Development of computer based two-tier multiple choice diagnostic test to identify misconceptions on chemical bonding

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Abstract. This research aims to find a computer-based two-tier multiple choice diagnostic test of student misconceptions on chemical bonding. The process of developing diagnostic test is conducted by: (1) analyzing student misconceptions on chemical bonding including analysis of the literature of previous journals and misconception books, (2) identification of concept targets, (3) analysis of student misconception through essay question given, and (4) the diagnostic questions compilation of a computer-based two-tier multiple choice misconception analysis result from related reference and essay test which given to student got ten general misconceptions. There are four materials which are ionic bonds, covalent bonds, metal bonds and coordination bonds. A computer-based of two-tier multiple choice diagnostic test on chemical bonding will be tested the affectivity by tested, misconceptions identification from feedback and re-tested again.

1. Introduction
Misconception is a false concept and is incompatible with scientific concepts [1]. To identify misconceptions students generally use the test. Firman [2] introduced standardized tests for research instruments of the criteria of validity and absolute reliability. Generally, the tests that used to identify student misconceptions only use interview methods and essay tests.

Clearly, to identify student misconceptions requires the development of new tests by two-tier test method [3] and computer-based development [4]. By using computers, we can know clearly and accurately where the difference of student concepts to the general concept of science given by the teacher.

In general, the application of this method can save time, get direct feedback, reduce the burden of teaching, research results are also faster and can reduce the student's possible fraud during the test [5, 6, 7, 8]. Some studies also say that the development of these tests received good response from students [9, 7]. Previous research has also shown that the development of computer-based tests to identify misconceptions has been successful in oxidation reduction reaction [10].

Identification of other misconceptions that have been studied in the science of chemistry education is the rate of reaction [11] and solubility [12]. Related to chemical bonding there is no identification of its misconceptions yet. Thus, this study aims to develop a two-tier multiple choice computer-based diagnostic test on chemical bonding.
2. Method
This development of computer based two-tier multiple choice diagnostic test is through two stages: a two-tier multiple choice development stage and the development stage of a computer-based two-tier multiple choice diagnostic test. The two-tier multiple choice development stage consists of misconception analysis on chemical bonding and the arrangement of two-tier multiple choice questions.

Analysis of misconceptions on chemical bonding based on literature which are books, related journals, and essay tests. Furthermore, the compilation of two-tier multiple choice questions using the modified two-tier multiple choice method is divided into three stages: determining the content of the learning area, designing two-tier multiple choice diagnostic tests, collecting alternative data on student misconceptions and analysis of student misconception data [13].

In determining the content of the learning area, there are analysis of misconception based on literature and essay test through 15 respondents. Meanwhile, in the design phase of the test of two-tier multiple choice consists of developing questions that include the proportion of content and analysis of student misconception data through the essay test provided.

When the development of computer-based tests that have been adopted from McIntire there are 8 test steps that must be passed which are, defining scope of the test, audience, and purpose, developing a test plan, composing the test items, writing the administration instructions, conduct piloting test, item analysis, revising the test, and validation of test. It is then converted to a swf-based application via Adobe Flash Player 11 program which includes animations, videos, images and tables in its presentation. It will be further validated by the expert judgment for its validity content.

3. Result and discussion
3.1. Identify misconceptions
The development of two-tier multiple choice is done by several stages, which are misconception analysis on chemical bonding based on literature from books, journals, and essay tests. Misconception analysis starts from selecting references. In this study used as a reference is a book in which there is a collection of misconceptions of chemicals, journals related to misconception on chemical bonds. Books and journals for reference from four sources [14-17]. After analysing the misconception of the referenced results obtained are listed in table 1.

| No | Misconceptions of students in chemical bonding |
|----|-----------------------------------------------|
| 1. | Ionic bonds are defined as electron transfer (Essay Test)  
The sodium chloride solution consists of water molecules and sodium chloride molecules, while hydrochloric acid contains hydrogen chloride molecules. In this case molecules are created from ions that play a role together (Boo, 1998)  
Ionic bonds can only form between one sodium ion and one chlorine ion, so that  
ionic interactions with other ions are just non-bonding forces (Taber, 1997) |
| 2. | Paired ions like Na+ and Cl− are molecules (Suyanti, 2010)  
Electron pairs are equally divided into covalent bonds (Suyanti, 2010)  
The covalent bond is weaker than ionic bonds and disconnects first during warming (Barker 1995)  
Couples that can form molecules and covalent bonds occur because relatively relative electronegativity values can bind and can form covalent molecules (Test Essays)  
Nonpolar covalent bonds are formed from atoms with the correct electronegativity (Essay Test)  
Chemical expression is formed from a physical material (Essay Test)  
A metal bond is a combination of two or more ionic bonds (Essay Test) |
Table 1 shows the results of the reference analysis and the essay test obtained five general misconceptions of the results of the essay analysis given to 15 respondents related to chemical bonding including ionic bonds, covalent bonds, coordinate bonds and metal bonds. Then, there were five misconceptions from other literature.

