# Using open reasoned Three-tier Test to identify acid-base conceptual understanding of senior high school student



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# Using open reasoned Three-tier Test to identify acid-base conceptual understanding of senior high school student

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**Abstract.** Acid-base is one of the first abstract chemistry course that high school student encounter. Research shows that many students find difficulty on the definition, macroscopic and microscopic conceptual comprehend. This research has the aim to identify the student's conceptual understanding in acid-base course. The subject for this research is 145 students from government school 2018/2019 school year. The data collected through 16 questions of the three-tier diagnostic test and questionnaire. Three validators validate the question with an average score of 159 from 176. The average score for the questionnaire is 39.75 with good category, and the Alpha Cronbach reliability is 0.714. Analysis of the result shows that the student has several difficulties with acid-base conceptual. Classical result for 145 students are 28% of the student understands the concept, 4% lack of conceptual understanding, 43% misconception and 21% don't understand the concept of acid-base.

## 1. Introduction

Conceptual understanding is essential to learn about chemistry. Learning concept is the main result of education [1]. A Well theoretical knowledge can increase the aim of education. Students can connect between their lessons and everyday problem, so learning is meaningful [2]. The complexity of concepts in chemistry is relatively high. Besides the abstract of chemistry concept, it also contains mathematical calculation so that the necessary math skill are needed to solve a chemical problem [3]. It makes the lesson is difficult for students and potentially leads to misconception. Multiple representations in chemistry contain macroscopic, microscopic, and symbolic. Acid-base materials is a chemical material that is close to daily life and has an essential role in several chemical processes. Acid-base elements involve the abstraction concept and have linked one to another concept so that students tend to have difficulty understanding all of its concepts. Understanding of acid-base concept requires the ability to solve the problem by the naked eye (macroscopic) into the structure and process at the level of particulate matter (submicroscopic) and present it into a chemical symbol (symbolic) [4,5].

To optimize the conceptual understanding of students, the teacher should integrate all of the multiple representations. The result of studies will provide whether the students are understood to connect the levels of representation during the learning process or not. Conceptual understanding can determine by using an appropriate method identification of student's conceptual understanding required tests. A formative or summative test can be used to identify the material that is hard to understand by the student [6].

In this research, the method that used is a diagnostic test. The diagnostic test is used to determine the strength and the weakness of the students when learning the concept of chemistry. The result can be used as the basis for providing follow-up. A diagnostic test with a three-tier model is suitable to analyze the student's conceptual understanding. The first tier in a three-tier diagnostic test consists of a question with five possible answers, the second tier is an opened reason refer to the first tier, and the third tier is a question about the student's belief in answering the first and second tier. Three-tier multiple-choice

considered as an accurate and can lead to an understanding of a concept since this test can detect the level of trust [7]. Three-tier multiple-choice test more valid and reliable than conventional multiple-choice to diagnose the conceptual understanding of students since it can detect between students that less understand and the students that have misconception [8].

A three-tier multiple-choice diagnostic test with open reasoned analyzed via table showing the possible combination students answer to each of question, reasoning, and their certainty. One student answer thus is shown in the table, the combination of the correct answers students gave in first, second, and third-tier created. Students receive score five if they write all correct answer in all three-tier, four if the third tier is wrong, 3 when one of the first or second tier is wrong, and the third tier is uncertain. Student scored 2 when either first or second tier is wrong, but they sure in the third tier, one if both first and second tier is false and uncertain in third tier, and least 0 if they answer wrong in both of first and second-tier, but certain in third-tier [9].

## 2. Methods

The purpose of this study was to identify a high school student's conceptual understanding. For this reason, this research using a survey model. The source of data used is primary and secondary data. Primary data are collected directly, while secondary data obtained from various sources. The source of primary data is from expert's validity for the instrument, students test result, and questionnaire. The source of secondary data is from the journal, theses, book literature, etc. Quantitative data collecting through three-tier multiple-choice diagnostic test consisting of 16 questions. Students answer are analyzed to identify the conceptual understanding with the categories presented in Table 1.

**Table 1.** Categories of student's conceptual understanding

| Answer | Reason | Certainty | Description |
|---|---|---|---|
| True | True | Certain | Scientific knowledge |
| True | True | Uncertain | Lucky guess |
| True | False | Certain | Positive Misconception |
| True | False | Uncertain | Less understand |
| False | True | Certain | Negative Misconception |
| False | True | Uncertain | Less understand |
| False | False | Certain | Misconception |
| False | False | Uncertain | Do not understand |

[10]

### *2.1. Participants*

This study conducted in the 2018/2019 academic year with the participation of 145 highschool students in Ungaran, Indonesia

### *2.2. Data Gathering instruments*

Data were collected using 16 questions of three-tier diagnostic test with open reasoning in the subject of acids and bases taught in the eleven-grade chemistry course.

