Analysis of Variations in Students' Conceptual Understanding on the Concept of Salt Hydrolysis Using Phenomenography

Elsa Vera Nanda* [1], Qoulan Karima[2], and Tritiyatma Hadinugrahaningsih[3]

[1,2,3] Chemistry Education Study Program, