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Research Article

Analysis of Students' Misconceptions on Acid-Base Topic Using the Two-Tier Diagnostic Test

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Abstract
This case study aims to explore the misconceptions surrounding acid-base concepts. It utilizes a qualitative descriptive research design to examine students' comprehension of the acid-base concept. The sample includes 231 students from grades XI and XII in the science stream who have studied acid-base, selected randomly from SMAN 54 Jakarta and SMAN 14 Bekasi schools. The methodology involves the use of a two-tier diagnostic test tool, interviews, and reflective journals. The research tool consists of a two-tier diagnostic test with 10 hierarchical questions - multiple-choice at the first level and reasons for the first-level answers at the second level, totaling 20 questions adapted from a previous study (Ibrahim, 2016) to ensure validity and reliability. The diagnostic test tool was administered to students through Google Forms. The study findings from 231 participants showed that 44% of students grasped the acid-base concept, 19% had a partial understanding, 17% held misconceptions, 20% did not understand, and 19% did not provide a response. The research results were corroborated by interviews and reflective journals with students who took part in the two-tier diagnostic test. The identification of misconceptions in acid-base material highlights the necessity to enhance teaching approaches, stressing the significance of teachers recognizing the individual learning styles of their students.

Keywords: Acid-base, diagnostic test, misconceptions, two-tier

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1. INTRODUCTION

Misconceptions play a crucial role in chemistry learning. Sources of misconceptions include everyday experiences or traditional learning strategies. Misconceptions are resilient to change, persistent, and challenging to eradicate even with instructional designs to address them. Effective learning strategies are key factors in understanding chemical concepts. To keep pace with the rapid development of chemical knowledge, learners need to be prepared to process information accurately and meaningfully so that it can be retained longer and applied in various life situations. To achieve this goal, learners must frame concepts within their cognitive domain. Learning transfer primarily relies on conceptual information as these concepts form the main building blocks of knowledge structure. The initial step involves identifying learners' misconceptions using the Chemistry

Misconception Test (CMT) and rectifying misconceptions through improvisational strategies using various learning models.

The study of acids and bases is crucial as it is interconnected with other chemistry subjects such as the concept of moles, compound nomenclature, and chemical bonding. This topic is highly contextual and relevant to students' daily lives. According to constructivist learning, students can explore their knowledge of acids and bases through concepts and phenomena they experience, utilizing sensory experiences, cultural backgrounds, peers, mass media, or classroom instructions.

Hand and Treagust (1991) identified five key misconceptions about acids and bases among sixty 16-year-old students. They then developed and implemented a curriculum on acids and bases based on a conceptual change approach aimed at correcting the students' misconceptions. The misconceptions found were: (1) acids are something that eat away materials; acid cans burn you, (2) testing acids can only be done by trying to eat something, (3) neutralizing is breaking down acid or changing it from acid, (4) bases are something that form acids, and (5) strong acids can eat away materials faster than weak acids. Almost all of these misconceptions were specifically related to acids. The research results indicate that students taught using the new curriculum on acids and bases achieved higher outcomes than those taught using conventional methods.

Nakhleh and Krajcik (1994) examined how varying levels of information, delivered through different technologies, engaged middle school students in grasping the concepts of acid-base and pH. They employed concept maps created from propositions articulated by the students during interviews conducted prior to and after a series of acid-base titrations. After the initial interviews, students were split into three groups. In each group, students individually carried out the same titration process using distinct technologies: chemical indicators, pH meters, and Microcomputer-Based Laboratories (MBL). The study results suggest that the order of technology impact on comprehension is: MBL > chemical indicators > pH meter.

The main difference between online learning and face to face learning is the lack of direct interaction between educators and learners. One significant advantage of blended learning, as experienced by learners, is the ability to review and replay the lessons provided by educators through video recordings. However, this is also accompanied by challenges such as quizzes, time constraints, and internet connectivity issues. Time constraints refer to the duration required to complete tasks. Learners may feel rushed and stressed due to discrepancies between what they learn asynchronously and the tasks assigned, differing from what was discussed during the learning process. Other disruptions are related to internet connectivity during synchronous activities (LDS. Lapitan Jr. et al., 2021). During the pandemic, misconceptions arose among learners due to the lack of content validity in the information they received from various learning sources (Winarni and Syahrial, 2022).

Misconceptions about acids and bases are common in the field of chemistry (Talib, et al. 2018). Some of these issues arise from limited understanding of acid-base concepts, practical constraints in the laboratory regarding types of titrations and indicators (Supatmi, et al. 2019). In connection with this, misconceptions about acid-base concepts stem from students' weak grasp of prerequisites such as the differences between weak and strong acids and bases, equilibrium, and acid constants (Barke, et al. 2009). Misconception issues also originate from educators. Teachers should comprehend acid-base theories and models, which need to be reconceptualized as part of the epistemology in understanding chemical concepts.

By facilitating sound concepts, correct understanding can be achieved (Kousathana, et al. 2005).

Meaningful learning also needs to consider material instructions. Teachers' instruction is built upon the prior knowledge of learners rather than the scientific knowledge of researchers. The concept of acids and bases cannot be fully grasped solely through instructional methods due to its extensive nature and limited learning time allocation (Sheppard, K. 2006). Textbooks also significantly influence misconceptions. Inexperienced teachers tend to strictly adhere to the guidelines in textbooks and overlook certain contexts or models of acids and bases (microscopic and macroscopic levels) that are challenging for learners to understand. Due to their lack of awareness, what teachers teach often remains incomprehensible to students (Drechsler and Driel, 2007).

