

Analisis Permasalahan Mahasiswa pada Materi Asam dan Basa untuk Meningkatkan Keterampilan Penyelesaian Masalah

Analysis of Student Problems on Acids and Bases Subject to Improve Problem-Solving Skills

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ABSTRACT

Acids and bases are one of the materials that students find difficult in learning chemistry. The objective of this study is to examine the difficulties encountered by students when learning about acids and bases, as well as their challenges in developing problem-solving abilities. Additionally, the study attempts to assess the importance of including ethical considerations in the problem-solving process. This is a qualitative study with a case study design. The study included a total of nine students and three lecturers from the chemistry education department of UIN Mahmud Yunus Batusangkar. Structured interviews were conducted to collect data, which was then analyzed using thematic analysis. The result revealed themes related to students' difficulties in studying acids and bases subject, namely understanding the initial concept, understanding the concept abstractly and complicatedly, memorizing formulas and theories, memorizing concepts and symbols, requiring deep understanding and thinking, and difficulty in calculating. Themes related to acid-base objectives that are difficult for students to master are the theory and concepts of acids and bases, naming acids and bases, water ionization, classifying acids and bases and calculating pH. Furthermore, the research results revealed that students were not adequately trained in the cultivation of problem-solving skills due to the teacher's failure to offer problem sets that effectively improved their problem-solving capabilities and were relevant to real-life situations. The importance of integrating ethics into the problem-solving process is underscored by several themes, including knowing Allah, increasing faith and piety in Allah, increasing students' insight and curiosity, enjoying learning chemistry, and ensuring that chemistry is not misused. For this reason, it is necessary to develop strategies, strengthen training and integrate ethics to improve problem-solving skills.

KEYWORDS

Student problems, Acids Bases, Problem-Solving Skills, Ethics

ABSTRAK

Salah satu materi yang dianggap sulit oleh mahasiswa dalam pembelajaran kimia adalah asam dan basa. Penelitian ini bertujuan untuk menganalisis permasalahan mahasiswa dalam mempelajari materi asam dan basa, menganalisis permasalahan mahasiswa dalam menguasai keterampilan penyelesaian masalah, dan menganalisis perlunya pengintegrasikan elemen etika dalam proses penyelesaian masalah. Penelitian ini merupakan penelitian kualitatif dengan desain studi kasus. Partisipan dalam penelitian ini adalah 9 orang mahasiswa dan 3 orang dosen pada jurusan pendidikan kimia UIN Mahmud Yunus Batusangkar. Wawancara terstruktur dilakukan untuk mengumpulkan data, dan dianalisis menggunakan analisis tematik. Hasil penelitian mengungkapkan tema-tema yang berkaitan dengan kesulitan mahasiswa dalam mempelajari materi asam dan basa, yaitu memahami konsep awal, memahami konsep abstrak dan rumit, mengingat rumus dan teori, mengingat konsep dan simbol, memerlukan pemahaman dan pemikiran yang mendalam, serta kesulitan dalam melakukan perhitungan. Tema-tema terkait submateri asam dan basa yang sulit dikuasai mahasiswa adalah teori dan konsep asam basa, penamaan asam dan basa, ionisasi air, mengelompokkan asam dan basa serta menghitung pH. Lebih lanjut, Hasil penelitian menemukan bahwa mahasiswa belum dilatih untuk mengembangkan keterampilan penyelesaian masalah karena permasalahan yang diberikan oleh guru tidak melatih kemampuan pemecahan masalah mahasiswa dan tidak berkaitan dengan kehidupan sehari-hari. Pengintegrasikan elemen etika yaitu mengenal Allah, meningkatkan keimanan dan ketakwaan kepada Allah, meningkatkan wawasan dan rasa ingin tahu siswa, menyenangkan pembelajaran kimia, dan memastikan ilmu kimia tidak disalahgunakan sangat diperlukan dalam meningkatkan kemampuan penyelesaian masalah mahasiswa. Untuk itu diperlukan pengembangan strategi, penguatan latihan dan pengintegrasian etika untuk meningkatkan ketrampilan pemecahan masalah.

KATA KUNCI

Permasalahan mahasiswa, Asam Basa, Keterampilan Penyelesaian Masalah, Etika



1. INTRODUCTION

The development of science and technology has brought convenience and progress to life. Since the beginning of the twenty-first century, commonly known as the "century of openness" or "globalization," there have been significant changes in humankind^[1]. Additionally, there are adverse consequences associated with this, including environmental damage and pollution, climate change^[2], and the utilization of hazardous substances in food in people's daily lives^[3].

The existence of these challenges is inherently intertwined with the ethical considerations, values, and morals of an individual or collective. Ethics plays a crucial role in establishing a moral framework and providing guidance for interpersonal and societal interactions.^[4] Education plays a significant role in shaping a person's ethics, personality, or morals^[5]. Therefore, it is important to integrate ethics into all aspects of the learning process, including chemistry lessons^[6]. The ethics referred to in this study are theological ethics, specifically derived from Allah through the holy book of Islam, the Qur'an^[7].

