conceptual Understanding in Chemical Bonding was obtained using a developed and validated two-tiered test on conceptual understanding. The test was 30 items. The first tier assessed the students' cognitive knowledge about the concepts in chemical bonding; and the second tier explored the students' reasons for their choice made from the first tier (Licayan, 2011). Hence, the second tier of the test assessed the conceptual understanding of students on the pre-organic chemistry concepts, specifically on chemical bonding. The test was tried out to the fourth year students. The try out results a reliability coefficient of 0.714 indicating that the said two-tiered test was

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reliable, consistent and dependable to assess the students' conceptual understanding of Chemical bonding.

The level of conceptual understanding was scaled to five points with corresponding descriptors. The descriptors for the levels of conceptual understanding were adopted from Feridon (In Licayan (2011): Scientifically Correct Understanding (121- 150); Partially Correct Understanding (91- 120); Functional Misconception (61 – 90); Incomplete Understanding (31- 60); and Worst Understanding (0 – 30).

Prior to the gathering of data for the study, protocol as well as research ethics were followed. The student-participants were given the informed consent letter. They were informed on the nature of the study; on their respective role in the study; on the benefits they would obtain from the study; as well as the assurance that their respective identity was kept confidential and that the data were used for research purpose. Their respective consent to participate was then solicited,

The data were treated with descriptive statistics, such as the mean, standard deviation, frequency and percentages.

FINDINGS AND DISCUSSION

The data in Table 1 show that the participants had Functional Misconception. This finding would mean that generally, the students had correct choice in the cognitive test; however, their correct choice was accompanied by incorrect reasons. Here, the data show that the students had vigorous misconception that may had enabled them to answer questions correctly, but for the wrong reasons. They could have been holding onto their initial beliefs firmly. This situation most often goes undetected because tests usually do not prove into the reasons supporting initial students' responses (Licayan, 2011). The standard deviation shows that there was variation in the distribution of the scores of the participants in the test for conceptual understanding.

Detailed analysis of the data in Table 1 reveals that the distribution of the scores of the participants clustered in the Functional Misconception level. There was about 25.92% who were in the Partially Correct Understanding level. This level shows responses involving correct choice but accompanied by incomplete reasons. About 7.41% was in the Scientifically Correct Understanding level. The participants who were in this level had the correct choice in the test of Understanding, and the choice was accompanied by scientifically correct and complete explanation. This was the best

possible situation which indicated a sound understanding of the concept in Chemical bonding.

Table 1
Profile of the Students' Level of Understanding of Pre-Organic Chemistry Concepts: Chemical Bonding

Level of Understanding	Frequency	Percentage
Scientifically Correct Understanding	2	7.14
Partially Correct Understanding	7	25.00
Functional Misconception	18	64.28
Incomplete Understanding	1	3.57
Worst Understanding	0	
Total	28	100 %
Mean Score	86.48	
s. d.	18.19	
Level of Understanding	Functional Misconception	

The profile in Table 1 shows that the cluster of the distribution was in the functional misconception. This means that, generally, the students had correct choice in the multiple item test which assessed their cognitive understanding, but they had incorrect reasons for their choice, as assessed in the second tier of the test. The students may had undergone instructions in a particular science topic, do reasonably well in a test, yet do not change their ideas pertaining even if these ideas are in conflict with the scientific concepts they were taught. Research shows (Treagust D.F. and Harrison, A.G., 2000) that even students who have been well trained and exhibited all the overt signs of success, faithful attendance at good schools, with high grades and good scores, praises

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or awards from leaders do not demonstrate or show as adequate understanding of material or concepts of which they have been working. Baybee (2011) earlier claimed that conceptual understanding is influenced by the prior knowledge brought by students to learning situations. This prior knowledge is labelled as preconceptions, naïve conception, alternative frameworks or misconception.

One key factor, Anderson (2010) cited, as contributing to the low level of conceptual understanding and large number of misconceptions among students, is the existence of their prior knowledge, which is either ignored or not recognized. This is possible when science concept, like chemical bonding, is taught as if the students do not have prior experience and knowledge relative to the topic being studied. This necessitates the importance of the study on conceptual understanding since students' misconceptions on particular topic in science would be given proper remediation. The ability to form concepts allows the student to make sense of the information being processed every day.

Duit, et. al (2011) earlier asserted two levels of scientific conceptual understanding: procedural knowledge (rules without reasons) and conceptual knowledge (understanding the procedures and their underlying relationships to science concepts. In order to achieve conceptual knowledge, students must make appropriate connections among science concepts and procedures.

Studies reveal that students bring with them to science lessons certain ideas, notions and explanations of natural phenomena that are inconsistent with the ideas accepted by the scientific community (Osborne, 2000). Students may undergo instruction in a particular science topic, do reasonably well in a test, and yet, not change their original ideas pertaining to the topic even if these ideas are in conflict with the scientific concepts they were taught (Tan & Treagust, 1999). In this study, some students still held to their own understanding even after being taught about Chemical Bonds as they could hardly conceptualize the concepts. Particularly on chemical bonding concepts, they interchangeably describe types of bonding and give incorrect examples and explanations in the test of understanding.

Sigler and Saami (2000) alleged that learning the basic is important. However, students who memorize facts and procedures without understanding often are not sure when and how to use what they know. Conceptual understanding would enable the students to deal with novel problems that they have encountered before.

Earlier, Chang (2011) and Taber (2002) had claimed that chemical bonding is one of the key concepts in Chemistry and one of the most fundamental. It is also one the areas in physical sciences where understanding is developed through diverse models – which are in turn built upon a range of physical principles and where learners are expected to interpret a diverse set of representations. If students are exposed to varied activities on constructing models, this would make them aware how chemical bonding concepts be conceptualized.

In the learning process, the teachers play a significant role. Good teaching and learning are linked with students' experiences. If the students performed well and actively participate in class activities, then it is concluded that the teaching strategy is effective.

CONCLUSION

The findings generally point out the functional misconception of some students taking Organic Chemistry course, in spite of having completed their General Chemistry. They still possess misconceptions found in younger, less experienced students. They must have not abandoned – or even have formed faulty beliefs about pre-Organic Chemistry concepts, like: H bond, Polarity of Chemical Bond, Covalent bond and Intermolecular forces.

The students' misconceptions could make it difficult, if not impossible for them to apply Chemistry concepts to data interpretations and analysis. Reliance to rote memorization as a means to analyze and interpret data may also pose problems in their study of advanced Chemistry concepts, particularly in Organic Chemistry and/ or in Biochemistry.

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