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# Using The Two-Tier Multiple Choice to Analyze Students' Understanding In Atomic Structure of The Chemistry Subject Material

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Abstract

Atomic structure is a subject material taught at the eleventh senior high school. It is an important principle to understand the basic concepts such as chemistry, the elements periodic system and the chemical bonds. This study was aimed to identify the level of understanding of eleventh grade students of the MAS Ex PGA Al Washliyah Medantowards the atomic structure concept. The population of this research was all of the eleventhgrade students ofthe MAS Ex PGA Al Washliyah Medan and the research sample was taken by using the purposive random sampling with ± 24 students as the samples. The two-tier multiple choice testwas used as the diagnostic test to analyze the students' understanding in atomic structure subject material. The result analysis showed that there were around 28,33% of the students understood concept, 39,5% did not understand the concept, and 32,08% of the students had misconception.

**Keywords :** Two-tier multiplier choice, Analysis, Student's understanding,Atomic structure

## Introduction

Based on the constructivism learning theory, knowledge is constructed uniquely by each individual learner. A learner will actively construct knowledge to comprehend nature, to interpret new information in their cognitive structure. Knowledge constructed by individuals are influenced by their prior knowledge, experiences and social context where the learning process was undergoing(Ozmen, 2004).

Pinker (2003) suggests that generally students who attend the classes did not come to the classroom with empty minds. They come to the class with a set of assumptions about things they will learn. Thus, their prior assumptions before a set of lessons given were called the prior knowledge or the preconcept (Al-Rubayea, 1996). It means that the real learning takes place before the students bring a number of ideas or notions when they interpret about symptoms in their surroundings. These ideas orinitial ideas are called preconception or alternative conceptions. This preconception is commonly identified as misconceptions(Gardner, 1991). Accordingto Suparno, (2005) chemistry misconception is a situation where the chemistry concept that is understood by a learner is not in accordance with the correct chemistry concepts according to the chemists. Aydin (2009) suggests that

students develop certain concepts abouts cientific concepts based on their experiences of every day life, media, and their interactions with others.

Skelly and Hall (in Nakiboghu and Tekin, 2006) state that the misconception is a mental representation of a concept that is not related to the accepted scientific theory nowadays. They divide the misconception into two categories: *firstly*, the experiential misconceptions known as the alternative conceptions or the intuitive conceptions; and *secondly*, the instructional misconception.

Therefore, teachers should have the ability to identify and overcome the students' misconceptions as an important tool in the learning processes. Some methods that are commonly used in determining the students' understanding of a concept is the concept map (Novak, 1996), interviews (Carr, 1996), and the multiple choice diagnostic instrument (Treagust, 1988, 1995). Nevertheless, the multiple-choice diagnostic instrument is scored and readily administered more than other methods, which makes it particularly useful for classroom teachers.

The comprehension achievement ofthe students'concept can be divided into three groups: knowing concept, did not know the concept, and misconceptions. The determination of the group of students is based on the CRI (Certainty of Response Index) method (Hasan, 1999). Barke (2009) said that the chemistry concepts that are often experiencing students' misconceptions are the concept of matter, energy, acids and bases, structure of atoms, molecules and chemical bonds, stoichiometry, a solution of electrolytes and non-electrolytes, chemical equilibrium, redox reactions, and complex reactions.

**Methods**

This study was conducted at a Modern Islamic High School namely the Madrasah Aliyah Swasta (MAS) Ex PGA Al-Washliyah Medan involving the eleventh grade students on the odd semester. The study population was all of the eleventh grade students consisting of four classes. Sampling was undertaken by using the purposive random sampling with about 24 students as the samples.

Data collected by using the two-tier multiple choice test developed by Tan & Treagust, (1999) and interviews. The indicator questions used in the diagnostic tests consist of : to compare the history of elements periodic table to identify benefit and inadequacy; to determine electron configuration and valence electron; to explain atomic theory; to analyze

table, graphic to determine regularity of atomic, radius, ionization energy, electron affinity and electronegativity; to explain the history of the atomic theory to show inadequacy and benefit of each atomic theory based on experiments; to determine quantum numbers (the possibilities of electron positions); using Aufbau principle, Hund's rule and the Pauli's principle of prohibition to write the electron configuration and orbital diagram.

Table 1. A sample question from atomic structure diagnostic test

| INDICATORS | QUESTIONS |
|---|---|
| 1. To compare the history of elements periodic table to identify benefit and inadequacy. | 1. Elements in periodic table were arranged based on the increasing atomic number.<br>a. True<br>b. False<br>Reason :<br>a. The atomic mass always increases from left to the rightward in one period, and from the top downward in one group.<br>b. Not all elements were arranged based on the atomic mass, there are also elements arranged based on the electron configuration.<br>c. Elements in periodic table was arranged based on increasing atomic number<br>d. Atomic mass largely determines the properties of elements, thus better to grouping in this way. |
| 2. To analyze table, graphic to determine the regularity of atomic, radius, ionization energy, electron affinity and electronegativity | 2.The atom which has an atomic radius of the smallest in the periodic table of elements is …<br>a. Hydrogen<br>b. Helium<br>Reason :<br>a. hydrogen has the smallest atomic mass of all elements in the periodic table<br>b. Hydrogen has only one valence electron<br>c. Helium has two protons which make it an attractive force of nucleus towards stronger electrons and the atomic radius is decreasing.<br>d. Helium is located at the top right corner in elements periodic table, from the left to the rightward of the period, the atomic radius is decreasing. In one group from the downward to the top,the atomic radius is decreasing. |

