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Identify Students' Concept Understanding Using Three-Tier Multiple Choice Questions (TTMCs) on Stoichiometry

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Abstract: The research addressed 1) to develop a three-tier test, 2) to identify students' concept understanding in stoichiometry. The design of this research is descriptive. Cluster sampling technique with proportional measuring is used to collect 176 selected samples from three different schools. Analyses were conducted to check on content validity, empirical validity, discrimination index, and difficulty index. Findings of the pilot study showed that the content validity is in the range of 0.56 – 1.00 score. The empirical validity value was found to be appropriate and good enough with 28 out of 30 questions are valid with t_{table} 1.99, reliability is 0.47. Discrimination index was found to be appropriate with 3.57% question in excellent, 42.86% question in good, 42.86% question in fair, and 10.71% question in poor. Difficulty was found to be appropriate with 17.86% questions in convenient and 82.14% question in fair. Identification of students' concept understanding using three-tier showed that 33.10% of students comprehend the concept correctly, 4.06% students are less understand the concept, 31.53% students are in misconception, 19.50% students did not comprehend the concept, and 11.81% students are guessing.

Keyword : Student's Concept Understanding, Two-Tier Multiple Choice Questions, Stoichiometry

1. Introduction

Chemistry is a part of science that studies the nature, material structure, material composition, changes and energy that accompany material changes [14]. Chemistry consists of simple concepts to the more complex and abstract concepts in which the Concepts are interconnected [15]. A stand-alone concept with no connection to other can't be used and has no meaning since it comes from relationships with other concepts [1]. To relate concepts to one another requires a correct understanding of concepts.

Understanding the concept is the ability to grasp meanings such as being able to express a material presented into a more comprehensible form, capable of interpretation, and able to apply it. Understanding the concept is very necessary for students who have experienced the learning process. Understanding concepts that are owned by students can be used to solve a problem that is related to it. In understanding the concept,

students are not only to know, but students must be able to connect one concept with another concept [14]. Understanding the concept of students to a material is divided into five, namely: understand the concept, less understand, misconception, not understand, and guessing. If student do not understand the concept well, then the student will get misconception, lack of concept, not understanding, and guessing as well when they given a test. If this situation is left continuously, then students will have difficulty working on more complex problems with the same concept.

Stoichiometry is one of the chemical subject that have interconnected concepts [15]. Stoichiometry is a chemical calculation content that underlies other chemical calculations. It would be very dangerous if students do not understand the concepts that exist in the material properly. For that, the learning process should be accompanied by an effort to identify students' conceptual understanding.

Many researchers recommend an alternative assessment to measure thinking ability and know the level of student understanding because most tests given to students only measure low-level thinking skills [19] and rarely to know the extent to which students understand the concepts being studied. The current assessment procedures are deemed not to provide a valid measurement of everything students know and do not allow students and teachers to engage in discussions about assessed work [2] in [3]. The existing formative assessment provides little opportunity for students to develop more in-depth knowledge [3].

Multiple-choice test is a test consisting of a basic sentence in the form of an incomplete question and to complete it must choose one of several possible answers (option) that have been provided [16]. The reason students are more successful answers at the first level because at the first level there is a 20% chance to answer correctly by guessing, meaning students can answer with guessing without knowing the reason for the selected answer [20]. As well as multiple-choice questions do not give students the opportunity to provide explanations for the answers they choose. One alternative assessment that can be developed is a modified multiple-choice question form of three-tier multiple choice question. A Three-tier multiple choice questions is developed from the form of two-tier multiple-choice questions with the addition of a choice of students' confidence levels on the third tier. Two-tier multiple choice questions are a multiple-choice question that requires not only the student to choose the given answer option, but also gives the answer of the option at the first level [12]. The multi-tiered multi-choice is much more accurate and effective for measuring students' higher-order concepts and thinking skills [5]. A Two-tier multiple-choice questions instrument may also serve as a detectable occurrence of misconceptions in students with different background knowledge appropriately if after the test is followed by interviews with unlimited or open questions can be used to test students' material understanding [11] [21] [7].