It is well established that the understanding of acids and bases is a crucial topic for students to grasp. This comprehension is intertwined with various other chemistry concepts, particularly in organic chemistry, to formulate reaction mechanisms (Petterson, et al. 2020). Schmidt (1995) utilized written assessments and group discussions in his study to pinpoint students' misunderstandings in chemistry lessons. The written assessments consisted of multiple-choice questions followed by explanations for their selections. Group discussions were then conducted to delve deeper into the rationales behind the students' choices. Prior research has also played a significant role in assessing misconceptions in chemistry, utilizing methods such as animations or cartoons (Smith and Villarreal. 2015; Kusumaningrum, et al. 2018), the bonding representations inventory (BRI) (Luxford and Bretz. 2014; Vrabec and Proksa. 2016), two-tier multiple-choice questions (Filocha Haslam & David F. Treagus. 1987; Emine Adadan & Funda Savasci. 2012), three-tier tests (Milenkovic, et al. 2016), four-tier tests (Habiddin and Page. 2019), interviews (Hackling and Garnett. 1985), among other approaches.

With the passage of time and the requirements during the COVID-19 pandemic, identifying misconceptions can now be done online. Google applications offer various advantages to support educational management. Google Forms, as a component of the Google suite, are valuable for gathering data and can be used to assess students' misconceptions. The user-friendly interface of this application is a result of its well-structured system, delivering prompt results and information. From the viewpoints of constructivist and cooperative learning, the utilization of educational applications like Google enhances academic performance in remote learning. This is because students can easily share and showcase their work, as well as collaborate with classmates and instructors. Given the research findings highlighting misconceptions in acid-base subjects, further comprehensive investigations on misconceptions in acid-base materials are essential.

2. METHODS

2.1 Research Design

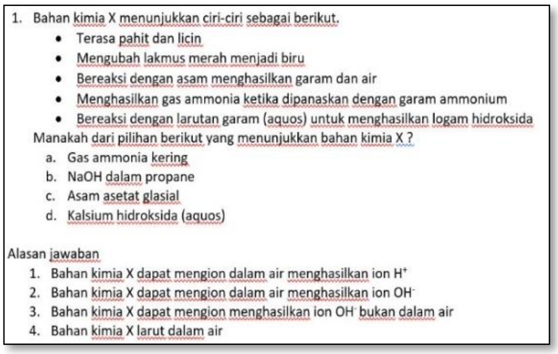
This study utilized a qualitative descriptive research design to analyze students' understanding of the concept of acids and bases.

2.2 Participants

The sample was randomly selected and consisted of 231 students from 11th and 12th grade science classes who had studied the topic of acids and bases. The students were from SMAN 54 Jakarta and SMAN 14 Bekasi. Their participation was voluntary.

2.3 Data Collection Tool

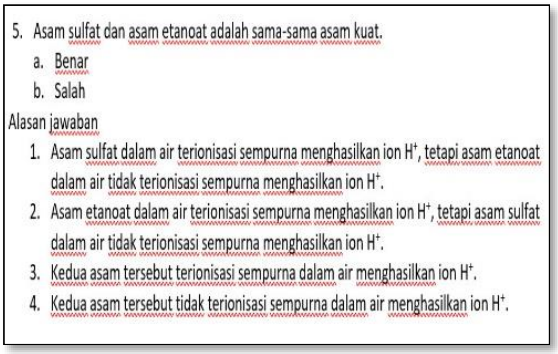
The research methodology involved the use of a two-tier diagnostic test instrument, interviews, and reflective journals. The research instrument employed a two-tier diagnostic test comprising 10 multiple-choice questions at the first level and reasons for the answers at the second level, totaling 20 questions. This diagnostic two-tier instrument was adapted from another researcher (Ibrahim, 2008).



1. Bahan kimia X menunjukkan ciri-ciri sebagai berikut.
   - Terasa pahit dan licin
   - Mengubah lakmus merah menjadi biru
   - Bereaksi dengan asam menghasilkan garam dan air
   - Menghasilkan gas ammonia ketika dipanaskan dengan garam ammonium
   - Bereaksi dengan larutan garam (aquos) untuk menghasilkan logam hidroksida

   Manakah dari pilihan berikut yang menunjukkan bahan kimia X ?
   a. Gas ammonia kering
   b. NaOH dalam propane
   c. Asam asetat glasial
   d. Kalsium hidroksida (aquos)

Alasan jawaban
1. Bahan kimia X dapat mengion dalam air menghasilkan ion H^+
2. Bahan kimia X dapat mengion dalam air menghasilkan ion OH^-
3. Bahan kimia X dapat mengion menghasilkan ion OH^- bukan dalam air
4. Bahan kimia X larut dalam air



5. Asam sulfat dan asam etanoat adalah sama-sama asam kuat.
   a. Benar
   b. Salah

Alasan jawaban
1. Asam sulfat dalam air terionisasi sempurna menghasilkan ion H^+, tetapi asam etanoat dalam air tidak terionisasi sempurna menghasilkan ion H^+.
2. Asam etanoat dalam air terionisasi sempurna menghasilkan ion H^+, tetapi asam sulfat dalam air tidak terionisasi sempurna menghasilkan ion H^+.
3. Kedua asam tersebut terionisasi sempurna dalam air menghasilkan ion H^+.
4. Kedua asam tersebut tidak terionisasi sempurna dalam air menghasilkan ion H^+.