## 3. Result and discussion

The first stage in this research is to arrange a three-tier multiple-choice diagnostic test based on multiple representations (Macroscopic, microscopic, and symbolic aspect) for acid-base material. Before the instrument used, it validated by one expert lecture and two chemistry teacher. Validation performed to determine whether the instruments used was feasible, and it can be used to obtain the data needed. In this research, the data required are the conceptual understanding of the student in acid-base material. Validation sheet has 11 question items. Recapitulation of the result analyzed by the researcher that the instrument test is valid with average from three validators is 39.3 from 44 score total with category good response and suitable for use. Average student's response to the instrument was collected with a questionnaire. The questionnaire that filled by 55 3$^{rd}$ year students have average 30.25 with a good category and the alpha Cronbach reliability is 0.714 that means the instruments are reliable to use in an

examination. The acid-base concept is consist of the development of acid-base theory, acid-base identification, acid-base strength, pH calculation, pH concept in the surrounding, acid-base reaction. The result of the analysis shows that students understanding of each question presented in Table 2.Based on table 2, question item number 1 has the highest student that understanding concept 52%. Question number 1 is a symbolic question that asks the student to analyze the acid-base property of water ($H_2O$) based on the reaction with HCl or $H_2O$ with $NH_3$. The correct answer is $H_2O$ can be as an acid or base depending on the reaction. To answer this question, the student must be mastering the concept of acid-base according to Bronsted-Lowry. Bronsted-Lowry's acid-base theory said that acid is a matter that donor its proton, while the base is a matter that accepts the proton, so $H_2O$ can be acid or base depending on the reaction.

**Table 2.** Percentage of students understand the concept in acid-base material

| Question Number | Proportion | % | Question Number | Proportion | % |
|---|---|---|---|---|---|
| 1 | 75 out of 145 | 52 | 9 | 19 out of 145 | 13 |
| 2 | 16 out of 145 | 11 | 10 | 9 out of145 | 6 |
| 3 | 72 out of 145 | 50 | 11 | 18 out of 145 | 12 |
| 4 | 55 out of 145 | 38 | 12 | 73 out of 145 | 50 |
| 5 | 50 out of 145 | 34 | 13 | 20 out of 145 | 14 |
| 6 | 26 out of 145 | 18 | 14 | 20 out of 145 | 14 |
| 7 | 61 out of 145 | 42 | 15 | 44 out of 145 | 30 |
| 8 | 71 out of 145 | 49 | 16 | 15 out of 145 | 10 |

Based on the analysis of the chosen answer and reason, the main factor causing the scientific knowledge is not too high is originate from students themselves. Finding on students responses pattern indicate that they are only memorizing the concept, not understand them. Based on Table 2, the most significant scientific knowledge presented in question number 1. Problem number 1 is a question with an analysis level (C4). Problem number 1 is a question that asks students to analyze the nature of water ($H_2O$) based on the reaction between $H_2O$ and HCl, as well as $H_2O$ with $NH_3$. As many as 75 students answered correctly the nature of $H_2O$ based on the response given, explained the reason correctly and chose confidence on the third level. An example of a student's true reason is "*$H_2O$ can be easily ionized into $H^+$ and $OH^-$ ions. Therefore, $H_2O$ can be acidic or basic according to other compounds that react with the $H_2O$ compound* ". This reason shows that students can classify $H_2O$ based on their reactions. Students who write such reasons are students who understand the concept because compounds can be classified according to the nature of acid or base from the reaction, besides that there are students that have the correct answer to this question, but the reason is wrong. The reason they applied is "*Because when I taste the water, I don't feel it is acid or base*" This is definitely a wrong reason because acids or bases can't be determined just by their taste.

Based on the understanding of the concept in each item, the problem with the lowest understanding of the concept is shown in question number 10. Problem number 10 is a question with a level of analysis(C4) according to bloom in 1956. This question asks students to analyze the neutralization of water from acid rain due to gases containing acid oxides using certain bases. It is stated that there is acid rain caused by acid oxide compounds. Some examples of acid oxides mentioned are carbon dioxide ($CO_2$), sulfur dioxide ($SO_2$), and also nitrogen oxide (NxOy). When the acid oxide reacts with water, it forms acids which eventually occur acid rain with a certain pH. Students are asked to neutralize water from acid rain by using weak $NH_3$ acids. The pH and volume of rainwater and KB from weak bases have been known to work on this problem. The number of students who understood the concept of an acid-base neutralization reaction in question number 10 were 9 out of 145 students or only 6% of the total students. This amount is the smallest amount on this diagnostic test. Students mostly experience misconceptions in the amount of 45%. After being confirmed to students, it turns out that students have never encountered a problem with this type of analysis. Students who already understand the concept can do the problem well, they can calculate $H^+$ from acid rain, then neutralize it with the base provided.

