



Sensitivity of two-tier and three-tier tests in detecting student's misconceptions of chemical bonding

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Abstract

This research study aims to determine how the sensitivity of two-tier and three-tier tests in detecting student's misconceptions about chemical bonding. This research is a quantitative study with a total sampling technique that is measured using three-tier multiple-choice with a modified CRI. Based on the findings, with a two-tier multiple-choice, the percentage value of the understanding category is 86.06%, misconceptions are 6.89%, and do not understand is 7.06%. Meanwhile, using a three-tier multiple-choice, the percentage value of the understanding category is 85.33%, misconception amounted to 7.61%, and did not understand 7.06%. This study concludes that three-tier multiple-choice is more sensitive than two-tier multiple-choice in detecting students' misconceptions of chemical bonding.

Keywords: Chemical bonding, Misconception, Three-tier, Two-tier

1. Introduction

In the learning process, students can have a good understanding, misconception, or do not understand the concept of learning. According to [Soeharto et al. \(2019\)](#) misconceptions are students' ideas from their life experiences or from informal education that are not well structured to produce false meanings according to scientific concepts. Teachers must be aware of the existence of misconceptions in students and must continue to work to overcome these misconceptions so that students have a conceptual understanding ([Halim et al. 2014](#)). Misconceptions that occur not only have an impact on the concepts being studied but will have an impact on the concepts of learning afterward ([Kamilah and Suwarna, 2016](#)).

Chemistry is abstract like atoms, molecules, and ions which are basic chemical materials that are difficult to understand when students are placed in a position to believe something by imagining the existence of the material without seeing it directly according to [Stojanovsk et al \(2014\)](#); [Safitri et al. \(2019\)](#). In this study, the material chosen was chemical bonds encompassing ionic bonds, covalent bonds, coordination covalent bonds, and metal bonds.

Chemical bonding is one of the subject matter with the concept of the abstract ([Silaban, 2017](#); [Sen et al. 2019](#)). The chemical bond is a difficult concept for students that can cause misconceptions ([Meltafina et al. 2019](#)). Misconceptions occur in this material as in the concept of covalent bonds in NaNO_3 compounds, students think that the bonds between o and N atoms in NaNO_3 compounds are coordination covalent bonds, but in fact, these bonds are not coordination covalent bonds ([Prodjosantoso et al. 2019](#)).

How understanding students' concepts can be known by evaluating the learning process. According to [Suryani \(2017\)](#) assessment or evaluation is a systematic system to determine the level of success and efficiency of a program. Evaluation of learning applied in this study is done when students will end the lesson. With this test, the teacher will know the extent to which lessons can be followed by students

One of the test methods that can be used as a test instrument to determine student understanding is to use the certainty of response index (CRI) method. This method was introduced by [Hasan et al. \(1999\)](#); [Sadhu et al. \(2017\)](#), according to them distinguishing students who did not understand the concept and the Misconception was quite difficult, therefore they made a method to distinguish the conceptual understanding, Misconception and don't understand the concept. From the results of these studies, they prove that the CRI method is effective for distinguishing students' understanding of concepts where the understanding of the concept can be identified based on the level of student confidence. In this case, students answer questions and fill in data for CRI. Each test question based on the combination of correct answers and wrong, and CRI high and low, by combining the CRI and the students' answers can be seen how the understanding of students in the learning process. Following are the CRI modified three-tier category developed by [Hasan et al. \(1999\)](#); [Sadhu et al. \(2017\)](#), with the provisions as in [Tabel 1](#).

Table 1
CRI categories

CRI	Category
0	Totally Guess Answer
1	Almost Guess
2	Not sure
3	sure
4	Almost sure
5	certain

The number 0 signifies not knowing the concept at all to answer a question (answers are guessed in total), while the number 5 indicates full confidence in the truth of the concept.

In this study, the CRI used was modified. The CRI scale was modified into three parts, where the level of confidence was divided into three aspects, namely: (I) Knowledge, (II) behavior, and (III) attitude, with the provisions as in [Tabel 2](#).

Table 2
Modified CRI categories

I	II	III
<input type="checkbox"/> True	<input type="checkbox"/> Sure	<input type="checkbox"/> Not Guessing
<input type="checkbox"/> Almost true	<input type="checkbox"/> Not sure	<input type="checkbox"/> Guessing

A score of 2 for each category is correct, sure, and not guessing. and a score of 1 for each category is almost correct, not sure, and guessing. So if students answer there will be 8 possible categories of student CRI, namely:

- True, Sure, Not Guessing: 6
- True, Sure, Guessing: 5
- True, Not Sure, Not Guessing: 5
- Almost True, Sure, Not Guessing: 5
- Almost True, Not Sure, Not Guessing: 4
- Almost True, Sure, Guessing: 4
- True, Not Sure, Guessing: 4
- Almost true, Not Sure, Guessing: 3

In this study, the highest score is 6 and the lowest score is 3 so that the central value of 4.5. CRI is high if > 4.5 and CRI is low if < 4.5 . This CRI is combined with a three-tier multiple-choice test. Three-tier multiple-choice consists of 3 levels, where the first tier is a question, the second tier is a reason and the third tier is a belief ([Anintia et al. 2017](#)).