Researchers modify the form at the second level into a semi-closed reason that has provided a reason for their answer but the students can also give their own reasons and also enhance the certainty of belief on the third level. The reason of researcher modified the second level becomes the semi-closed reason in the form of 'right-wrong' because

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the multiple-choice instrument with semi-closed reasons gives instructions to the student to choose the answer of multiple-choice on the matter by including or choosing the reason why he chose the answer. By this way it is expected to familiarize students to provide the correct and logical reason and train students to account for their choice.

One way to use the three-tier test instrument. The three-tier test is a multiple-choice test consisting of three levels of matter where the first is a simple multiple-choice question, the second is the possibility of choosing the answer at the first level, and the third is the belief of the answer at the first level [14]. By developing the three-tier test is expected to be used to identify the understanding of the concept of high school students on stoichiometric material chemistry lesson.

2. Methodology

This study used the descriptive qualitative method. Research subjects involved were 178 students of grade X Senior High School in Mataram City which was determined using cluster sampling technique with comparable size. The instrument developed in this study is a matter of three-tier multiple choice question with first-tier in the form of multiple choice questions about concepts on stoichiometry, second-tier of reason with 'right-wrong' choice, and third-tier is a belief in choice at first level. There are 28 questions used in this research. The example of three-tier multiple choice question used in this research can be seen in the table 1 above

Table 1. Example of three-tier multiple choice question on stoichiometry

First-Tier	Second-Tier	Third-Tier
Make the right of this chemical equation! $Mg_{(s)} + HCl_{(aq)} \rightarrow MgCl_{2(aq)} + H_{2(g)}$ a. $Mg_{(s)} + H_2Cl_{2(aq)} \rightarrow MgCl_{2(aq)} + H_{2(g)}$ b. $Mg_{(s)} + 2HCl_{(aq)} \rightarrow MgCl_{2(aq)} + H_{2(g)}$ c. $2Mg_{(s)} + 2HCl_2(_{aq}) \rightarrow 2MgCl_{2(aq)} + H_{2(g)}$ d. $2Mg_{(s)} + 2HCl_{(aq)} \rightarrow 2MgCl_{2(aq)} + 2H_{2(g)}$	Equalization of the equation of reaction is done by adding the reaction coefficient but the formula of the compound remains o True o False If the reason is wrong, write down the correct reason:	Are you sure of your answer? o Sure o Not Sure

Analyses were conducted to check on the content validity analysis (Aiken's V test), item validity (product moment correlation test), reliability test question using Cronbach Alpha formula, discrimination index, and difficulty index to know the quality of the instrument. The group of students' answers following category shown in Table 2.

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Table 2. Category of Student's Concept Understanding using Three-Tier Multiple Choice Questions

First-Tier	Second-Tier	Third-Tier	Category
Correct	Correct	Sure	Understanding the concept
Correct	Correct	Not Sure	Less understood concept
Correct	False	Sure	Misconception
Correct	False	Not Sure	Guessing
False	Correct	Sure	Misconception
False	Correct	Not Sure	Guessing
False	False	Sure	Misconception
False	False	Not Sure	Not understanding the concept

3. Result and Discussion

The obtained value of content validity was in the range of 0.56 - 1.00, indicating that the items is valid. Calculation of validation using Pearson formula (product moment) obtained as many as 28 out of 30 questions are valid. A valid question is then calculated by using Cronbach's Alfa formula and obtaining a reliability of 0.47 which means the reliability of the matter is a fair category.

The result of the analysis of discrimination index of grain matter obtained the value between 0,166 until 0,756. 3 out of 28 (10.71%) categorized in bad quality of discrimination index, 12 out of 28 (42.86%) categorized in a fair quality of discrimination index, 1 out of 28 (3.57%) categorized in a very good quality of discrimination index.