Figure 1. Second-Level Multiple-Choice Questions

The two-tier diagnostic test instrument utilized by researchers was adapted from Ibrahim (2016) and has previously been used to uncover students' misconceptions regarding acid-base materials. This decision led the researchers to forgo validity and reliability testing. Students' alternative concepts can be identified through the ten-item two-tier diagnostic test instrument developed based on their misconceptions. This instrument comprises two formats: five multiple-choice two-tier items and five true-false second-tier items. Two examples of each test item are illustrated in Figure 1.

The first type of two-tier items is multiple-choice, which provides a series of answers and a series of reasons for the previous answer as in previous studies (Haslam and Treagust 1987; Tsai and Chou 2002). These items consist of one correct answer and reason; the distractors reflect possible alternative conceptions of learners about acids and bases. The second-tier item type is a variation of the first-tier answer reasons. Here, the true/false answer is the first tier followed by the second tier consisting of a series of reasons for choosing true or false as in the study conducted by Mike and Treagust (1998). These items also include distractors reflecting possible alternative conceptions of learners about acids and bases except for one correct answer and reason. In both types of two-tier test items, learners select the most appropriate answer reason from the provided choices.

2.3 Data Analysis

Diagnostic test instruments are integrated into Google Forms and then distributed to participants. The instrument consists of two-level multiple-choice and true-false items. The test items can be analyzed through several stages: 1. Participants' answers are downloaded in Excel format; 2. Participants' answers are manually checked for classification; 3. The classification is divided into four categories, namely Sound Understanding (SU) (3 points), Partial Understanding (PU) (2 points), Sound Misconception (SM) (1 point), No Understanding (NU) (0 points), and No Response (NR) (0 points). These criteria are adapted from Bayram (2007); 4. Each participant's answers are scored according to the category of their conceptual understanding; 5. Researchers calculate each category. This is done to determine the number of participants experiencing misconceptions; 6. The data is represented in the form of a pie chart.

Table 1. Two-Tier Diagnostic Test Analysis

Categories				Marks
First tier	–	Second tier		
True response	–	True reason	(T-T)	3
False response	–	True reason	(F-T)	2
True response	–	No reason	(T-N)	2
True response	–	False reason	(T-F)	1
False response	–	No reason	(F-N)	0
False response	–	False reason	(F-F)	0
No response	–	No reason	(N-N)	0

Table 1 shows that the analysis of the two-tier diagnostic test instrument can be classified based on the response at level one and the reasoning at level two. If at the first level the response is true-reason true (T-T), it scores 3 points in the Sound Understanding (SU) category; true-reason false (T-F) scores 1 point in the Sound Misconception (SM) category; false-reason true (F-T) scores 2 points in the Partial Understanding (PU) category; true-no reason (T-N) scores 2 points in the Partial Understanding (PU) category; false-no reason (F-N) scores 0 points in the No Understanding (NU) category; false-reason false (F-F) scores 0 points in the No Understanding (NU) category; no response-no reason (N-N) scores 0 points in the No Response (NR) category.

3. RESULTS

Based on the research conducted on 231 science students who have studied acid-base materials, the following research findings were obtained:

Table 2. Students' Conception of Acid-Base Topic

Students' Conception	**Percentage (%)**
Sound Understanding (SU)	44
Partial Understanding (PU)	19
Sound Misconception (SM)	17
No Understanding (NU)	20
No Respon (NR)	19

The table and Figure 2 indicate that 44% of the students understand the concept of acids and bases. This is evidenced by the students being able to correctly answer the two-tier diagnostic test in accordance with the knowledge of acids and bases. Some students partially understand the concept (PU) by 19%. Students experience misconceptions by 17%. Misconceptions can be caused by the students themselves, teachers, textbooks used, context, and teaching methods of the teacher (Suparno, 2013). Students do not understand (NU) the concept of acids and bases by 20%. According to the theory, students who do not understand the concept (NU) of acids and bases have two possibilities: answering questions incorrectly without reasons (F-N) or giving wrong answers with incorrect reasons (F-F). Based on the data analysis, 20% do not understand the concept of chemistry because they answer questions incorrectly with incorrect reasons.