Chemistry is regarded as a difficult and uninteresting subject^[8,9]. Acids and bases are commonly regarded as challenging^[10, 11] due to their abstract concepts^[12], intricate concepts^[13], intricate mathematical solutions^[14], and the need for high-level thinking skills^[15] and deep understanding^[16]. Additionally, it was discovered that there were misconceptions on this subject^[17,18]. Meanwhile, acids and bases are fundamental topics that serve as prerequisites for comprehending more advanced subjects, including hydrolysis, buffer solutions, and acid-base titration^[19,20].

The learning process of acids and bases lacks interactivity, as students show reluctance to engage in asking questions, providing answers, or expressing their opinions^[21]. Consequently, the learning of chemistry becomes monotonous and uninteresting^[22]. Traditional learning methods, which focus on transferring knowledge from teacher to student and prioritize memorization of facts and concepts, do not allow students to actively explore and construct their own knowledge. This can lead to students feeling compelled to learn without fostering a desire for critical thinking^[23]^[24]^[25]. As a result, the learning process does not sharpen students' thinking skills. Research indicated that pupils' cognitive abilities, including problem-solving skills, were assessed to be at a low level^[26-28]. Meanwhile, problem-solving skills are 21st century skills that students need to master through active involvement in learning sessions^[29].

Students encounter challenges in problem-solving due to a lack of comprehension of the presented problems and a failure to employ logical and rational thinking in their approach to problem-solving^[30]. Active learning approaches, such as problem-based learning (PBL), have been shown to effectively overcome the shortcoming of problem solving. Previous studies assert that problem-based learning

(PBL) is highly beneficial in enhancing problem-solving abilities^[31]^[32-36]. PBL originated in the West, first introduced in medicine at McMaster University in Hamilton, Ontario, Canada, in the late 1960s by Barrows and colleagues^[37]. Based on the philosophy of epistemology, the fundamental pillars of scientific knowledge in the Western tradition are rationalism, which prioritizes the use of reason, and empiricism, which is based on human sensory experience^[38]. In contrast to Islam, the main source of knowledge in science is taken from the Quran, along with reason and sensory experience^[39]. For Muslims, disregarding the importance of valuing the Quran while gaining knowledge may adversely affect Muslims and lead to a shift towards secular thinking^[38].

The process of knowledge acquiring in Indonesia system aims to develop persons who are comprehensive and harmonized in terms of their physical, emotional, spiritual, and intellectual dimensions, as stated in the goals of Indonesian National Education^[41,42]. Therefore, it is necessary to integrate ethics in chemistry learning to improve problem-solving skill.

This study aims to (1) analyze student problems in learning the subject of acids and bases; (2) analyze student problems in mastering problem-solving skills in acids and bases subject; (3) analyze the need to include an ethical element in problem-solving process in acids and bases subject.

2. METHOD

This study is qualitative research based on the case study design. According to Merriam^[43] an appropriate method for offering a "holistic description and analysis of a single instance, phenomenon, or social unit" is qualitative research based on the case study design. Participants in this research were 9 students and 3 lecturers at the chemistry education department, faculty of education, and teacher training at UIN Mahmud Yunus Batusangkar. These students are students who take basic chemistry courses in the first semester of the academic year 2023-2024 and attend every meeting in class completely, and chemistry lecturers who have more than 5 years of experience teaching basic chemistry. To collect research data, structured interviews were conducted. There are 19 interview question, which are divided into 3 constructs: acid and base subjects, problem-solving skills, and ethical integration. In order to obtain the validity of the structured interview question instrument, the views of two experts, consisting of a chemical education expert and an Islamic education expert, were involved. A pilot study of structured interview questions was also conducted before the actual interview to identify weaknesses that needed to be overcome in the structured interview questions.

Data from the interviews was recorded. The responses from interview sessions were transcribed for analysis by using thematic analysis^[44]. There are six steps to conducting this analysis as shown in Figure 1

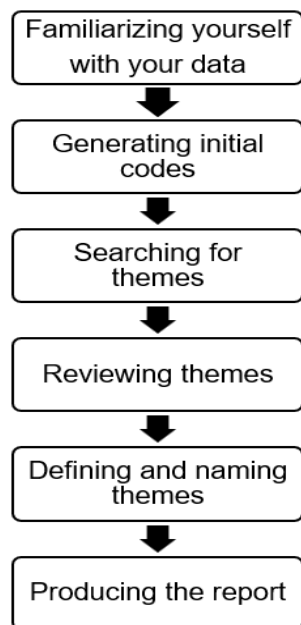


Figure 1. Phases of thematic analysis

The first step is to familiarize yourself with the data. Preparing the audio recording transcription process, then reading the data repeatedly to get the main idea. The second step is to identify the initial codes based on the transcribed data. Then, in the third step, the codes that have been identified are included in the initial themes. The fourth step is carried out by reviewing the themes that have been identified in the previous step and combining similar themes into a new theme. For the fifth step, define and refine the themes obtained by re-reading all the data to see the relationship or connection between one theme and another theme. In the last step, which is the sixth, the data is presented through narrative or graphic methods.