Based on the results of the interpretation of the combination of the answers obtained profile data results of student answers in accordance with the criteria in Table 1. The data in the form of the percentage of all research subject presented in Figure 1.

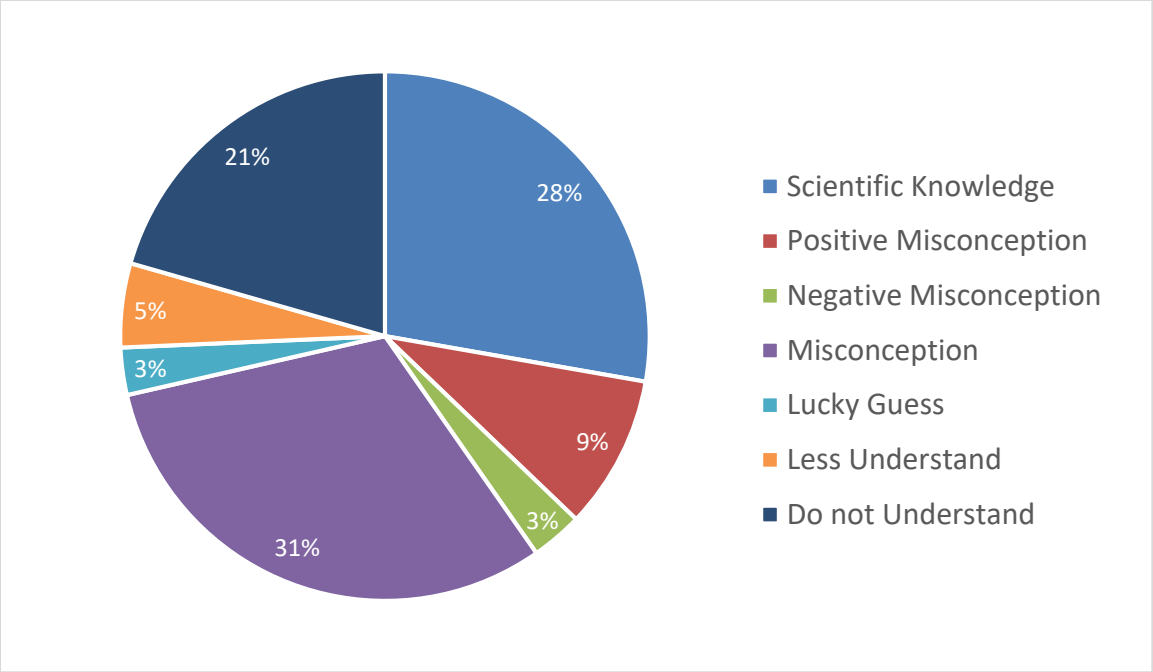


**Figure 1.** Scientific Knowledge profile of all research subject

The average percentage of student's conceptual understanding classically in acid-base material is 28%, according to the results of the study of Nada in 2018 which measured the understanding of classical concepts of students on redox material by 26.86 and opposed to student's conceptual understanding proposed by Drastisianti in 2018 amounting to 47,061%. Conceptual understanding of less than 50% requires further discussion of concepts that experience misconceptions or do not understand the concept. It is because the subject of acids and bases has an important place in the high school chemistry course. Concept concerning acids and bases are inter-related. It frequently thought of by students as the most complex to learn, these concept needs to be taught using appropriate methods, so misconception can be prevented. When students have difficulty to understand one of these concepts, they also have difficulties related the subject [11] and triggers the misconception [12] which is definitely will affect to their grades later.

## 4. Conclusion

Based on the result and discussion of research, the instrument's validity score is 39,75 from 44 and the reliability is 0,714. so, a three-tier diagnostic test can be used to analyze the conceptual understanding of acid-base material. it can conclude that conceptual understanding for acid-base material is not completely scientific, there are students that misconception, guessing, less understand, and do not understand [13]. It caused by several factors. Based on the student's reason analysis, obtained that the student mostly just memorize the material of acid and base [14]. Students do not understand about acid-base conjugation and fail to integrate between macroscopic, microscopic, and symbolic [15]. It happened because of student's weakness to interpret the explanation from symbolic to microscopic state and the opposite. Student's conceptual understanding shows from 145 students 28% of them has scientific knowledge, 9% positive misconception, 3% negative misconception, 31% misconception, guessing 5%, and do not understand 21%

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