Analysis of Student's Conceptual Understanding Using Two-Tier Multiple Choice Diagnostic Test on Acid-Base Topic

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Abstract. This study aims to determine students' understanding of concepts using a two-tier multiple-choice diagnostic test on acid-base material. The number of samples is 31 respondents. This type of research is descriptive qualitative. The instrument used is a Two-Tier Multiple-Choice Diagnostic Test. The first level consists of 5 answer choices, and the second level consists of 5 reason choices. The number of questions is 15 items. The results showed that students in the category of understanding concepts were 78.552%, misconceptions were 13.704%, and students in the category of not understanding concepts were 7.74%. Students understand the concept is in the high category of the three categories.

1 Introduction

Education is a conscious and planned effort to create a learning atmosphere and learning process, enabling students to actively develop their potential in terms of religious and spiritual strength, self-control, personality, intelligence, noble character, and self-skills required by themselves, the community, the nation, and the state. The nature of education, as defined in Law of the Republic of Indonesia No. 20/2003, Article 3 concerning the national education system, states that education aims to develop abilities and shape the character and civilization of a dignified nation to educated individuals who possess noble morals, good health, knowledge, capabilities, creativity, independence, and the qualities of democratic and responsible citizens.

The realization of the purpose of national education hinges on emphasizing students' learning outcomes and nurturing their thinking, working, and critical qualities through the learning process[1]. Their potential can be developed by actively engaging students in concept exploration 2]. Science is a discipline that inherently involves discovering concepts through systematic processes. In chemistry education, students are encouraged to acquire direct learning experiences by developing process skills, scientific attitudes, and knowledge[3]. Most concepts in chemistry are abstract and typically follow a hierarchical structure, progressing from simple to complex [4–6]. Consequently, understanding chemistry requires adequate time. However, the relatively limited study time in school contributes to students perceiving chemistry as challenging, and many admit to experiencing difficulties in understanding chemical concepts.

Based on the results of initial observations conducted at SMA Negeri 1 Bintauna, it was found that acid-base material is still classified as material that is still difficult for students to understand. This is due to a lack of understanding of students' concepts, so that in applying concepts to complex acid-base problems, students have difficulty in applying the concept. In addition, students' difficulties translating abstract concepts in chemistry on the acid-base matter into their own words, thus causing understanding of the concepts taught or misconceptions. Based on the results of an interview with one of the chemistry subject teachers during the daily test, especially on acid-base material, many students still often guess in answering objective or multiple-choice questions. Most of them often answer objective questions by guessing. So asked how to solve it, students could not answer why they chose that answer. This is supported by data on the daily test results of students studying chemistry class XI on acid-base materia, which still many students have not reached the minimum completeness criterion of 75.

Based on preliminary data observations made by 31 students of grade XI of SMA Negeri 1 Bintauna and those who completed, only ten were incomplete, as many as 21. By looking at these problems, it is necessary to analyze learning test instruments to determine students'

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understanding of the concepts and not just carelessly answer questions to avoid misconceptions. Misconceptions taught by students continuously will result in students' cognitive abilities declining. Therefore, appropriate assessment instruments are needed to measure the level of understanding and location of student learning difficulties in chemistry. Multiple choice tests can be an alternative to identify students' level of understanding of concepts.

Multiple choice tests are considered easier to implement because they have many benefits. Teachers can conduct assessments quickly and objectively[7,8]. Teachers can apply multiple-choice tests easily to a large number of students. Multiple choice tests have some limitations to their application, such as determining answers correctly because they understand or guess[9,10]. In addition, the level of students' understanding of concepts in the multiple-choice test was only seen based on the number of correct answers. Some researchers have developed forms of the test that can be used to determine learners' alternative concepts[11,12]. A Connecting Concepts Test was also developed to measure the relationship between two or more concepts and improve students' logical thinking ability in conceptual understanding. These alternative tests measure students' and teachers' beliefs, experiences, understanding, and misconceptions regarding certain concepts. By identifying alternative frameworks and misconceptions, educators can intervene early to inculcate students' interest in mastering fundamental concepts and prevent alternative frameworks from becoming deeply rooted among students[13,14]. The test instrument can detect misconceptions and has a very small possibility for students to guess using a two-tier test. This test instrument has two levels. The first level consists of 5 answers, choices while the second level consists of the choice of reasons that arise in the first level [9,15,16]. Based on the description above, analyzing students' conceptual understanding using the Two-Tier Multiple Diagnostic Test instrument on the acid-base topic is crucial.

2 Method

2.1 Type of Research

This qualitative study describes the level of understanding of concepts based on indicators of learning outcomes in the cognitive domain of acid-base topics through a two-level diagnostic test. Students' understanding will be analyzed qualitatively using percentages.

2.2 Subject

The subject in this study is Class XI students of SMA Negeri 1 Bintauna totalling 31 students.

2.3 Procedures

In this research, the data needed is conceptual understanding based on six indicators of student learning outcomes on the acids-base topic, especially on acid-base material. The methods used in data collection can be combined or use one of the above problems. The research process is through a written test on the material taught before. This research data is through observation tests, preparation of test instruments, validation tests and reliability of instruments before being used on research objects. This student learning outcome data uses a test instrument in the form of a reasoned objective test.

a. Test Instruments

The test is a way used by researchers to find out the ability to master students' concepts indirectly from the responses given by students[17]. The test given to students is a two-tier multiple-choice diagnostic test of 15 reasoned multiple-choice questions. The instrument consists of two levels of questions, where the first level Q1 is multiple choice consisting of five answer choices that measure students' cognition and the second level, or Q2 consists of five choices of reasons to measure students' cognitive ability in explaining the reasons for the answer choices at the first level or Q1[18].

b. Test validity

This study used content and empirical validity for validity testing, and validator lecturers carried out content validity. Meanwhile, empirical validation is carried out by testing the question in class XI SMA Negeri 1 Bintauna by comparing the criteria in an instrument with facts that occur in the field empirically.

