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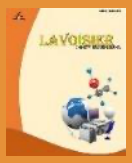

Misconception Analysis of Acid-Base Material in SMK Kimia PGRI Serang City

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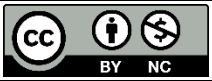
Abstract
Chemistry is a branch of science that studies various natural phenomena, including the properties, changes in matter, structure, and the energy that accompanies them. The study of chemistry is interconnected with its concepts, making it continuous. The aim of this research is to analyze misconceptions about acid-base materials using a four-tier multiple-choice diagnostic test instrument. The research method used is descriptive qualitative, aiming to analyze student misconceptions. The subjects of this research were class XI students of SMK Kimia PGRI Serang City. To collect data, observation techniques, four-tier diagnostic tests, interviews, and documentation were used. The results of this research show that 40% of students have misconceptions about acid-base materials, 13% of students understand the concept, and 47% of students don't understand the concept. There are more students who experience misconceptions compared to students who understand the concept. Based on the percentage results, the level of misconceptions for class XI students at SMK Kimia PGRI Serang City is classified as medium. According to the results of interviews with students, student misconceptions are caused by two factors: internal factors (coming from students) and external factors (coming from learning media such as books and teachers). The factor that causes students' misconceptions is that schools emphasize practice rather than theory, where practice is 60% and theory is 40%.



1. Introduction

Learning involves a series of changes in behaviour that are permanent and influenced by interactions with the environment. It is a process of interaction between

educators, students, and learning resources, all of which are influenced by the surrounding environment. Educators provide support to students to help them acquire knowledge, develop character, form attitudes, and build self-confidence. This learning process is universal and can be implemented anywhere and at any time (Merdicko, 2022).

Chemistry is a branch of science that studies various natural phenomena, including the properties, changes in matter, structure, and the energy that accompanies them. The concepts in chemistry are interconnected and continuous. In order to properly understand chemistry, learning must be continuous and coherent. The abstract and complex nature of chemistry material often leads students to view it as a difficult subject. This difficulty is often caused by a lack of understanding of basic concepts, making it challenging for students to comprehend more complex material. Chemistry has characteristics as an abstract science, a simplification of the actual state, sequential, and hierarchical. These characteristics make chemistry one of the subjects that is difficult for students to learn (Erlina, 2012).

Misconception refers to a misunderstanding or incorrect belief about something. According to the Oxford Dictionary, "conception" refers to a specific understanding or belief related to a subject. Therefore, a misconception can be viewed as a perspective or interpretation that deviates from widely accepted knowledge and contradicts established scientific principles. These incorrect beliefs often arise due to incomplete or inaccurate information, leading to misconceptions that hinder the correct understanding of a concept (Nurulwati, 2014).

Success in learning can be measured by the level of understanding of concepts by students. Understanding a concept involves a series of stages, starting from basic concepts obtained through experience and influenced by the surrounding environment. The development of a concept leads to a more complex understanding. According to Anggraeni & Wiwiek (2017), misconceptions are the beliefs held by students that do not align with scientific rules. This can be influenced by factors such as the learning style of students, who may tend to memorize rather than understand concepts. It is important to detect these misconceptions in students so that they can be addressed, ensuring that the knowledge provided aligns with scientific concepts. Misconceptions can significantly hinder the learning process, especially if they go undetected for a long time by the teacher or the students themselves.

The presence of misconceptions in chemistry learning can be attributed to two factors: internal and external aspects. Internal aspects are those experienced by the students themselves, including preconceptions, learning methods, student abilities, interests, and intuition. External aspects, on the other hand, involve teachers, learning methods, and the study materials. According to Saskia & Ritonga (2021), detecting learning difficulties in students can be achieved through observation, diagnostic tests, interviews, and documentation. In their research, a diagnostic test was used as an instrument to detect misconceptions. This test was developed as a four-tier multiple-choice diagnostic test, which differs from general multiple-choice tests as it can identify students who are guessing their answers. This is possible because the test is designed to measure the strength of student concepts by detailing answer errors and the integrity of the knowledge that students possess.

The acid-base material is a fundamental part of chemistry that students need to master in order to understand subsequent topics such as acid-base titration, buffer solutions, and salt hydrolysis (Putri, Wigati, & Laksono, 2022). Misunderstandings in this material can lead to misconceptions in further studies. According to Laliyo et al. (2023), students often have misconceptions about acid-base theories, pH measurements, and reactions related to acids and bases, despite the practical and everyday applications of these concepts.