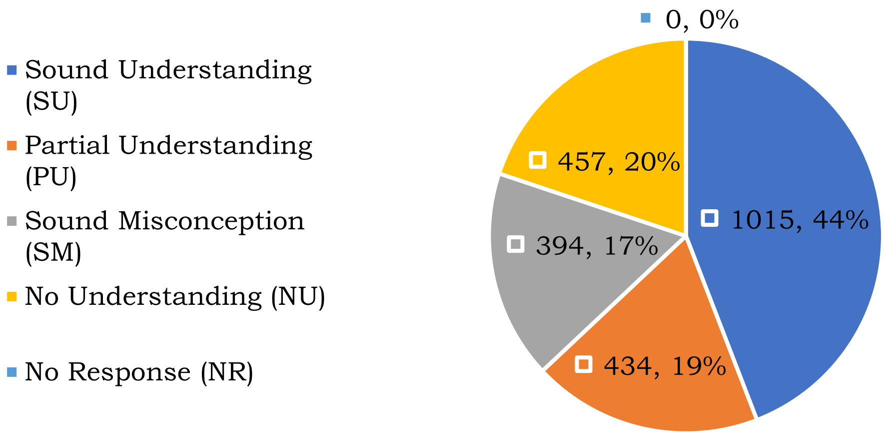


Figure 2. Students' Conception of Acid-Base

Based on the reflection results of the students, "acids and bases are difficult to understand" due to the lack of explanation by the teacher during teaching. This is in line with other researchers (Suparno, 2013) who revealed that one of the factors causing misconceptions is the teaching method. According to Marsita (2010), learning difficulties in students can be diagnosed by a two-tier multiple-choice diagnostic test. Therefore, the researcher used a two-tier diagnostic test to analyze students' misconceptions about acids and bases. After analyzing the misconceptions, teachers should have appropriate and effective learning strategies to deepen the concept of acids and bases. There are many effective teaching methods to avoid misconceptions and improve students' understanding. Additionally, students can also use their diverse learning styles to better understand the concept of acids and bases. Students who recognize their learning styles can understand the material provided by the teacher easily and process it effortlessly. If they can easily process and remember the material, they can understand the concept of the material (Wulandari, 2009).

4. DISCUSSION

The following are the concepts of acids and bases being studied:

Table 3. Acid-Base Concept on Two Tier Diagnostic Test Instruments

No.	Acid-Base Concept on Test Instruments
1	Characteristics of chemical substances are basic.
2	Chemical reactions with reactants of acidic substances
3	Properties of metyl Orange indicators
4	Standard solution making tools
5	Different types of acids in Sulfuric Acid and Ethanoic Acid
6	The concept of Acid according to Archenius
7	pH value in acid
8	Alkaline properties of cleaning agents
9	Benefits of Calcium Oxide in soil fertilization
10	Examples and characteristics of weak bases

To obtain information from respondents, all concepts are presented in detail as follows:

3.1 Concept of The Characteristic of Chemical Substances That are Basic

Based on research findings, students' scientific understanding of the chemical concept of Calcium Hydroxide indicates that it is a base with characteristics such as a bitter and slippery taste, turning red litmus paper blue, reacting with acids to produce salt and water, releasing ammonia gas when heated with ammonium salt, and reacting with salt solutions to produce metal hydroxide. Calcium hydroxide is considered a base due to scientific reasoning that the substance can ionize in water to produce OH- ions. The first question was answered correctly in terms of scientific concept by 30% of students demonstrating Sound Understanding (SU).

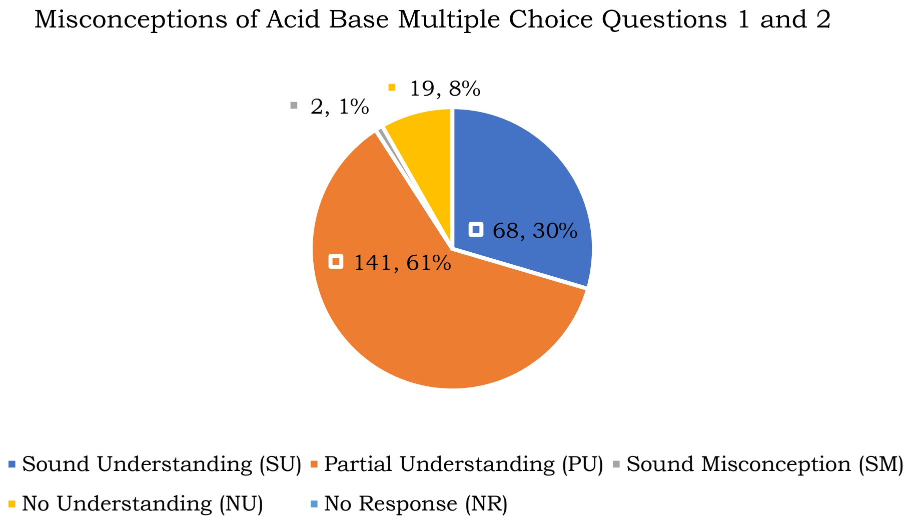


Figure 3. Student Conception on the Concept of Characteristics of Alkaline Chemicals

According to the interview results, Mars stated that:

"In my understanding, an acid is a substance that can release H^+ ions in water, while a base is a substance that can release OH^- ions in water. For example, acids include HCl, HNO_3, H_2SO_4, and bases include NaOH, KOH."

The characteristic of calcium hydroxide according to Arandi (2017) states that calcium hydroxide is basic and can be used in the field of dentistry. However, overall, students have a partial understanding, with 61% related to the basic nature of calcium hydroxide. Here are some interview results reflecting a student named GR who has an incomplete understanding:

"The hindering factor may be due to my lack of understanding and insufficient practice at home. The distance learning habit makes students reluctant to review the material at home."

Based on the findings, students were able to identify the characteristics of bases in calcium hydroxide, but their alternative understanding remains high. Students did not provide the scientific reasoning, namely that calcium hydroxide can ionize to produce OH- ions in water. According to student with the initials GR, they only knew that potassium hydroxide (KOH) is a metallic compound that is highly basic. The misconceptions in concept understanding were at 1% (SM) and students who did not understand the concept were at 8% (NU). Misconceptions in questions 1 and 2 were not significant, but the highest percentage of conceptual understanding still remains partial.

