HYDROGEN
Jurnal Kependidikan Kimia
https://e-journal.undikma.ac.id/index.php/hydrogen/index

April 2023. 11(2)
e-ISSN: 2656-3061
p-ISSN: 2338-6487
pp. 202-208.

Analyzing Misconceptions of Acid-Base Topic among Chemistry Education Students in Online Learning Settings: A Case Study

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Article History
Received: 02-02-2023
Revised: 14-03-2023
Published: 29-04-2023

Keywords:
misconceptions, online learning, acid-base material

Abstract
This study aims to identify the misconceptions of 11 third semester Chemistry Education students at Cenderawasih University in relation to online learning during the Covid-19 pandemic. Online learning poses various challenges for both students and lecturers, resulting in incomplete explanations and hindering students' understanding of the material, leading to possible misconceptions. A descriptive qualitative method was employed, utilizing diagnostic tests with a Certainty or Response Index (CRI) and interviews. The findings revealed that 41% of the students had a clear understanding of the acid-base concepts, 30% lacked understanding, and 29% had misconceptions. The students' misconceptions related to six subconcepts in acid-base materials, including acid-base theory, acid-base indicators, acid strength (pH), weak acid-base equilibrium constant (Ka/Kb), calculation of solution pH, and the concept of pH in the environment, with a range of misconceptions from 9-45%. This study highlights the need for addressing misconceptions in online learning, specifically in the acid-base topic, to ensure effective understanding and learning outcomes for students.

How to Cite: Djarwo, C., & Kafiar, F. (2023). Analyzing Misconceptions of Acid-Base Topic among Chemistry Education Students in Online Learning Settings: A Case Study. *Hydrogen: Jurnal Kependidikan Kimia*, *11*(2), 202-208. doi:https://doi.org/10.33394/hjkk.v11i2.7147

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INTRODUCTION

The outbreak of the Covid-19 pandemic has had a significant impact on the education system of Indonesia and many other countries. In response, institutions of higher education have implemented online learning as an alternative to traditional face-to-face teaching. This approach has been encouraged by the government as a means of preventing physical contact between students and instructors (Firman & Sari, 2020). As part of this shift to online instruction, the Chemistry Education program at Cenderawasih University has adopted an online learning system for several courses during the 2021/2022 academic year. This system utilizes the Zoom Meeting application and Google Classroom to deliver course content and facilitate interactions between instructors and students, including discussions and question-and-answer sessions. Google Classroom is also used for the submission of coursework and the distribution of study materials.

The implementation of online learning in the chemistry education study program at Cenderawasih University has not been without its challenges. Both lecturers and students have encountered several obstacles, one of which is the limited strength of internet signals. The quality of internet connections varies in each location, resulting in unclear images and choppy sound during online lectures, as well as a lack of interaction between students. These limitations can cause incomplete explanations and misunderstandings of certain materials, hindering students' understanding of chemistry concepts. This is supported by a study conducted by Elvia, Rohiat, and Ginting (2021) which identified limited internet signal strength as one of the major obstacles faced by students in online learning, resulting in misconceptions. Misconceptions, defined as unacceptable statements that reflect inaccurate understanding or application of concepts, can hinder students' ability to solve advanced chemistry problems, especially those related to understanding and calculating chemistry (Sariati et al., 2020). To address these misconceptions, lecturers must be prepared to respond effectively to students' challenges in interpreting concepts, such as inaccurate understanding, the use of wrong concepts, and confusion or misinterpretation of concepts.

The acid-base concept is one of the areas in chemistry where students often experience misconceptions. Studies by Izza, Nurhamidah, & Elvinawati (2021) showed that students' overall percentage of misconceptions in acid-base materials was 25.38%. Among the sub-concepts, determining the degree of acidity had the highest misconception rate of 36.6%, while analyzing the Bronsted Lowry acid-base reaction equation had the lowest misconception rate of 13.3%. Similar findings were reported by Elvinawati, Rohiat, and Solikhin (2022), which classified the level of student misconceptions in acid-base materials under the low category, with the highest misconceptions found in the concept of salt hydrolysis. Therefore, it is important to analyze student misconceptions in acid-base subjects, especially during the COVID-19 pandemic where online learning has become the new norm. The objective of this study is to assess the level of understanding of chemistry education students and identify the concepts that cause misconceptions in acid-base materials, as supporting material for the Inorganic Chemistry 1 course. By doing so, this study aims to prevent or mitigate the impact of misconceptions and improve the quality of learning as well as the quality of chemistry education graduates.

METHOD

Misconceptions that occur in students are analyzed using data obtained by descriptive analysis based on diagnostic tests equipped with a Certainty or Response Index (CRI) and interviews. Hasan in Tayubi (2005) suggests that to measure the level of confidence of respondents in answering each question given, the CRI method can be used, while interviews are given in the form of questions to students about their feelings, their ability to solve problems, and obstacles they encounter during implementation. This interview is conducted after students complete diagnostic tests.

Test data is processed using the CRI method, where student tests will be analyzed based on a combination of true or false answers and CRI scores (low or high), which will be able to determine whether students understand concepts, do not understand concepts, or have misconceptions. The matrix in Table 1 below is used to identify misconceptions in each student.