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**Result and Discussion**

Based on the analysis using the two-tier multiple choice diagnostics, the result showed there are about 28,33% of the students fully understand the concept, 39,5% do not understand concept, and 32,08% experiencing misconception. It means that the students who do not understand and have misconception in understanding the chemistry concept take the large proportion of the data categories. Details of the discussion as follows:

Table 2. The percentage of comprehension achievement of students'concept for each question

| No | Indicators | Multiple choice answers | A | B | C | D |
|---|---|---|---|---|---|---|
| 1 | To compare the history of elements periodic table to identify benefit and inadequacy | I<br>II | 79,17<br>0 | 4,17<br>0 | 4,17<br>0 | 4,17<br>8,33* |
| 2 | to determine electron configuration and valence electron | I<br>II | 16.67*<br>0 | 79,17<br>0 | 8,3<br>0 | 0<br>0 |
| 3-4 | To explain atomic theory | I<br>II<br>I<br>II | 100<br>0<br>58,33<br>0 | 0<br>0<br>8,33<br>8,33* | 0*<br>0<br>4,17<br>4,17 | 0<br>0<br>4,17<br>4,17 |
| 5-6 | To analyze table, graphic to determine regularity of atomic, radius, ionization energy, electron affinity and electronegativity | I<br>II<br>I<br>II | 0<br>0<br>8,33<br>0 | 0<br>8,33<br>75,00<br>0 | 0<br>12,5*<br>0<br>8,33* | 0<br>75<br>8,33<br>0 |
| 7 | to explain the history atomic theory to show inadequacy and benefit each atomic theory based on experiment | I<br>II | 8,33<br>0 | 0<br>25* | 29,17<br>4,17 | 4,17<br>29,17 |
| 8-9 | to determine quantum numbers (the possibility of electron position) | I<br>II<br>I<br>II | 4,17<br>16,67<br>0<br>0 | 25,00<br>8,33<br>0<br>95,83* | 0<br>25,00*<br>0<br>4,17 | 0<br>8,33<br>0<br>0 |
| 10 | UsingAufbau principle, Hund's ruleandthe Pauli's principle of prohibition to write the electron configuration and orbital diagram | I<br>II | 0<br>0 | 0<br>16,67 | 0<br>83,33* | 0<br>0 |

Note : * This indicates the correct answer of the questions.

Based on the analysis of the result details (as can be seen in the table no.2), it clearly showed that the percentage of students who do not understand the concept and have misconceptions

took a large proportion of the total students(about 39.5% 32.08% respectively). Based on the interviews to the students about the given problem, it was found that the first question is answered incorrectly by a large number of students since the question is a fundamental concept of the atomic structure material.

The same result is also occurred in the question of the development of the atomic theory of matter. This caused by some reasons, two of them are: Firstly, teachers are less focused when explaining the subject of the development of the atomic theory. Secondly, the hand books used by the students also contributed to the false answer. Some studies showed that handbooks lead to the misconception and misunderstanding of the students about the preparation of the elements periodic table concept. The learning material given to the students only used the Students' Practice Sheets (Lembaran Kerja Siswa (LKS) books to understand the atomic structure material, while the books did not discuss the concept comprehensively and only provided the summary of the concept for the readers.

In addition, the students in general are somewhat confused with the two-tier model of multiple choice tests and not accustomed using these types of evaluation. Thus, even though the two-tier model evaluation multiple choice techniques are quite a better role to examine the extent of the students' understanding about the basic concepts of chemistry, the model evaluation like this does requires finest think that sharpened in the learning processes in the classroom.

Another finding showed that some students also admit that during the learning processes, the materials were not taught in detail. Moreover, the atomic structure material was not in detail since the teachers' explanations did not lead the students to fully understand the basic chemistry concepts comprehensively. It was taught merely based on memorization rather than the meaningful learning processes. Based on the results of this study,it is discovered that the chemistry teaching in the classroom is quite low in quality, so that there is a need to improve the teaching methods and this study can become a good input to the chemistry teachers.

**Conclusion**

Based on this study, it is revealed that the students' understanding towards the atomic structure subject material is relatively low and experiencing misconception. The large percentages of the students who did not understand and had misconception were generally caused by the learning processes that did not support the comprehensive understanding of the atomic structure concept. Another factor that caused this situation is the hand books used by

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the students. Some students only used Students' Practice Sheets (Lembaran Kerja Siswa (LKS)) books to learn about the material, while the books only provided the summary of the concept.

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