The concept of credibility in describing the validity and reliability of qualitative research was used for the analysis of this interview. Therefore, the transcript of the interview was shown to students and lecturers as soon as the transcription process was carried

out. This method is identified as sample verification, or 'member checking', which wants to ensure that the interview transcript data is accurate. This is in line with Creswell^[45] who stated that this method can increase the credibility of the study.

This research is confirmed to have complied with the ethical consideration. The things emphasized in this research are informed consent, confidentiality and anonymity and voluntary participation XX. All participants are given complete information regarding the objectives of the research, procedures to be carried out, potential risks, and their rights as participant. Guarantee that the identity of participants will be kept confidential and that the data obtained will be processed anonymously. Personal information will not be shared or published without the participant's permission. Participation in this study is completely voluntary. Participants should be given the freedom to withdraw from the study at any time without negative consequences.

3. RESULT AND DISCUSSION

3.1 Student problem in learning the subject of acids and bases

The results of interviews with students and lecturers revealed difficulties in learning acids and bases. Students and lecturers were interviewed to gather their perspectives on the difficulty of the acids and bases subject and the underlying reasons for their opinions. Furthermore, students and lecturers were also queried regarding the objectives pertaining to the topic of acids and bases that posed challenges in terms of mastery. Figure 2 displays the outcomes of a theme analysis that highlights the challenges faced by students when learning about acids and bases, while Figure 3 shows the results of the thematic analysis regarding students' difficulties in studying the topic according to the lecturers' opinions.

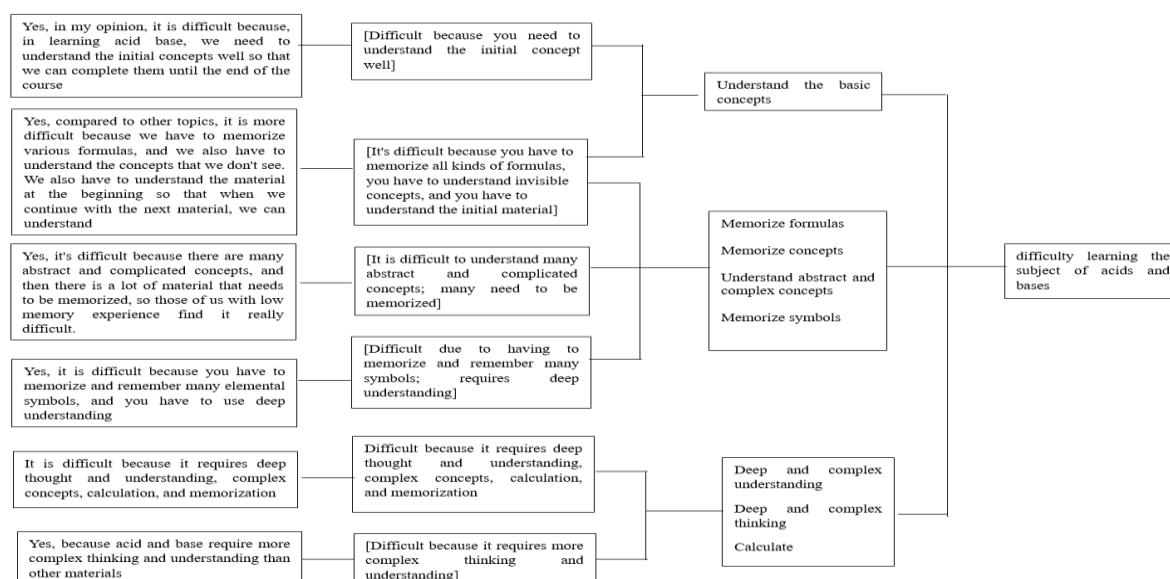


Figure 2. Results of a thematic analysis of difficulties in learning acid and base subject according to students

The thematic analysis, as depicted in Figure 2, has revealed the underlying causes contributing to the challenges encountered in learning the subject of acids and bases. These causes, as identified by both lecturers and students, include: (1) inadequate comprehension of the initial concept due to insufficient existing knowledge; (2) difficulty grasping the abstract and complex nature of the concept; (3) reliance on rote memorization of formulas and theories; (4) memorization of concepts and symbols; (5) the need for profound understanding