Table 1. Terms of grouping understanding of concepts based on CRI

Answer	CRI	Conclusion
True	High (>2,5)	Understand the concept
False	Low (<2,5)	Don't understand the concept
False	High (>2,5)	Misconceptions

Furthermore, the interpretation results are converted into a percentage for each answer classification in the inorganic chemistry 1 acid-base material course. The percentage of students who experience misconceptions, understand concepts, and do not know the concepts for each question item is calculated using the following formula:

$$Persen\ (\%)PK = \frac{Students\ who\ understand\ the\ concep}{Total\ number\ of\ Students}\ x\ 100\ \%$$

$$Persen\ (\%)\ MK = \frac{Misconception\ of\ students}{Total\ number\ of\ students}\ x\ 100\ \%$$

$$Persen\ (\%)\ TPK = \frac{Students\ who\ do\ not\ understand\ the\ concept}{Total\ number\ of\ Students}\ x\ 100\ \%$$

Note:
PK = Students who understand the concept,
MK = Student misconceptions,
TPK= Students who don't understand the concept.

RESULTS AND DISCUSSION

Based on the results of research on online learning during the COVID-19 pandemic, it was found that there were students of the Chemistry Education Study Program who understood the concept, students who did not understand the concept and students who experienced misconceptions in acid-base material. The percentage of students who understand concepts, do not understand concepts and experience misconceptions is shown in figure 1.

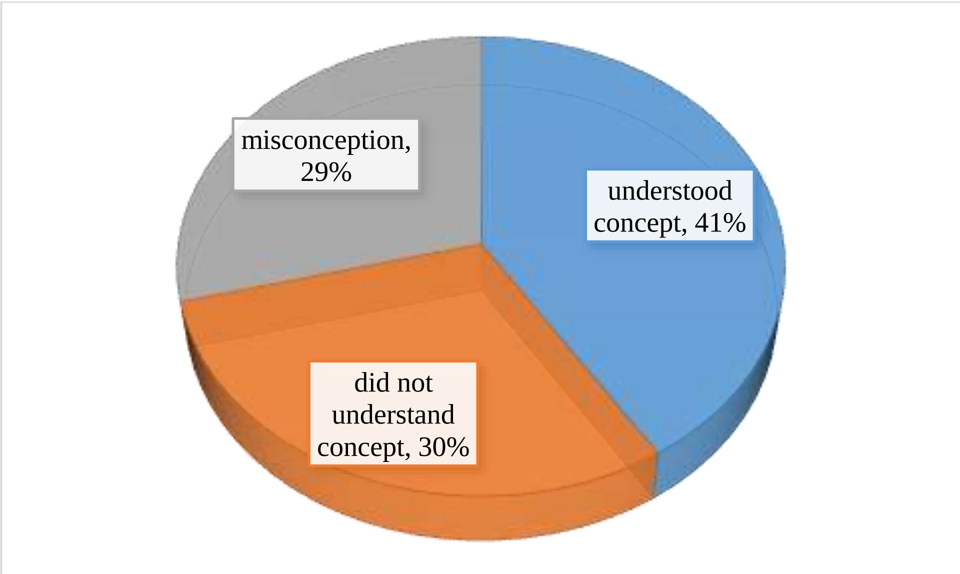

Figure 1. Percentage Diagram of Concept Comprehension Level

Analysis of diagnostic tests revealed that 41% of college students understood concepts, 30% did not understand concepts, and 29% experienced misconceptions related to acid-base materials.

Table 2. Percentage of Student Misconceptions Based on Sub-Concepts on Acid-Base Material

No	Sub Concept	Question Number	Level of Misconception (%)
1	Acid-base theory	1	9
		2	18
		3	18
		4	45
		5	36

		6	27
		7	27
		8	18
	Average Percentage		25
2	Acid-base indicators	9	18
		10	27
		11	27
	Average Percentage		24
3	Acid strength (pH)	12	27
		13	36
	Average Percentage		32
4	Weak-base acid equilibrium constant (Ka/Kb)	14	45
		15	36
		16	27
	Average Percentage		36
5	Calculation of the pH of the solution	17	36
		18	45
		19	36
		20	36
	Average Percentage		38
6	The concept of pH in the environment	21	18
		22	27
		23	18
	Average Percentage		21

The present study investigated the misconceptions experienced by students in the chemistry education study program in online learning during the COVID-19 pandemic, specifically in the sub-concepts of acid-base theory, acid-base indicators, acid strength (pH), weak-base acid equilibrium constant (Ka / Kb), calculation of solution pH, and the concept of pH in the environment. The study utilized diagnostic tests to collect data on students' understanding and misconceptions of the material. The diagnostic test score data showed that the percentage of students who understood concepts, had misconceptions, and did not understand concepts varied greatly, with an average of 41%, 29%, and 30%, respectively, on acid-base material. The data also showed that the percentage of misconception levels in acid-base material ranged from 9% to 45%, with different levels of misconception for each question item. The sub-concepts with the highest percentages of misconceptions were acid-base theory, weak acid-base equilibrium constant (Ka / Kb), and calculation of solution pH, while the sub-concept with the lowest percentage of misconceptions was acid-base theory according to Arrhenius.