In this study, three experts in the field of chemistry were asked to act as validators who would assess each question item that focused on two things: the sentences used must be communicative and contain concepts to be studied. Each validator is given 15 questions with the same question number.

The scoring for each question item to be validated has been determined, where if the sentence structure is communicative and contains the concepts to be studied, a score of 2 will be given. However, if the sentence structure is communicative but does not contain the concept to be measured or vice versa, the validator will give it a score of 1. And if these two things are not met, the validator will give a score of zero.

To get the percentage of each rater using the percentage formula (P), namely:

$$P = \frac{\text{Number of questions that get a score of 2}}{\text{The total number of questions}} \text{ x } 100\ \% \quad (1)$$

Furthermore, to carry out the high and low validity of the research instrument is expressed by serial correlation points, where the correlation index number given the RPBI symbol can be obtained using the formula:

$$rpbi = \frac{M_p - M_t}{SD_t}\sqrt{\frac{p}{q}} \quad (2)$$

Description:

rpbi : Coefficient of validity item

Mp : Flat Scores from subjects who answered correctly for the item for which validity was sought.

Mt : Average score from the total score

Tsp : Standard deviation from total score proportion

P : Proportion of students who answered correctly

$$P = \frac{\text{number of students correct}}{\text{The total number of students}} \quad (3)$$

Q : Proportion of students who answered incorrectly

$$(q = 1-p) \quad (4)$$

With the item testing criteria declared valid if the value of $r_{calculated} \geq r_{tabel}$ at a significant level $\propto$ =0,05

c. Reliability Test

A research instrument is highly reliable if the test consistently measures what will be measured. This means that the more reliable a test has requirements, the more confident we can state that the results of a test have the same results when retested[19].

The formula used to determine the reliability of the objective form test instrument is the 20th Kuder and Richardson formula (K.R-20), namely [20]:

$$KR_{20} = \frac{n}{n-1}\left(1 - \frac{\sum pq}{SD}\right) \quad (5)$$

Description:

K_{20} : Correlation Coefficient

n : Number of Question Items

p : Proportion of correct answers on a given item

q : Incorrect answer proportions on certain items

SD : Standard Deviation

significant level = 0.05 and degrees of freedom (dk = n – 1)

2.4 Data, Instruments and Data Collection Techniques

In this research, the data needed is conceptual understanding based on six indicators of student learning outcomes on the acids-base topic. The methods used in data collection can be combined or use one of the above problems. The research process is through a written test on the material taught before. This research data is through observation tests, preparation of test instruments, validation tests and reliability of instruments before being used on research objects. This student learning outcome data uses a test instrument in the form of a reasoned objective test.

2.5 Data Analysis Technique

Data analysis aims to make sense of the data collected from the research object by using a descriptive test to make conclusions. Data analysis is systematically searching and compiling data from field notes and other materials to be easily understood, and the findings can be informed to others. Data analysis is done by synthesizing, arranging into patterns, choosing what is important and what will be learned, and making conclusions that can be told to others.

3 Result and Discussion

The results of the two-tier multiple-choice test of students as a whole. The use of student concepts on the Acid-Base material with five concepts tested was 78.552%, while for the misconception category, it was 13.704%, and the theory did not master it by 7.74%. The biggest percentage of the three categories is in the category of understanding the concept. The largest percentage of concepts explaining the acid-base theory, according to Arrhenius, Brounsted-Lowry and Lewis, was 84.95%, In comparison, the smallest percentage in the concept of understanding the relationship between PH and POH was 3.23%. In the misconception category, the largest percentage of the concept of understanding the relationship between PH and POH was 18.27%, while the smallest percentage in the concept of strong acid and strong base solutions was 11.29%. In the last category, namely not understanding the concept, the largest percentage in the concept of calculating and measuring the pH of a solution is 13.97%, while the smallest percentage in the concept of acid-base theory, according to Arrhenius, Brounsted-Lowry and Lewis is 3.22%. Based on the answer category data for each concept, a comparison of each category of overall acid-base material is obtained, which can be seen in Fig. 1 below:

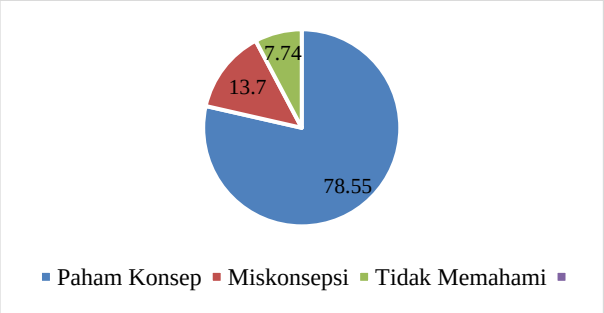

Fig. 1. Presentation of students' overall understanding of acid-base concepts.

Based on Fig. 1, The results showed that students in the category of understanding concepts were 78.552% (High), misconceptions were 13.704% (Low), and students in the category of not understanding concepts were 7.74% (Low).

4 Conclusion

Based on the results of research and discussion that can be seen in the previous chapter, it can be concluded that the student's understanding of the concept of class XI SMA Negeri 1 Bintauna on the acids-base topic is in the High category (78.552%)

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