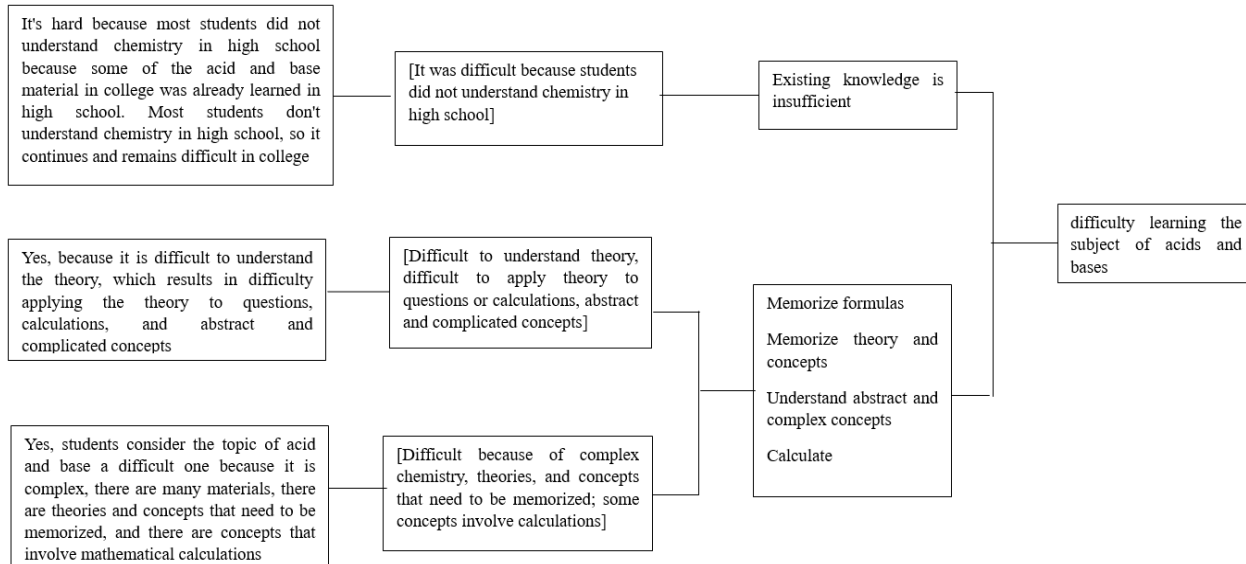


Figure 3. Results of a thematic analysis of difficulties in learning acid and base subject according to lecturer

The topic analysis identified the subjects on acids and bases that students find problematic, which include: (a) understanding the theory and concepts; (b) naming acids and bases; (c) understanding the ionization of water; (d) Calculating pH; and (e) categorizing acids and bases. The findings of the thematic analysis on challenging learning objectives

and critical thinking; and (6) struggles with calculations. Consistent with Timelsena's research, it was found that students lacked prior knowledge, struggled to understand chemical concepts and their abstract nature, and faced challenges in developing a deep conceptual understanding^[46]In addition, research findings suggest a limited comprehension of fundamental ideas ^[47], and students' lack of mathematics skills contributes to their struggles in studying chemistry ^[48].

in the topic of acids and bases, as reported by both students and the lecturer, are presented in Figures 4 and 5.