2. Materials and Methods

The type of research used is descriptive qualitative research, which aims to analyze misconceptions in students by using a four-tier diagnostic test on acid-base materials. The population in this study were 89 students. The sample is part of the population that is used as the object of research. The purposive sample technique was used in this study by means of the chemistry teacher concerned directly selecting the class to be sampled for a consideration of the efficiency of the researcher's time.

In this study, researchers are seeking four-tier multiple choice Diagnostic Test questions that are relevant and validated. The data collection technique involves direct observation using instruments in the form of school chemistry material questions on "Acid-Base" given to students, as well as online interviews conducted via Google Meet. Subsequently, the researcher corrected the questions and obtained the results of the observation. The research instrument used a four-tier multiple choice diagnostic test of 20 items. The data analysis technique involves evaluating students'

responses to given questions and conducting interviews with the students. If a student answers a question correctly, they receive 5 points (provided their reasoning is correct), but if their reasoning is incorrect, they receive only 3 points. The level of confidence is assessed to determine how certain the student is about their answer. If a student expresses uncertainty, it suggests that they may have guessed the answer without understanding the concept. Interviews are conducted to identify any misconceptions held by the students, allowing researchers to analyze the misconceptions that arise.

3. Results and Discussions

The data in this four-tier multiple-choice diagnostic test covers Arrhenius, Bronsted-Lowry, and Lewis acid-base theories, chemical reactions in acid-base models, acid-base indicators based on pH, and the determination of pH values in acidic or basic solutions. The student understanding level is presented as a percentage, making it easy to detect the level of understanding. The results are listed in the diagram below.

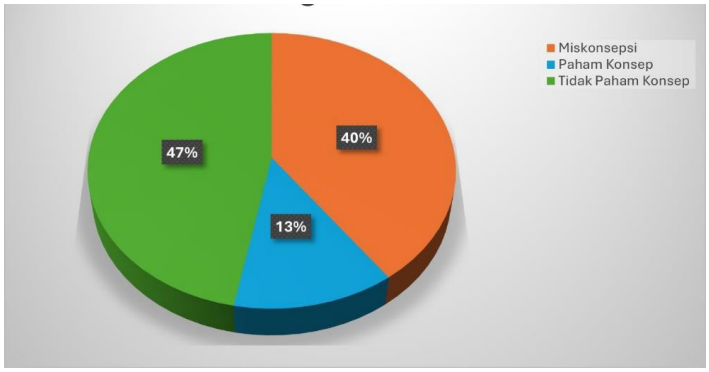


Figure 1 Percentage of Students' Comprehension Level

Based on the test results, student understanding is divided into 3 levels. The first level includes students who understand the concept and answer questions correctly along with providing the right reasons. The second level consists of students who have misconceptions, meaning they give the right answer but provide incorrect reasons, or vice versa. The third level includes students who do not understand the concept, as they answer both the questions and the reasons incorrectly.

The results of the study conducted on 22 student samples showed that 13% of students understood the concept, 40% had misconceptions, and 47% did not understand the concept. This indicates that the percentage of students with

misconceptions is higher than the percentage of students who understand the concept. Based on these percentages, the students' misconception level is classified as moderate. The detailed results are presented in the following table.as moderate. The detailed results are presented in the following table.

Table 1 Percentage Categories of Misconception Levels

Percentage	Category
0 – 30 %	Low
31 – 60 %	Medium
61 – 100%	High

The analysis of student understanding is based on the interpretation of their answers, as shown in table 1. It reveals that students may not fully understand the acid-base material or may not provide the desired responses. The results of student interviews indicate that the teacher's explanation is brief and lacks detail, relying mainly on practical demonstrations.

First Indicator (Identifying Acid-Base Theories According to Arrhenius, Bronsted-Lowry, and Lewis)

In the first indicator, a four-tier multiple-choice test was conducted regarding Acid-Base Theories proposed by Arrhenius, Bronsted-Lowry, and Lewis, with three total questions found in question numbers 1, 2, and 7. The percentage of misconceptions was found to be 61.82% on average, with a breakdown of 45.45% for question 1, 45.45% for question 2, and 50% for question 7. The percentage of students who understood the concept was 18.19%, with details of 36.37% for question 1, 13.64% for question 2, and 4.55% for question 7. Meanwhile, the percentage of students who did not understand the concept averaged 34.85%, with 18.18% for question 1, 40.91% for question 2, and 45.45% for question 7.