3.2 Chemical Reaction Involving Acidic Reactants

In the second subsection, 59% of the students accurately answered the chemical reaction with acidic reactant in terms of scientific understanding (SU). Based on the reflection results, a student named GR found out that a solution with a pH of 3, when reacted with calcium carbonate, will produce carbon dioxide gas.

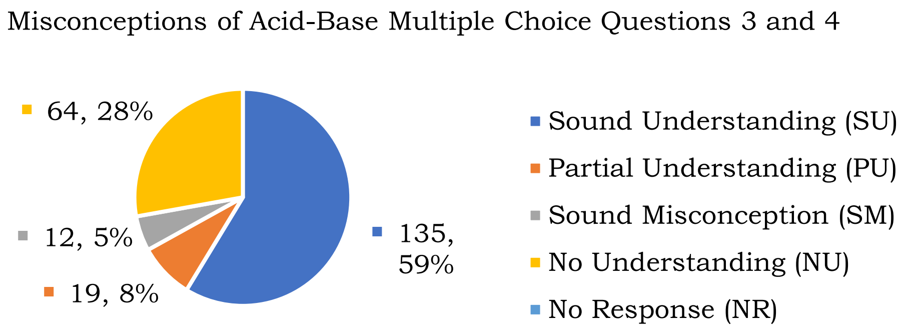


Figure 4. Student Conception on the Concept of Chemical Reactions with Acid Reactants

The student correctly answered hierarchical questions regarding the pH at which calcium carbonate can produce carbon dioxide, indicating an acidic pH of 3. This was supported by the explanation that the solution contains a higher concentration of H+ ions compared to OH- ions. Among the students, 19% partially understood the concept (PU), 5% had misconceptions, and 28% did not understand the question. Misconceptions may arise from the students themselves, teachers, textbooks used, context, and teaching methods (Suparno, 2013). This aligns with the interview findings from respondent Mer.

"Some topics were left out due to the school holidays, so let's proceed directly to practicing math problems."

3.3 Concept of the Properties of Methyl Orange Indicator

The fifth and sixth diagnostic questions are about the characteristics of acid-base indicators, one of which is methyl orange.

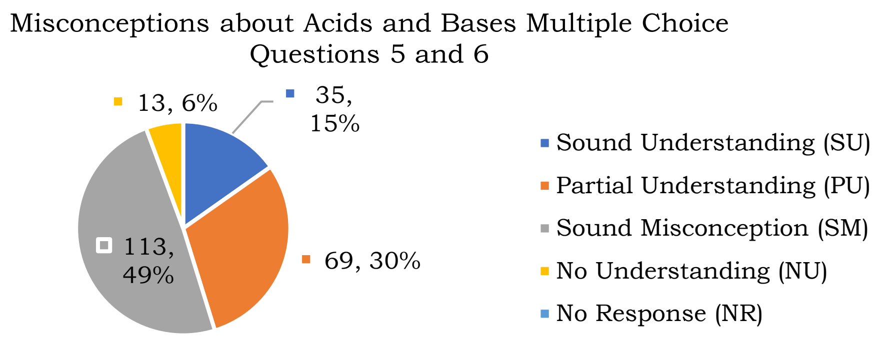


Figure 5. Students' Conception on the Concept of Properties of Methyl Orange Indicators

Based on interviews, this topic is considered difficult because students do not have practical experience using methyl orange, resulting in an incomplete scientific understanding.

This aligns with Redhana (2021), indicating that one of the reasons for low conceptual understanding is the lack of orientation towards practical work. Students' reflection on this subtopic reveals their difficulty in understanding the properties of methyl orange. One respondent, Gld, stated that methyl orange is acidic because of its sour taste. Another student, R, mentioned familiar acid-base indicators such as rose petals, turmeric, hibiscus, while methyl orange can change color in slightly acidic pH commonly used in acid titrations. KC also added that,

"Red litmus paper, blue litmus paper, bromothymol blue, methyl orange, methyl red, phenolphthalein, thymolphthalein. Yes, I am familiar with methyl orange indicator. It is acidic due to its pH being less than 7, specifically 3.1-4.4."

Based on the interview, according to the diagnostic test results, 30% of students' understanding of methyl orange falls into the category of partial understanding. The understanding that corresponds to scientific concepts is 15%. 6% do not understand the concept at all, and misconceptions account for 49%. Misconceptions are caused by students not reading the material and never conducting experiments using methyl orange as an indicator. This is confirmed by the students' statement regarding Mer.

"I am not aware because I have never read about the material and have not practiced it yet."

Misconceptions can arise from the learners themselves, teachers, textbooks used, context, and the teacher's teaching methods (Suparno, 2013).