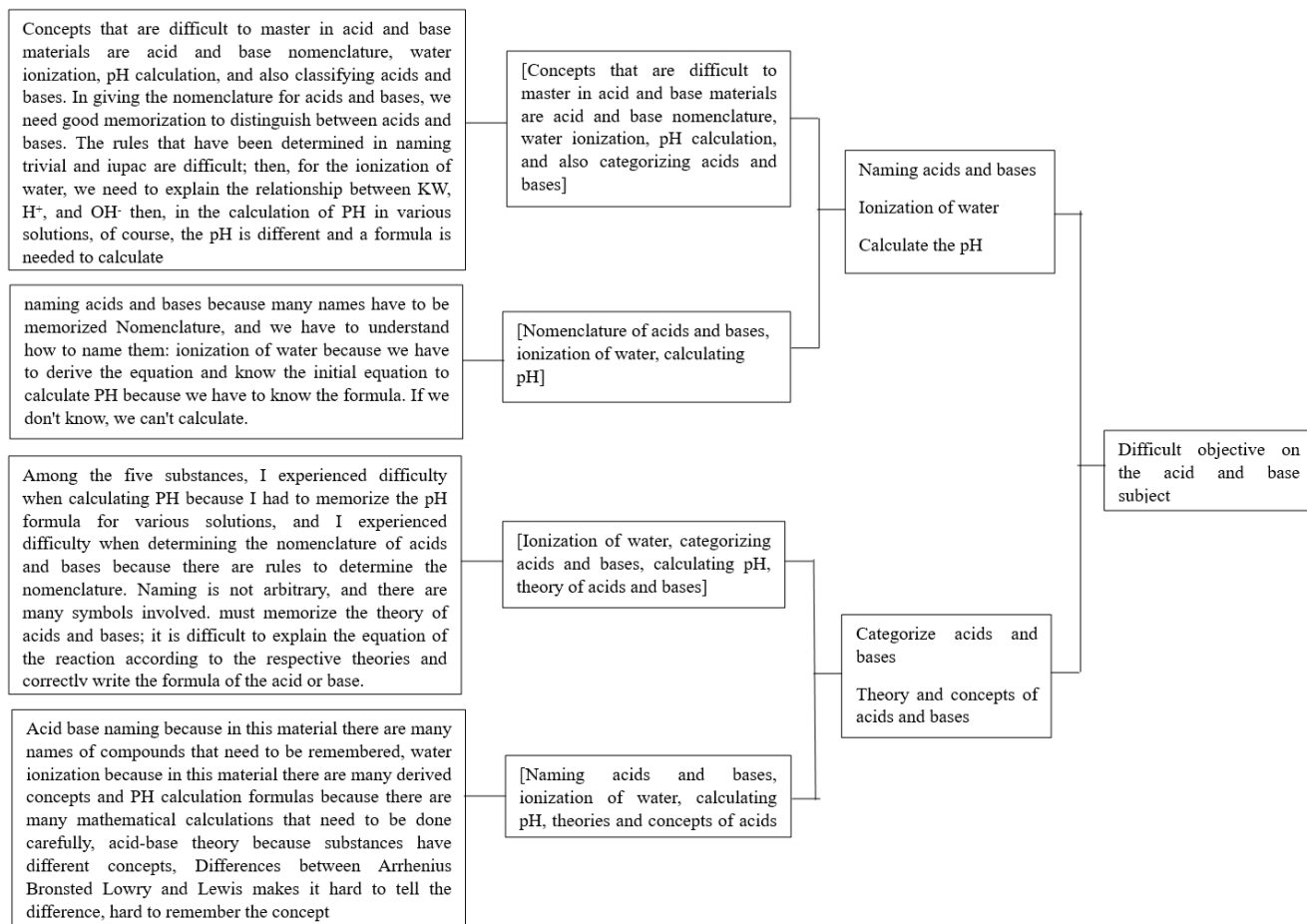


Figure 4. Results of a thematic analysis of difficult objectives in the subject of acids and bases according to students

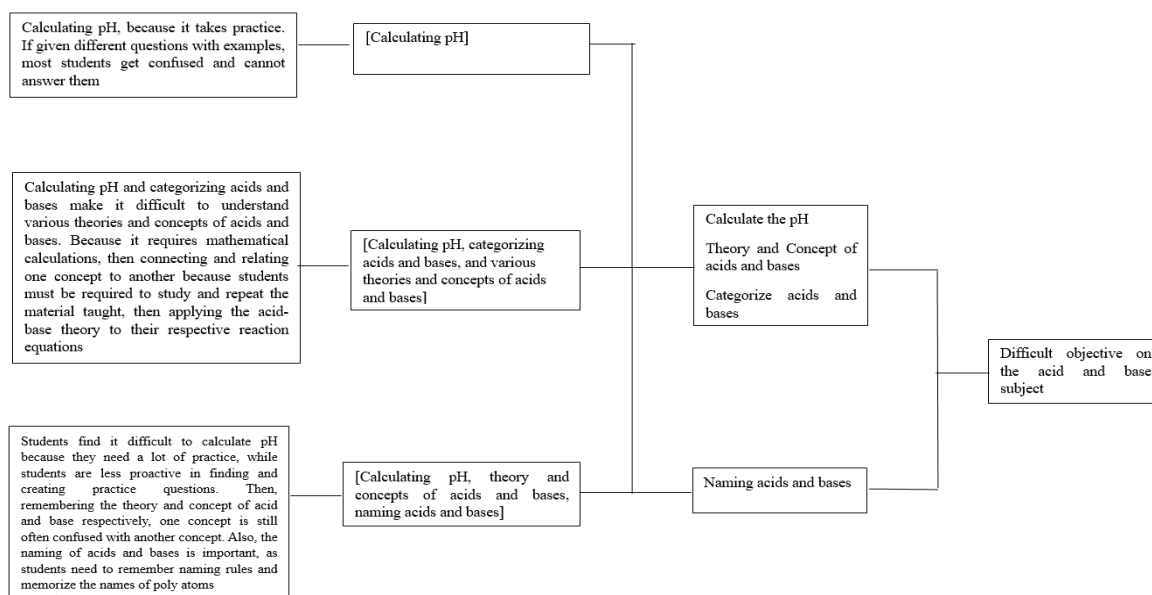


Figure 5. Results of a thematic analysis of difficult objectives in the subject of acids and bases according to lecturer

Based on figure 3 and 4, The objective were difficult to master on the subject of acids and bases are naming acid and base, ionization of water, calculate the pH, theory and concepts of acids and bases, and categorize acids and bases. The following will describe the difficult acid and base objectives according to students and lecturers and the type of difficulty based on the results of the thematic analysis.