Further analysis revealed that question number 4, which required students to demonstrate their understanding of acid-base reactions according to Lewis, had the highest presentation of misconceptions at 45%. The reason for the misconceptions was that students understood the meaning of the problem but were wrong in giving reasons for their answers. This finding is consistent with previous research indicating that students may experience misconceptions when they do not accompany their understanding with rational and intellectual reasoning.

Another question that had a high percentage of misconceptions was question number 14, which assessed students' ability to analyze the strength of acid in two different solutions. Misconceptions occurred because students were unable to relate the concept of acid ionization constant with the number of hydrogen ions possessed by the strength of the acid produced. Furthermore, students only knew the formula for finding the value of Ka without understanding the basic concepts and terms such as Kw, Ka, and Kb. The third question with a high percentage of misconceptions was question number 18, which required students to calculate the pH of a strong acid solution with a known valence and pH. The difficulty in determining acid-base solutions and not knowing the number of H+ ions for strong acids or OH- ions for strong bases released by strong acid or base compounds were factors in miscalculating the pH of strong acid-base solutions. The sub-concept with the largest percentage of misconceptions was the concept of pH in the environment, specifically in question number 27, where students could not relate the concept of pH to the environment. This difficulty stemmed from the requirement for students to apply their understanding of the concept of pH to the environment, which necessitated a solid understanding of the concept of pH.

In conclusion, the present study sheds light on the misconceptions experienced by students in the chemistry education study program during online learning of acid-base materials. The findings highlight the need for effective teaching methods and strategies that address the root causes of students' misconceptions, especially in complex sub-concepts such as acid-base theory and weak acid-base equilibrium constant (Ka / Kb). Moreover, instructors should guide students to develop their analytical and reasoning skills to overcome the tendency to rely on memorization.

The analysis shows that for some college students, online learning has a significant impact on their ability to grasp concepts. This is due to the lack of optimal online learning processes, such as the use of Zoom meetings, poor interaction between students and lecturers due to unstable internet networks, and when students are not actively asking questions in discussions, so misconceptions are very likely to occur. In addition, because lecturers cannot monitor student work directly related to practice questions, lecturers cannot determine which subconcepts students still do not understand or which misconceptions students have. Some students have difficulty using the Google Classroom app used to upload materials and submit assignments. Therefore, increasing students' understanding of concepts related to material that has been confusing is part of the lecturer's responsibility to correct misconceptions about a number of concepts. In addition, to reduce student misconceptions and increase understanding of concepts, the online learning process must use a more diverse learning model.

The factors causing misconceptions were also concluded by Putri, Wigati, and Pandu J Laksono (2022) who stated that there are internal and external factors that can affect students' misconceptions on acid and base materials. The teaching methods used, the classroom environment that is less conducive to learning, and the learning resources used are examples of external factors. Meanwhile, internal factors can include students' lack of interest in chemistry lessons, lack of focus in following learning, wrong learning methods, and fear of asking questions. Based on the results of Elvia, Rohiat, and Ginting's research (2021) concluded that students who took the Chemistry Mathematics course in the 2020/2021 academic year had an overall misconception rate of 10-50% as a result of online learning in the course.

CONCLUSION

In conclusion, the present study reveals that a considerable proportion of students experience misconceptions in acid-base chemistry during online learning amid the COVID-19 pandemic. Specifically, the findings indicate that 29% of students have misconceptions, 30% do not understand concepts, and only 41% demonstrate a clear understanding of the material. These misconceptions are observed across six sub-concepts of acid-base chemistry, including acid-base theory, acid-base indicators, acid strength (pH), weak-base acid equilibrium constant (Ka / Kb), calculation of solution pH, and the concept of pH in the environment. The prevalence of misconceptions in acid-base material ranges from 9% to 45%, varying across different question items. The highest percentage of misconceptions is observed in acid-base theory, weak acid-base equilibrium constant (Ka / Kb), and calculation of solution pH. This study highlights the need for further research using different data collection materials and techniques to examine the level of student mastery of concepts in other chemical topics.

RECOMMENDATIONS

Additionally, it is recommended that lecturers use various teaching strategies to increase student understanding and mastery of the acid-base material. For example, lecturers can use case studies or real-life examples to help students relate the material to their daily lives. Furthermore, lecturers can provide opportunities for students to practice problem-solving skills related to acid-base concepts.

It is also suggested that chemistry education study program students should be encouraged to participate in discussions related to acid-base material, both in online forums and in face-to-face discussions. This will provide opportunities for students to exchange ideas and clarify any misconceptions they may have.

Finally, future research can be conducted using different data collection methods and techniques to provide a more comprehensive understanding of student misconceptions in other chemical materials. This can help inform the development of more effective teaching strategies and materials to enhance student learning outcomes.

ACKNOWLEDGMENTS

We would like to express our gratitude to the Institute for Research and Community Service of Cenderawasih University for providing funding for this study.

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