The result of difficulty index analysis obtained the type of item from easy to moderate. 5 out of 28 items (17.86%) categorized in easy and 23 out of 28 (82.14%) in moderate. Understanding the concept of students, in general, can be seen in Table 3 below:

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Table 3. Percentage of Students' Concept Understanding Using Three-Tier Multiple Choice Questions on Stoichiometry

Indicator	Category (%)				
	Understand the Concept	Less Understand the Concept	Misconception	Not Understand the Concept	Guessing
Determine the relative atomic mass and relative molecular mass	40.343	1.323	40.72	11.363	6.25
Explain the basic laws of chemistry	40.057	3.125	39.77	9.092	7.955
Write down the correct and equal chemical equations	54.546	3.406	30.113	4.736	7.196
Solve chemical problems related to the concept of moles	35.145	2.274	32.387	19.885	10.3
Complete chemical calculations	26.775	8.736	20.81	28.196	15.482
Determine the limiting reagents in a reaction	7.196	0.38	39.393	32.196	20.833
Total	33.10%	4.06%	31.53%	19.50%	11.81%

This study aims to develop a three-tier test instrument and its use to know the understanding of the concept of high school students on stoichiometry. Based on Table 3 there are students understand the concept of 33.10% classified in fair, students are less understand the concept of 4.06% in low, students misconception 31.53% in fair, students do not understand the concept of 19.50% in low, and students guess 11.81% in low.

3.1. Understand The Concept

Students are said understand the concept if they can explain the concept or can be interpreted that the student can express again what has been communicated to him/her. Also, students who understand the concept can use it in different situations and develop some consequences of the existence of a concept can be interpreted that students understand the concept as the result the students have the ability to solve every problem correctly [17].

When answering the three-tier multiple choice questions test, the student who understands the concept answers the first-tier and the second-tier correctly, and the student is sure about the answer. The student most understands the concept of item number 5. In item number 5, students are asked to equalize a reaction equation. As many as 84.09% of students answered the first tier correctly, but as many as 74.44% of students who understand the concept correctly. The remaining 5.68% of students are

less understood the concept, 14.77% of students experience misconception, 0.00% of students do not understand the concept, and 5.11% of students are guessing.

3.2. Less Understand The Concept

Students who do not understand the concept can be identified by looking at the pattern of three-tier multiple choice questions test answers. The student answered correctly on the first-tier and the second-tier but was unsure of the answer. It indicating that students are quite aware of the concept, but they doubt whether the concept they understand is acceptable by the expert or not. Uncertainty, it caused by students who only understand some concepts, because if students understand the whole concept, then the students will not hesitate to the answer.

Students at least understand the concept of item number 22. In item number 22, students are asked to determine the mass of the solute if it is known to the molarity, the volume of the solution, and the relative atomic mass of the constituent elements. As many as 75% of students answered the first-tier correctly, but then as many as 42.04% out of 75% students who understood the concept correctly. The remaining 29.55% of students are less understanding of the concept, 13.07% of students experience misconception, 6.25% of students do not understand the concept, and 9.09% of students are guessing.

3.3. Misconception

The next category of the kind of students' concept understanding is a misconception. Understanding of concept owned by student influenced by student conception or interpretation of student to a concept. Students come to the classroom with the conception and the initial knowledge of a concept. Conception and the initial knowledge that students sometimes have not by the explanation scientifically. It can lead to errors in understanding the concept so as to elicit alternative concepts or misconceptions [17]. The misconception is a conception of someone who is inconsistent with a scientific recognized by experts.

The cause of misconceptions are students, teachers, textbooks, context, and teaching methods [18]. The cause of it that come from the students consist of a variety of things: preconception, humanistic thinking, student associative thinking, incomplete reasoning, false intuition, student cognitive development, student interests, and student abilities.