3.4 Standard Solution Preparation Tool

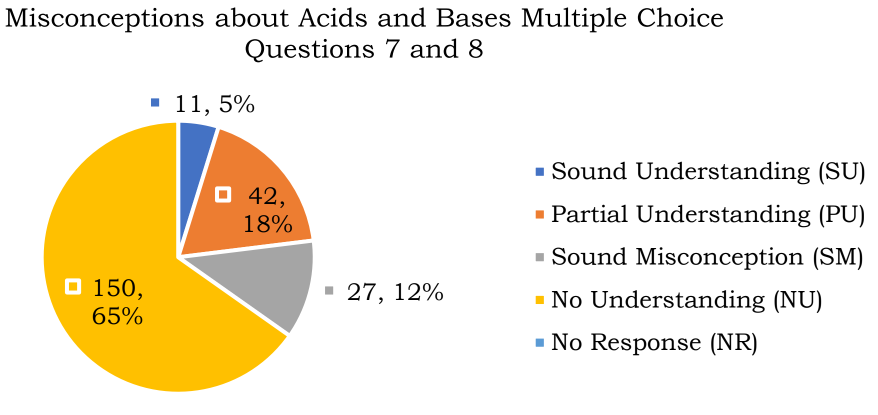


Figure 6. Students' Conception of the Tool Concept of Making Standard Solutions

When it comes to acid-base chemistry, the practice of preparing solutions through experiments is quite common. Previous research conducted by Waghorne (2022) indicates that solutions are essential in various fields of chemistry such as physical chemistry, inorganic chemistry, organic chemistry, and biochemistry. The concept of acid-base solutions falls under organic chemistry. The preparation of solutions requires specific tools like volumetric pipettes for precise measurement. However, diagnostic test results have revealed that 65% of students do not grasp this concept well. There are several reasons contributing to this lack of understanding, one of which is the absence of hands-on acid-base experiments due to distance learning. Consequently, students only learn from home without the practical experience of using volumetric pipettes in acid-base experiments.

There are 18% of students experience partial understanding (PU). This suggests that students' grasp of the subtopic of tools used for creating standard solutions is not thorough. This is attributed to the limited opportunities for hands-on experimentation with volumetric pipettes during the COVID-19 pandemic. The overall scientific understanding (SU) stands at only 5%, with a misconception rate (SM) of 12%. This is evidenced by feedback from students expressing:

"I am unsure about the process of creating a solution."
"I lack knowledge on how to prepare a standard solution as I have not observed it being done on platforms like YouTube or other online media."

Furthermore, students who understand the preparation of solutions state the following steps for making standard solutions:

1. Determine the type:
   a. If it is solid, calculate its mass.
   b. If it is liquid, calculate its volume.
2. Add water, stir until dissolved.
3. Pour into a volumetric flask.
4. Add water according to the desired amount or concentration.
5. Shake the volumetric flask until completely dissolved and evenly mixed.
6. Transfer the solution into a reagent bottle.

Equipment for making standard solutions: Analytical balance, Watch glass, Spatula, Beaker glass, Spray bottle, Stirring rod, Volumetric flask, Funnel.

According to Mauliza (2021), it is important to conduct chemistry experiments at the secondary school level. The preparedness of school chemistry laboratories should also meet the standard facilities and infrastructure of the school.

3.5 Differences in The Types of Acids in Sulfuric Acid and Ethanoic Acid

Based on the subtopic of the differences in the types of acids in sulfuric acid and ethanoic acid, students experience a scientific understanding of 75%.

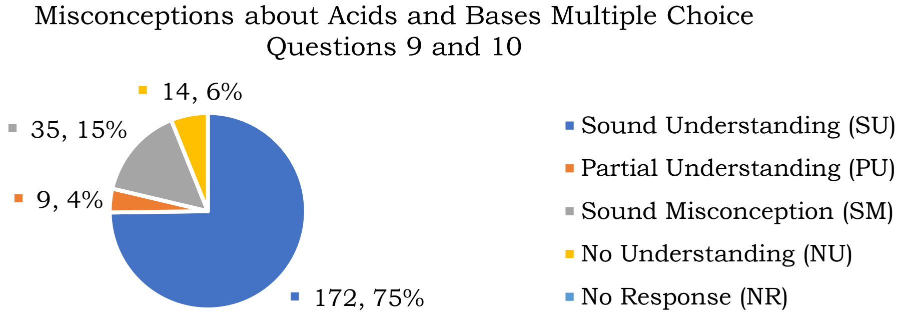


Figure 7. Students' Conception on the Concept of Different Types of Acids in Sulfuric Acid and Ethanoic Acid

Students stated that H_2SO_4 is classified as a strong acid because it can completely dissociate in water, producing H^+ and SO_4^{2-} ions. The scientific concept is diagnostically correct with a layered reasoning that sulfuric acid and ethanoic acid are both strong acids, which is an incorrect statement.

This is due to sulfuric acid completely ionizing in water to produce H^+ ions, whereas ethanoic acid does not completely ionize in water to produce H^+ ions. Students have a partial understanding (PU) of 4%, and a lack of understanding of the concept (NU) of 6%. This is reinforced based on interviews with students stating,

"I do not understand whether sulfuric acid and ethanoic acid are classified as strong acids or not."

Students experience a misconception (SM) of 15%. According to interviews from KC, this subtopic is considered difficult. In this study, many students provided alternative reasons stating that ethanoic acid in water ionizes completely to produce H^+ ions, whereas sulfuric acid in water does not ionize completely to produce H^+ ions.