3.2. Development of a two-tier diagnostic test multiple choice

The arrangement of two-tier multiple choice test using two-tier multiple choice method of modified Treagust is divided into three stages namely, determining the content of learning area, designing two-tier multiple choice diagnostic test, alternative data collection of student misconception and analysis data misconception of students. At the stage of determining the learning content, designing test diagnostic tests of two-tier multiple choice results obtained are listed in table 2.

**Table 2. Item of two-tier multiple choice diagnostic test**

| Target concept                                             | Alternative misconceptions                                                                                                                                       | Item                                                                                     |
|------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------|
| Ionic bonds are formed due to the attraction of attracting positive ions with negative ions | Ionic bonds can only form between one sodium ion and one chlorine ion, so that ionic interactions with other ions are just non-bonding forces (Taber, 1997) | Factors that cause sodium atoms to bind to chlorine atoms are....                        |
|                                                            |                                                                                                                                                                  | A. The release of electrons                                                              |
|                                                            |                                                                                                                                                                  | B. The transfer of electrons                                                              |
|                                                            |                                                                                                                                                                  | C. The presence of electrostatic forces                                                   |
|                                                            |                                                                                                                                                                  | D. The presence of metal ions and electrons                                               |
|                                                            |                                                                                                                                                                  | The exact reason to explain the 1st stage answer is the occurrence of...                 |
|                                                            |                                                                                                                                                                  | I. The sodium atom releases an electron to be received by the chlorine atom               |
|                                                            |                                                                                                                                                                  | II. Elements that have different electronegativity can experience the handover of electrons from element 1 to another element |
|                                                            |                                                                                                                                                                  | III. Metallic elements can bind to each other in the presence of electrical forces between metal ions and free-moving electrons |
|                                                            |                                                                                                                                                                  | IV. Two elements that tend to be different loads, will attract each other pull so that it can bind |

Table 2 shows the items that have been made from the identification analysis of misconception obtained 20 items of 10 misconceptions with each misconception there are 2 items developed. The development of a diagnostic test to identify misconceptions with a two-tiered multiple choice method according to Tuysuz [18] is appropriate, because in practice the students only have a 4% chance of guessing the answer. With the explanation there is a matter of two-tier test there are 2 levels (tier) that is, the first tier is a question that asks the concept or knowledge to be measured, then the second tier is the reason of the answer in the first level.
3.3. The development of computer based two-tier multiple choice diagnostic test

Development stage of diagnostic tests two-tier multiple choice computer based which adopted from McIntire has 8 steps test, which are defining the test universe, audience, and purpose, developing a test plan, composing the test items, writing the administration instructions, conduct piloting test, conduct item analysis, revising the test, and validation of test. The results of the steps that have been done are listed in in table 3.

| Target concept | Alternative misconceptions | Item |
|----------------|---------------------------|------|
| Ionic bonds are formed due to the attraction of attracting positive ions with negative ions | Ionic bonds can only form between one sodium ion and one chlorine ion, so that ionic interactions with other ions are just non-bonding forces (Taber, 1997) | VIDEO |

Factors that cause sodium atoms to bind to chlorine atoms are:

A. The release of electrons
B. The transfer of electrons
C. The presence of electrostatic forces
D. The presence of metal ions and electrons

The exact reason to explain the 1st stage answer is the occurrence of:

I. The sodium atom releases an electron to be received by the chlorine atom
II. Elements that have different electronegativity can experience the handover of electrons from element 1 to another element
III. Metallic elements can bind to each other in the presence of electrical forces between metal ions and free-moving electrons
IV. Two elements that tend to be different loads, will attract each other pull so that it can bind

Table 3 shows the conversion results from the two-tier multiple choice development stage to the development stage of a two-tier multiple choice computer-based. Then developed by the developer in the form of SWF applications via Adobe Flash Player 11 includes animations, videos, images and tables in its presentation. Following, the stages in the development of a two-tier multiple choice diagnostic test based on the computer’s appearance are listed on figure 1.
Figure 1 shows the results of the development of a two-tier multiple choice diagnostic test with an early look that is titled computer-based two-tier diagnostic test based computer choice. The next look is the name, class, and school students aiming for after conversion to the pdf form the results of the test will appear immediately and facilitate the process of inputting data later. Looks C and D are questions items as well as if student’s misconception. This is things called with direct feedback [19].

3.4. Follow up study
The next stage further, the question developed will be validated by the expert judgement which is its validation content and will be tested twice to the students.

4. Conclusion
In the development stage of the question of two-tier multiple choice resulted ten general misconceptions based on the literature which are books, journals related to misconception of chemical bonding material, and essay test given to 15 respondents. Consists of five misconceptions of book and journal analysis, as well as five from the analysis of essay tests on chemical bonding materials including ionic bonds, covalent bonds, coordination bonds, and metal bonds. In the development of a two-tier multiple choice computer based diagnostic test, there’s a test that developed so that it can identify student misconceptions on chemical bonding material. It will be further validated by the expert chemical education judgement for its validity content.
Acknowledgments
The researcher would like to thank the Head of Chemistry Study Program of Master Degree at Indonesian University of Education which has supported in conducting this research.

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