2. Methods

This research is quantitative, the population this research is all class X Madrasah Aliyah Laboratory of the Tarbiyah and Teacher Training Faculty of UIN Sulthan Thaha Saifuddin Jambi, odd semester academic year 2018/2019. Consisting of class X MIPA 1 and X MIPA 2, which amounted to 45 students. The sample in this study was taken by a total sampling technique.

The questions given were 40 three-tier multiple-choice questions and the results were analyzed with a one-tier multiple-choice rubric, a two-tier multiple-choice rubric, and a three-tier multiple-choice rubric.

2.1 One-Tier Multiple Choice Analysis

The first step in the analysis of research data is to analyze multiple-choice answers with one tier as the basis for further analysis.

2.2 One-Tier Multiple Choice Analysis Category

For One-Tier answer analysis, if the answer:

1 = Right

0 = False

2.3 Two-Tier Multiple Choice Analysis

Rubric Analysis of Two-Tier Multiple-Choice Test with CRI modification is a rubric proposed by [Hasan et al. \(1999\)](#); [Sadhu et al. \(2017\)](#) with modified CRI, with the provisiona as [Table 3](#).

Table 3
Rubric analysis results with two-tier multiple-choice of CRI modification

Criteria The answer	CRI < 4,5 (1)	CRI > 4,5 (2)
Correct answer (1)	Don't Understand (DU)	Understand (U)
Incorrect answer (0)	Don't Understand (DU)	Misconception (M)

Note: Tier 1 (answer choice), if an answer is scored 1 = Right, 0 = False; tier 2 (CRI), if an answer is scored 2 = High CRI, 1 = Low CRI

2.4 Two-Tier Multiple Choice Analysis Category

If given a score as follows:

- [1][2] : Understand (P)
- [0][2] : Misconception (M)
- [1][1] : Don't Understand (DU)
- [0][1] : Don't Understand (DU)

2.5 Three-Tier Multiple Choice Analysis

The rubric of the data analysis tests identifies students' understanding of the concept using a three-tier multiple-choice rubric by [Mustaqim et al. \(2015\)](#) which is modified, with the provisions as in [Tabel 4](#).

2.6 Three-Tier Analysis Categories

If given a score as follows:

- [1][1][2] : Understand (U)
- [1][0][2] : Misconception (M)
- [0][1][2] : Misconception (M)
- [0][0][2] : Misconception (M)
- [1][1][1] : Don't Understand (DU)

- [1][0][1]: Don't Understand (DU)
- [0][1][1]: Don't Understand (DU)
- [0][0][1]: Don't Understand (DU)

Table 4
Rubric analysis results with three-tier multiple choice of CRI modification

Tier 1 (Question)	Tier 2 (Reason)	Tier 3 (CRI)	Category
Right (1)	Right (1)	CRI > 4.5 (2)	Understand (U)
Right (1)	Right (1)	CRI < 4.5 (1)	Don't Understand (DU)
Right (1)	False (0)	CRI > 4.5 (2)	Misconception (M)
Right (1)	False (0)	CRI < 4.5 (1)	Don't Understand (DU)
False (0)	Right (1)	CRI > 4.5 (2)	Misconception (M)
False (0)	Right (1)	CRI < 4.5 (1)	Don't Understand (DU)
False (0)	False (0)	CRI > 4.5 (2)	Misconception (M)
False (0)	False (0)	CRI < 4.5 (1)	Don't Understand (DU)

Note: Tier 1 (answer choice), if an answer is scored: 1= Right, 0 = False; Tier 2 (Reason Options), if an answer is scored 1= Right, 0 = False; Tier 3 (CRI), if the answer is given a score 2 = High CRI, 1= Low CRI

3. Results and Discussion

The results of identifying students' understanding of concepts such as [Table 5](#). The result of sensitive identification used two-tier and three-tier tests in detecting student's misconceptions about chemical bonding are shown in [Fig 1](#).