(a) Naming acids and bases

The difficulty experienced by students with the objective of naming acids and bases is related to theme 4

which is memorizing concepts and symbols. In the naming of acids and bases, there are rules that must be followed, and students must understand the rules, such as how to name acids and how to name bases, and then they need to memorize the symbols for the names of atoms and polyatomic ions so that they are correct in naming acids and bases. This is compatible with Timilsena^[46] that memorize symbol were the difficult areas of chemistry. This is in line with the informant's statement, as follows: "I need a good memorization to distinguish the names between acids and bases and follow the rules that have

been determined in naming them, there are trivial names, there are names according to iupac, it's difficult" (KG1)
"Many names have to be memorized and we have to understand how to name them" (KG2).
"Can't be random, I have to follow the rules" (KG3).
"Many compound names to remember" (KG7).
"I've already memorized the name of the element, the name has to be different in the compound" (KG9).

(b) Ionization of water

Through the interviews conducted, it was found that there are three difficulties faced by students in understanding the concept of water ionization: difficulty in understanding abstract and complicated concepts (theme 2), difficulty in memorizing chemical formulas and in understanding the concept of ionization (theme 3) and requires a deep understanding (theme 5). This is because students need to understand the water ionization process, where water will ionize to produce H_3O^+ ions and OH^- ions. This concept is abstract for students because what happens in this reaction cannot be seen directly. Next, from the equation of the water ionization process, a formula related to the water balance constant (K_w) is derived. Students need to understand the formula obtained, and this concept becomes the basis for students' understanding of the acid, base, or neutral nature of a solution depending on the high or low concentration of H_3O^+ ions. This statement is supported by several examples of interview excerpts:

"For the ionization of water, it is necessary to explain the relationship between K_w , H^+ , and OH^- " (KG 1).

"Water ionization because we have to derive the equation" (KG 4).

"Water ionization because in this material there are many derived concept" (KG 9).

Through the three examples of the passage, it was found that students had difficulties understanding the objective of the water ionization process.

(c) Calculate the pH

As for the objective of calculating pH, there are three main difficulties experienced by students: understanding the initial concept, memorizing the formula, and determining the value of $[H_3O^+]$ and $[OH^-]$. Determining the pH of various solutions starts with students' understanding of determining $[H_3O^+]$ and $[OH^-]$, then memorizing various formulas and understanding which formula to use. In addition, this section also involves mathematical calculations that require precision related to exponential operations and logarithmic operations. Some interview excerpts are as follows:

"Calculating pH in various solutions is, of course, different and needs a formula to be calculated." (KG 2)

"To calculate PH because we have to know the formula. If we don't know, we can't calculate." (KG 4)

"I had difficulty calculating pH because I had to memorize pH formulas for various solutions." (KG 5)

"Calculation of PH because many mathematical calculations need to be done carefully." (KG 6)

"Calculating pH is important because it takes a lot of practice." (KG 8)

This student's opinion is also in line with the opinion of the lecturer, who stated that students have difficulty determining pH because it requires mathematical calculations and requires a lot of practice.

Sahlan^[41] confirmed that student errors in these questions lie in the student's inability to determine $[H^+]$ and $[OH^-]$, students' errors in deriving the formula to find $[H^+]$, $[OH^-]$, incorrect application of the formula, lack of ability in mastering mathematical operations (incorrectly calculating operations exponentiation, rooting, and logarithm operations) and students are unable to plan the way to solve the problem.

(d) Theory and concepts of acids and bases

Through the interviews conducted, it was found that among the difficulties experienced by students in understanding the learning object theory and concept of acid and base is that they find it difficult to understand the initial concept and theory of acid and base, which includes the definition of acid and base according to Arrhenius, Bronsted Lowry, and Lewis. The student's inability to distinguish between these three theories causes the student's initial conceptual understanding to be weak. This then causes students to make mistakes in applying acid and base theory to the reaction equation. They also have difficulty understanding abstract and complicated concepts and have difficulty memorizing concepts and symbols. This is proven when students state, "You must memorize the theory of acids and bases, it is difficult to explain reaction equations according to their respective theories" (KG 3) and "the difference between Arrhenius, Bronsted Lowry, and Lewis makes it difficult to distinguish them; it is difficult to remember concepts" (KG 7). The students' difficulty in understanding the acid and base theory is supported by the lecturer's statement that "students are often unable to apply the acid-base theory to their respective reaction equations" (LC2) and "a concept is still often confused with another concept" (LC 3). Those are compatible with Annisa's ^[42] research, which reveals students are still experiencing inverse concepts between Arrhenius acid-base theory, Bronsted-Lowry acid-base theory, and Lewis acid base theory

(e) Categorize acids and bases.

This section discusses the categorization of acids into weak acids and strong acids, and strong bases and weak bases. Students find it difficult to remember the definitions and concepts of weak acid and strong acid, and strong base and weak base. This learning objective is also difficult for students to master. It requires deep understanding and thinking, such as deducing the relationship between pH and the strength of acids and bases. This is stated by the students as in the example of the following quote:

"connecting pH with the strengths and weaknesses of acids and bases is still wrong" (KG 1) "you need to remember the requirements for the strength and weakness of acids and bases" (KG 5)

This is also stated by the lecturer that if the student is wrong in calculating the pH, then stating that an acid or base is strong or weak will certainly be wrong as well. Further, finding of Hali^[51] studies showed that most student fail to recognize and consider all factors that affect acid strength, because student did not conceptualize acid strength as an emergent property that results from interactions among multiple factors.