Second Indicator (Determining Chemical Reactions in Acid-Base Models)

In the second indicator, a four-tier multiple-choice test was conducted on chemical formulas resulting from acid-base reactions, with five questions in total, found in question numbers 3, 4, 5, 6, and 8. The average percentage of misconceptions was 33.63%, with the breakdown as follows: 36.36% for question 3, 27.27% for question 4, 50% for question 5, 27.27% for question 6, and 27.27% for question 8. The percentage of students who understood the concept was 15.55%, with details of 4.55% for question

3, 31.82% for question 4, 27.73% for question 5, 4.55% for question 6, and 9.1% for question 8. The percentage of students who did not understand the concept averaged 51.82%, with 59.1% for question 3, 40.91% for question 4, 27.27% for question 5, 68.18% for question 6, and 63.64% for question 8.

Third Indicator (Differentiating and Identifying the Use of Various Acid-Base Indicators Based on pH)

In the third indicator, a four-tier multiple-choice test was conducted regarding the differences in using various acid-base indicators based on pH, with three questions in total, found in question numbers 9, 10, and 11. The average percentage of misconceptions was 45.46%, with a breakdown of 45.45% for question 9, 59.1% for question 10, and 31.82% for question 11. The percentage of students who understood the concept was 7.58%, with details of 4.55% for question 9, 18.18% for question 10, and 0% for question 11. Meanwhile, the percentage of students who did not understand the concept averaged 48.64%, with 50% for question 9, 27.73% for question 10, and 68.18% for question 11.

Fourth Indicator (Determining the pH Value of Acidic or Basic Solutions)

In the fourth indicator, a four-tier multiple-choice test was conducted using calculation data to determine the pH value of a solution that is either acidic or basic, with nine questions in total, from question numbers 12 to 20. The average percentage of misconceptions was 27.36%, with the breakdown as follows: 40.91% for question 12, 54.54% for question 13, 27.73% for question 14, 36.26% for question 15, 9.1% for question 16, 27.73% for question 17, 13.64% for question 18, 18.18% for question 19, and 18.18% for question 20. The percentage of students who understood the concept was 13.64%, with details of 0% for question 12, 4.55% for question 13, 9.1% for question 14, 0% for question 15, 31.82% for question 16, 4.55% for question 17, 0% for question 18, 0% for question 19, and 72.73% for question 20. The percentage of students who did not understand the concept averaged 60.61%, with 59.1% for question 12, 40.91% for question 13, 68.18% for question 14, 63.64% for question 15, 59.1% for question 16, 77.27% for question 17, 86.36% for question 18, 81.82% for question 19, and 9.1% for question 20.