3.6 Arrhenius' Concept of Acids

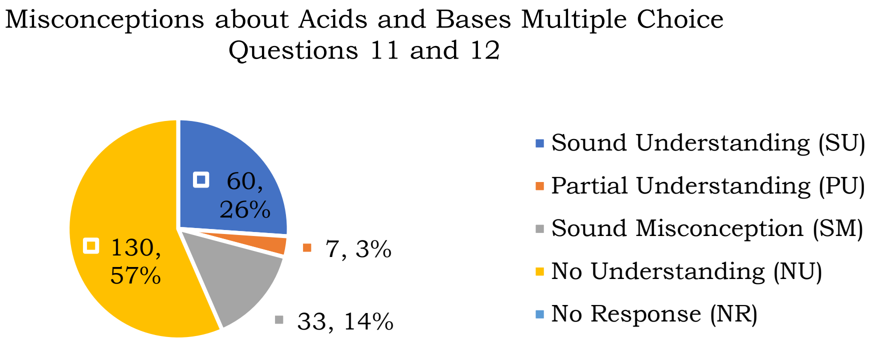


Figure 8. Students' Conception of the Acid Concept According to Arrhenius

Based on questions 11 and 12, which are true or false statements about acids according to Arrhenius, two compounds with the chemical formulas HCl and CH_4 both contain H atoms. However, only HCl is acidic while CH_4 is not. This statement is accurate because only HCl releases H^+ ions in water. Research findings show that partial understanding is at 3%, misconception (SM) at 14%, scientific understanding (SU) at 26%, and lack of understanding of the concept at 57%. Further analysis reveals that students lack theoretical comprehension of the acid-base concept according to Arrhenius, such as the ability of HCl to generate H^+ ions in water. Many students mistakenly identify hydrochloric acid and methane as acids due to their shared H atoms, leading to 57% of students being categorized as lacking comprehension of the concept.

3.7 pH Value of Acid

Questions number 13 and 14 are about the pH value of acids, namely lemon and orange. Many students already understand the concept that fruits like lemon and orange are acidic because they have a pH value lower than 7. Research results show that scientific understanding (SU) is at 72%, partial understanding (PU) at 8%, misconception (SM) at 15%, and lack of understanding (NU) at 5%.

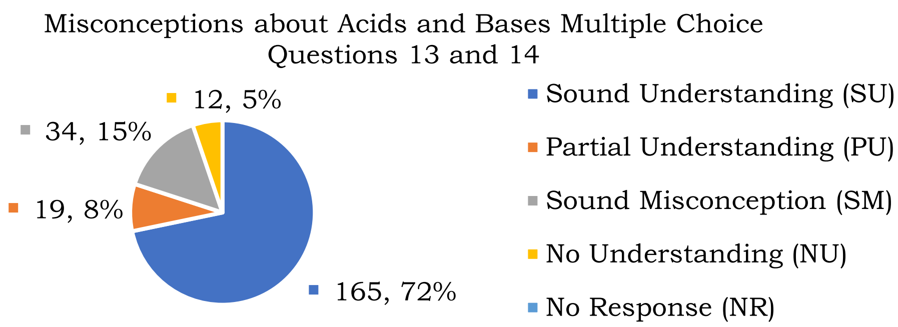


Figure 9. Students' Understanding of the Concept of pH Value in Acids

During interviews, students mentioned understanding the acidity concept of oranges due to being accustomed to eating sour-tasting oranges. However, upon further examination, the acidity of fruits like oranges is not the sole reason for their sour taste. According to a student named GL,

"Lemons are acidic because they naturally taste sour."

This misconception about acids and bases is often influenced by students' everyday experiences.

3.8 Alkaline Properties in Cleaning Agents

Based on the data provided in question items 15 and 16 regarding the alkaline properties of cleaning materials, some students have understood that soap is alkaline because it contains alkalis that can remove dirt from clothes. Research results show that 31% have a scientific understanding (SU), 25% have partial understanding (PU), 41% have misconceptions (SM), and 3% do not understand the concept (NU).

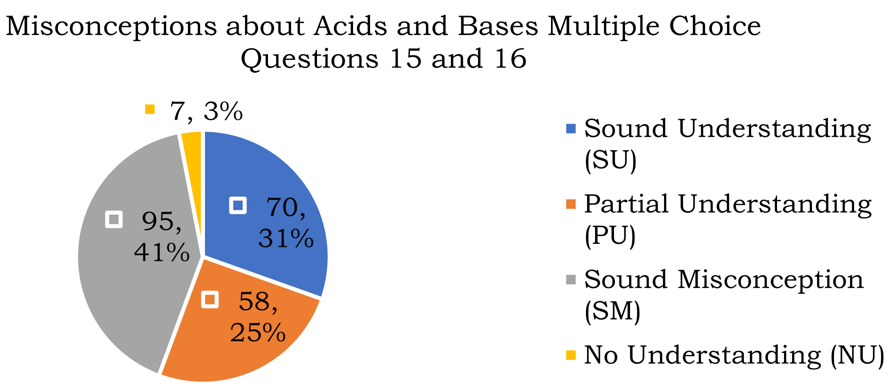


Figure 10. Students' Conception of the Concept of Alkali Properties in Cleaning Agents

This is supported by interviews with students with the initials GR who stated:

"Soap and detergent have alkaline properties that can clean dirt from anything."

and Kath who stated:

"Soap can clean dirt because it has nonpolar groups that will attract fats and polar groups that can dissolve in water. When used for washing, soap acts as an emulsifier (to help maintain the stability of oil and water emulsions) so that soap is said to be able to clean fats and dirt."