3.2 Student problems in mastering problem-solving skills

Interview data revealed that none of the students had ever solved a problem involving the use of acid and base in daily life. This student's statement was also confirmed by the confirmed. The lecturers provided essay questions that had no relevance to everyday life. Based on those facts, it seems that students have not been trained to solve problems. Consequently, they lack the ability to discern the accurate methodology and approach for problem-solving.

Improving problem-solving skills are one of the essential promises of PBL [52]. The findings of this study suggest that the implementation of the PBL approach may have been ineffective, highlighting the necessity of integrating this method to enhance students' problem-solving abilities. To solve a problem, students are expected to know and use the scientific research

process. Because the essential point in PBL is not to solve the problem by any means, but to solve it through a methodical scientific research process and teach students who have this consciousness and implement this approach in their life [54]. [53]

3.3. The need to include an ethical element in the problem-solving process

The results of the interview revealed that lecturers have not linked the subject of acids and bases taught with divine values, Islamic values, or the Qur'an, while most students and lecturers stated that it is very important to integrate the subject in the subject of chemistry with divine values, Islamic values, or the Qur'an. The results of the thematic analysis regarding the importance of including ethical elements in chemistry learning are shown in figures 6 and 7.

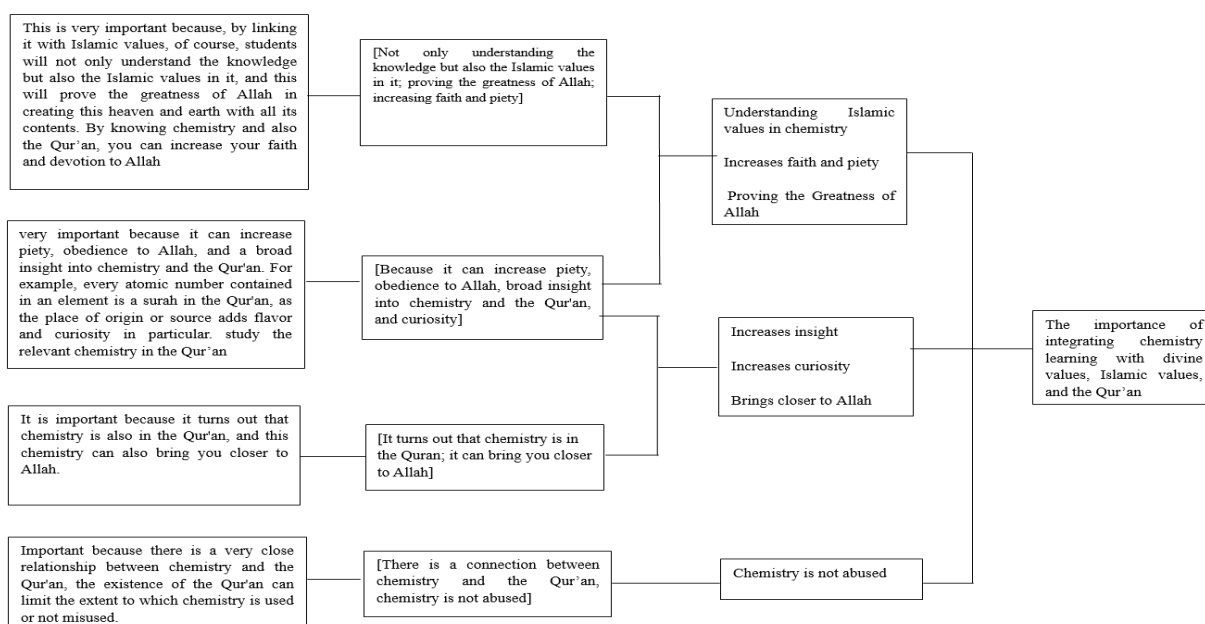


Figure 6. Results of a thematic analysis of the importance of integrating chemistry learning with divine values, Islamic values, and the Qur'an according to student