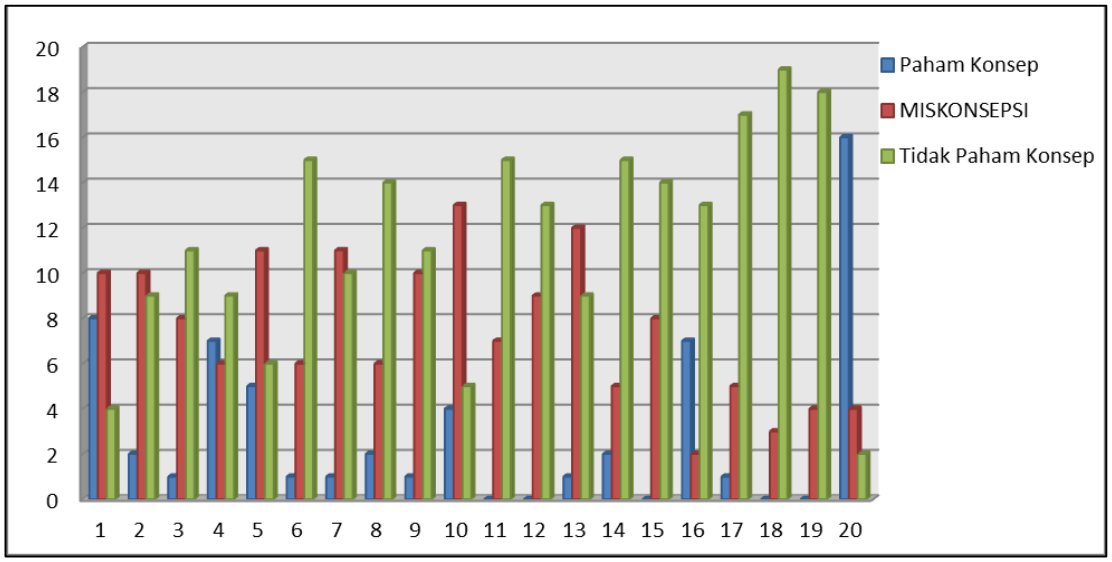


Figure 2. Comparison of Level of Students' Understanding of the Acid-Base Concept

Based on Figure 2, it is evident that the 11th-grade students of SMK Kimia PGRI Serang City have misconceptions about the concept of acid-base, as indicated by the four-tier multiple choice diagnostic test. These misconceptions are present in almost all question numbers, with varying numbers of students. The question with the highest misconception is number 10, with a total of 13 students. This question pertains to the use of different types of acid-base indicators in determining pH. Overall, the average percentage of students with misconceptions in the acid-base material is 40%. This indicates that the average misconceptions experienced by 11th-grade students of SMK Kimia PGRI Serang City fall within the criteria for moderate misconceptions, as explained in Table 1, where the criteria for the percentage of moderate misconceptions is 31%-60%.

In this study, a four-tier multiple-choice diagnostic test was conducted. The four-tier diagnostic test is developed from the three-tier test with the addition of reasons to provide confidence in choosing answers (Zulfikar, Samsudin, & Saepuzaman, 2017). Students take this test in the form of multiple-choice questions with open-ended reasons and are equipped with a level of confidence in answering questions and providing reasons. Multiple-choice tests have several advantages, including the ability to measure student memory from learning to evaluation, easy determination or scoring of answers, speed, objectivity, and appropriateness for exams with a large number of participants (Suharman, 2018). When teachers give tests to students, the tests must meet the requirements for validity, reliability, objectivity, practicability, and economy (Kadir, 2015).

Student misconceptions are influenced by two factors: internal factors originating from the students themselves, and external factors stemming from learning materials such as books or worksheets, as well as teachers. The first factor, internal factors, leads to misconceptions about acid-base material because students tend to memorize the material without truly understanding the concepts. After the diagnostic test, interviews were conducted with both teachers and students to explore how the teacher presented the material in class and to understand students' reactions to the chemistry lessons, particularly those related to acid-base concepts. The interview results revealed that the school places more emphasis on practical work (60%) than on theoretical learning (40%), which leads students to excel in practical activities but struggle with understanding theoretical concepts. Furthermore, many students have difficulty recalling the material taught, which confuses them when answering related questions. Although practical skills are important, a stronger emphasis on theoretical understanding could help bridge the gap and improve learning outcomes. This highlights the need for a more balanced approach integrating theory and practice to support student's knowledge and retention of key concepts.

Misconceptions can be caused by incomplete reasoning, student ability, student interest, and teaching methods (Ekawisudawati, Wijaya, & Danial, 2021). Based on interviews with students, it was revealed that they often forget the material taught by the teacher, indicating the importance of teachers not only focusing on memorization but also on fostering a deeper understanding of the concepts being taught. External factors, such as the teaching methods employed and study materials like worksheets or books, also contribute to students' misconceptions. At SMK Kimia PGRI Serang City, most of the material is taught through experiments with minimal theoretical explanations, which leads to a lower understanding of the acid-base concept among students.

5. Conclusions

The study found that 40% of students at SMK Kimia PGRI Serang City have misconceptions, 13% understand the concept, and 47% do not understand the concept. These misconceptions are present in almost all question numbers, with varying numbers of students. The question with the highest misconception is number 10 on the Third Indicator, which is differentiating and identifying the use of various acid-base indicators based on pH. The main reason for these misconceptions and lack of understanding is that the school focuses more on practical work (60%) than on theory

(40%). As a result, students tend to excel in practical work but struggle with theoretical understanding. Additionally, many students have difficulty recalling the material, leading to confusion when answering questions. The researcher suggests that while practical work is important, it should be integrated with theory to ensure a better understanding. They also recommend making theoretical learning more engaging, possibly through gamification.

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