3.9 Benefits of Calcium Oxide in Soil Fertilization

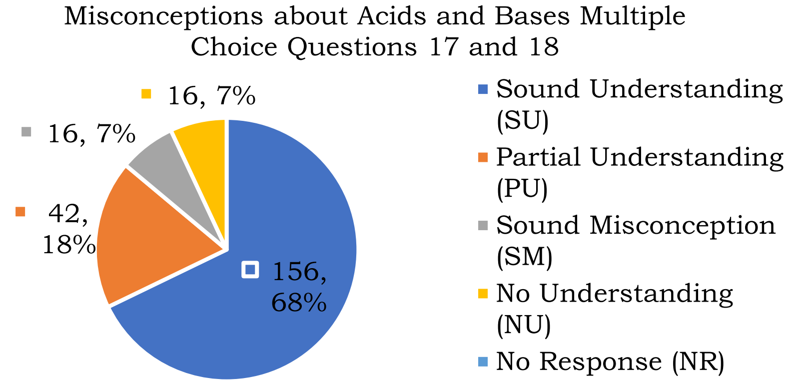


Figure 11. Students' Understanding of the Benefits of Calcium Oxide in Soil Fertilization

Based on the questions about calcium oxide in soil fertilization, as found in question numbers 17 and 18, the research results show: scientific understanding (SU) at 68%, partial understanding (PU) at 18%, misconception (SM) at 7%, and lack of understanding of the concept (NU) at 7%. This indicates that students generally understand the concept of soil fertilization with acidic properties using CaO. This is supported by interviews with a student with the initials Iv stating that:

"Some nutrients cannot be absorbed by plants due to chemical reactions in the soil that bind or trap ions from these nutrients. When the soil is acidic, the pH is considered low and must be increased to approach neutral conditions. This can be addressed by liming using agricultural lime, such as quicklime (CaO), calcite ($CaCO_3$), or dolomite ($CaMg(CO_3)_2$)."

3.10 Example and Characteristics of Weak Acid

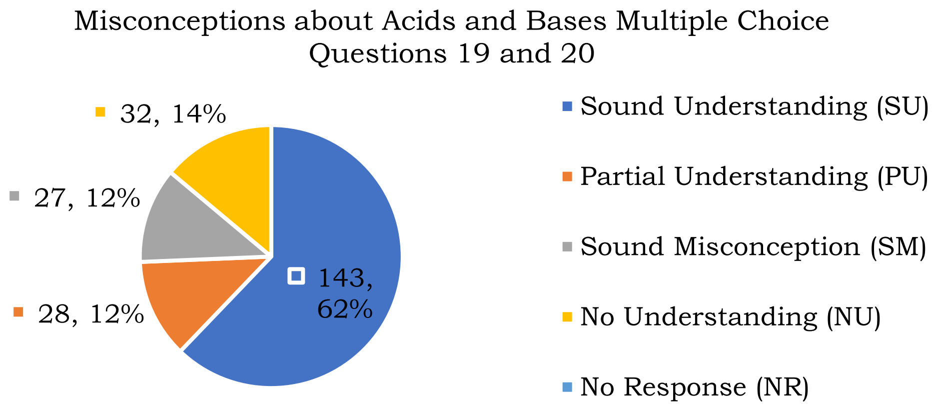


Figure 12. Students' Conception on the Concept of Examples and Characteristics of Weak Bases

Research results based on questions about examples and characteristics of weak bases obtained scientific concept data (SC) of 62%, partial understanding (PU) of 12%, misconceptions (MI) of 12%, and lack of concept understanding (NC) of 14%. Generally, students have understood the scientific concept of examples and characteristics of weak bases. This is supported by an interview with a student identified as Kath who stated that:

"Ammonia is classified as a weak base. Ammonia dissolves in water and exhibits weak base properties because it forms an equilibrium system with ammonium ions and hydroxide ions."

4. CONCLUSION

Based on the qualitative data distribution conducted and supported by interview results, misconceptions were found in students' understanding of acid-base with 44% categorized as having a good grasp of the acid-base concept. This is evidenced by students being able to accurately answer two-tier diagnostic tests in line with their knowledge of acid-base materials. Some students partially understood the concept (PU) at 19%. Students experienced misconceptions at a rate of 17%. Misconceptions occurred due to students themselves, teachers, textbooks used, context, and teaching methods. Students did not understand the acid-base concept (NU) at 20% because they answered questions incorrectly with incorrect reasoning. Based on student reflections, the acid-base concept is difficult to grasp because teachers provide insufficient explanations due to time constraints during distance learning. The teaching hours were reduced from 4 periods to 2 periods, while teachers had to meet the established curriculum targets. Researchers used two-tier diagnostic tests to analyze students' misconceptions regarding acid-base materials.

After conducting misconception analysis, it is advisable for teachers to have appropriate and effective teaching strategies to deepen the concept of acids and bases. There are various effective teaching methods to avoid misconceptions and enhance students' understanding, such as using the flipped classroom model so that students can learn in advance. This way, during classroom learning, they already have initial knowledge about acid-base materials. Furthermore, teachers can assign students to gather information from various sources according to their learning styles, for instance, by watching educational videos about acids and bases on platforms like YouTube. Additionally, students can utilize their diverse learning styles to better understand the concept of acids and bases. Students who are familiar with their learning styles can comprehend the material provided by teachers, making it easier for them to process and remember the material

Conflict of Interest

The authors declare no conflict of interest.

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