There are three patterns of students' answers that have misconceptions. First, the student answers the first tier correctly, but the second-tier is wrong, and the student is sure of the answer. Second, the wrong answer on the first-tier, but the second tier is correct, and the students are confident of the answer. Thirdly, the answers on the first-tier and second-tier are wrong but was sure of the answer. The students suffered the most misconceptions on the item number 8. In question item number 8, students were asked to determine the composition ratio of the two compound masses, each consisting of 2 elements using the Law of Multiple Comparisons. A total of 34.66% of students answered the first tier correctly, but only 9.66% out of 34,66% students understood the

concept correctly. This large difference is due to the number of students experiencing misconceptions. The most common misconception is that the student considers finding the comparative figure of the comparative is the mass of element 1 in compound 1 with the mass of element 1 in compound 2 and compares the mass of element 2 in compound 1 with the mass of element 2 in compound 2. The correct formula is comparing The mass of element 1 in compound 1 with the mass of element 2 in compound 1 and comparing the mass of element 1 to compound 2 with the mass of element 2 in compound 2. Also, in the second-tier, the student is less thorough reading the reason given. They choose the 'right' option without realizing that the Multiple Comparisons Law given is wrong; the comparison should be denoted by the smallest integer, not the smallest number including the decimal number in it. At number 8 there are 0.57% of students are less understood concepts, 60.22% of students experience misconception, 22.73% of students do not understand the concept, and 6.82% of students are guessing.

3.4. Not Understand The Concept

The next category of students' concept understanding is not understanding the concept. Students who do not understand the concept are students who are unable to relate what they learn to how the knowledge will be used or utilized. Answers to students who are not familiar with the concept are irrelevant and illogical [17]. When answering a three-tier test, students who do not understand the concept would answer incorrectly on the first tier and the second tier, and are unsure of the answer. Students who did not answer or did not complete the three tier tests could also be classified as students who did not understand the concept.

Most students do not understand the concept on the question number 25. Students are asked to determine the number of atoms of an element in a compound if known Avogadro number, a mass of a compound, and the relative atomic mass of compounds. A total of 16.48% of students answered the first tier correctly, but only 1.14% of students understood the concept correctly. The remaining 0.00% of students are less understood concepts, 24.43% of students experience misconception, 62.50% of students do not understand the concept, and 11.93% of students are guessing. The percentage of students who do not understand the concept is very high when compared with students who understand the concept. Many students know the formula used but the students do not understand that in the matter of number 25 the element sought is the number of atoms there are eight atoms in the compound so that the elemental mole is eight times the mole of the compound. It makes students choose the wrong answer on the first and second tier.

3.5. Guessing

The last category of students' conceptual understanding is guessing. Guessing in the Big Indonesian Dictionary is defined as guessing, guessing, or guessing. Students who guess correctly will boost students' scores so as to cause a student's (student's) overestimated score when compared to actual student abilities [13]. One of the three-tier test advantages is that it can differentiate students who guess with other conceptual

categories of understanding. There are two patterns of students' guesses. First, the student is right on the first tier, but is wrong on the second tier, and is unsure of the answer. Secondly, the student is wrong on the first tier, right on the second tier, and unsure of the answer.

The student predicted to the most is question number 28. On the question, number 28 students were asked to determine the volume of a compound in the state off room temperature pressure (RTP) in part per million (ppm) if known the number of moles and the volume of the whole mixture. A total of 39.20% of students answered the first-tier correctly, but only 29.55% of students understood the concept correctly. The remaining 8.52% of students are less understood the concept, 18.18% of students have misconception, 15.91% of students do not understand the concept, and 27.84% of students are guessing. The student's mistake to answer this is that the student does not change the total volume of the solution from kiloliter to liter, so the results obtained differ from the correct results.

Based on interviews with chemistry subjects teachers at the three schools, the teacher complained about the lack of material delivery time, whereas in the even semester of class X there is a lot of difficult material that takes extra time in teaching, especially stoichiometry that contains many difficult concepts in it. Also, students are usually weak in the calculations of decimal and mathematical logic so that in doing the matter stoichiometry count many difficulties.

4. Conclusion

The findings of this study ascertained that the developed TTMCs has relatively good validity and reliability. Overall, TTMCs is suitable for identify student's concept understanding. Thus, the researchers believe that TTMCs could be used to assess and identify students' concept understanding of the X graders in science on stoichiometry.

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