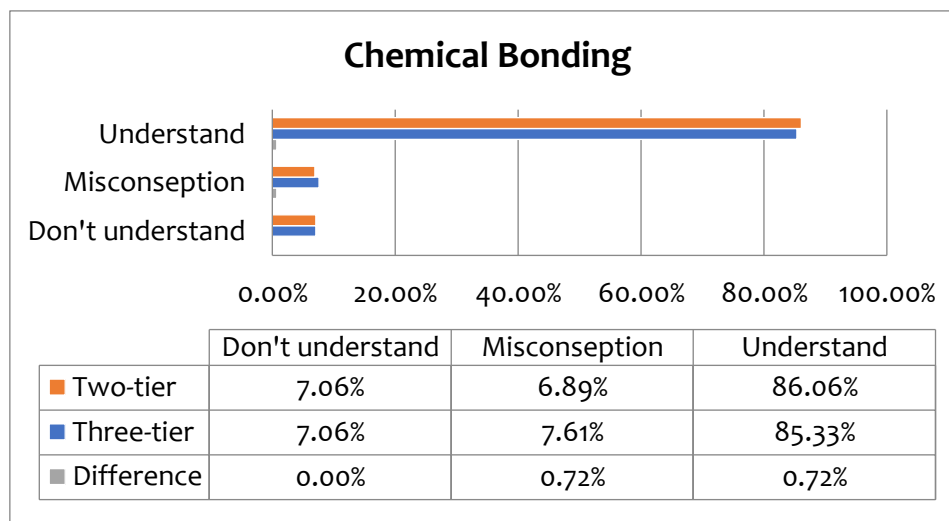


Fig 1. Results of identification understanding of chemical bonding concepts

The results of understanding concept research are divided into 3 (three) categories, namely: understanding, misconception, and not understanding. The chemical bonding concept chapter consists of 3 subchapters: ionic bond, covalent

bond, and metal bond. Overall the test instrument tested 16 indicators consisting of 40 questions. Each sub-chapter of the chemical bond concept has a number of indicators and a number of different questions. The following is explained specifically the analysis of learning outcomes of chemical bond concept with multiple-choice two-tier and three-tier.

Table 5
Results of Identification Understanding of Chemical Bonding Concepts

One-Tier		Two-Tier			Three-Tier		
R (%)	F (%)	U (%)	M (%)	DU (%)	U (%)	M (%)	DU (%)
87.33	12.67	86.1	6.89	7.06	85.33	7.61	7.06

In identifying understanding of concepts using one-tier multiple-choice tests, it was found that 87.33% of students answered correctly and 12.67% answered incorrectly. In this case, it can not be concluded whether the understanding of concepts owned by students is good or still lacking. This is because the use of one-tier multiple-choice is still vulnerable to the *gambling* system with a 20% correct answer chance (has five answer choices).

In the identification of concept understanding using a two-tier multiple-choice test, it was found 86.06% of students understood the concept being taught, 6.89% of students were Misconceptions with the concept being taught and 7.06% of students did not understand the concept being taught. In this case, it can not be concluded whether the understanding of concepts owned by students is good or still lacking. So we need to add reasons so that results are more accurate.

In the identification of concept understanding using a three-tier multiple-choice test, it was found that 85.55% of students understood the concepts taught, 7.61% of students of Misconceptions with the concepts taught, and 7.06% of students did not understand the concepts being taught. can be seen as a decline in students who understand the concept at two-tier to three-tier of 0.72%. This is because the identification of understanding the concept of three-tier multiple more accurate and has sensitivity better than two-tier. So in this case, it can be concluded that students have a good understanding of the concept because three-tier multiple-choice includes the reasons for each answer given by students.

Example of the sensitivity of three-tier multiple choice was previously analyzed by rubric two-tier showed that the responses of the students are categorized familiar with the code Categories: [1] [2] = Understand (U), (Tier 1 = True (1) and Tier 2 = High (2), then when analyzed with three-tier it becomes Misconception with category code categories: [1] [0] [2]: Misconception (M), (Tier 1= True (1), Tier 2 = False (0), and Tier 3= High (2).

The use of one-Tier and two-Tier multiple-choice is not able to analyze students' understanding of concept well, but the use of three-tier multiple choice is very feasible and superior in the measurement. As revealed by [Dindar and Geban \(2011\)](#) who developed a three-tier multiple-choice of acid-base concept and stated that the three-tier test developed provides a reliable and valid instrument for assessing the conception of high school students and identifying their conceptual understanding. Three-tier multiple choice tests are more effective in assessing student understanding than conventional (one-tier) multiple-choice tests or two-tier multiple-choice tests. This is because the three-tier multiple-choice test can distinguish how the students understand the concepts, whether students have good knowledge or their knowledge is still lacking. Another convenience in using the three-tier multiple-choice test is because it is easy and fast to assess student understanding. Besides, three-tier instruments can greatly help teachers to find out how students' knowledge is in depth in a large group of students.

It was also revealed by [Caleon and Subramaniam \(2010\)](#) who conducted research on the development of three-tier instruments and stated that the three-tier became very effective instruments in measuring students' understanding of concepts. The results obtained in the study were 10% of 243 class X students who were recorded as students who did not understand the concept. Even with large samples, three-tier instruments are very effective in use.

Another result is the research conducted by [Kirbulut and Geban \(2014\)](#) with the research title using three-tier diagnostic tests to assess students' misunderstanding. According to them the three-tier multiple-choice instrument predicts very accurately the understanding of students' concepts compared to two-tier and one-tier. That is because the three-tier multiple-choice instrument includes one tier, two-tier instruments, and has a level of confidence. The three-tier multiple-choice instrument also allows us to calculate negative scores derived from student misunderstanding scores.

4. Conclusion

The three-tier multiple-choice test instrument is more sensitive than the two-tier multiple choice test because there's been a decline in concepts on two-tier to three-tier by 0.72%.

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