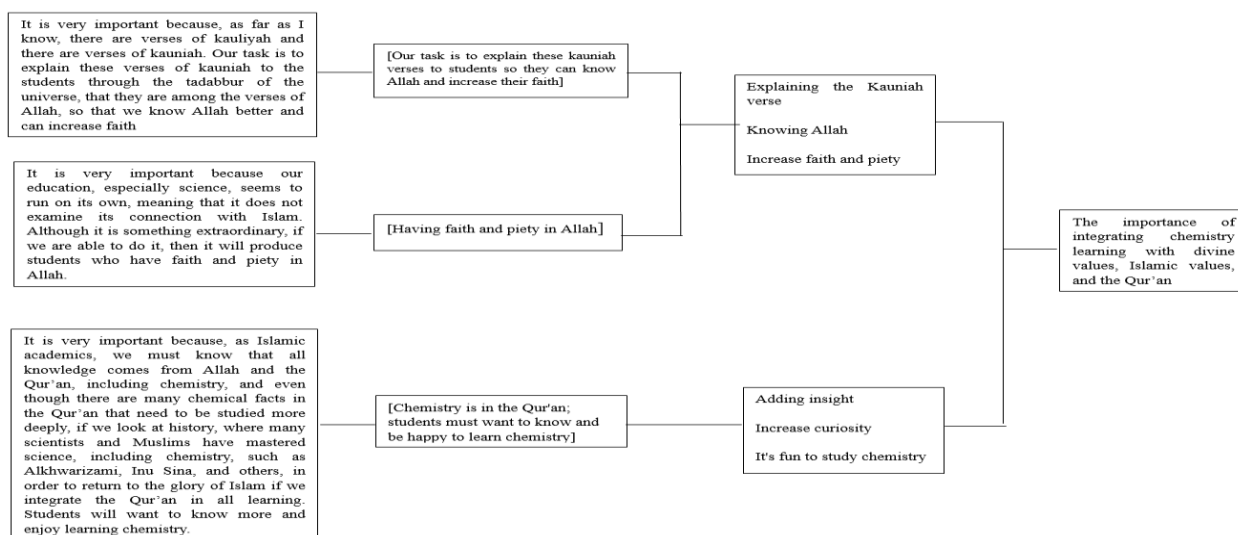


Figure 7. Results of a thematic analysis of the importance of integrating chemistry learning with divine values, Islamic values, and the Qur'an according to lecturer

Based on Figure 5 and 6, there are several themes obtained based on this matter, namely: (1) knowing Allah; (2) increasing faith and piety in Allah; (3) increasing students' insight and curiosity; (4) enjoying learning chemistry; and (5) ensuring that chemistry is not misused. The importance of the integration of chemistry with divine values, Islamic values, and the Qur'an is also supported by the fact that all students and lecturers have never found a basic chemistry textbook that links chemistry with divine values, Islamic values, and Al-Quran. This is consistent with the following lecturer statement: "it is very necessary because, actually we learn something that knowledge should bring us closer to Allah" (LC 1) and "It is very necessary because the purpose of learning is not only to improve the aspect of knowledge but also the spiritual attitude" (LC 3). Students also think it is important to integrate ethics, as in the following statement: "By knowing chemistry and also the Qur'an, you can increase your faith and devotion to Allah" (KG 2) dan "the existence of the Qur'an can limit the extent to which chemistry is used or not misused" (KG8). Harahap asserted that Learning process is essentially a process of observing, discovering, understanding, and appreciate the sunnatullah, which is a natural phenomenon and social, then apply that understanding to the benefits of human life and the environment, and make the awareness of the existence of Allah with His Almighty attributes Perfect as the true purpose of learning activities. This will guide the learning participants to awareness. Supernatural reality beyond the external reality that he can sense.

From the results of the interview, it was also found that all students and lecturers agreed that the module can support learning, but in fact, the lecturer has not used the module as a teaching aid. All lecturers stated that they really need a module that applies the concept of solving acid and base problems in daily life like the following statement:

"very necessary because there will be guidelines that help students learn how to solve problems and problem solving skills need to be developed in students

so that they get used to and have problem solving skills in preparation for entering the world of work later " (LC 1)

"It is necessary because it will be very easy to apply in class if there is a complete, systematic, and organized guide. If there is a problem in the form of a daily problem that must be solved, students will also learn the concept of problem solving, and of course it will be useful to form skills they need" (LC 2). "I need it because I feel helped by having such a module because of my various limitations in preparing materials" (LC3)

Based on Vygotsky's theory, learning must be relevant to the student's social and cultural context. By linking chemistry learning with ethical and religious values known to students, such as knowing Allah and increasing piety, learning becomes more meaningful and enjoyable. That it can increase students' interest in studying chemistry

4. CONCLUSION

The results showed that students experienced problems studying the subject of acids and bases, namely understanding the initial concept, understanding the concept abstractly and complicatedly, memorizing formulas and theories, memorizing concepts and symbols, requiring deep understanding and thinking, and difficulty in calculating. Acid and base objectives that are difficult for students to master are the theory and concepts of acids and bases, naming acids and bases, water ionization, classifying acids and bases, and calculating pH. Themes about the importance of integrating ethics in chemistry learning, namely knowing Allah, increasing faith and piety in Allah, increasing students' insight and curiosity, enjoying learning chemistry, and ensuring that chemistry is not misused. Students have not been trained to develop problem-solving skills. Therefore, it can be concluded that students have problems in studying acids and bases, students lacked

training in problem-solving skills and it is important to integrate ethics in the problem-solving process in chemistry learning.

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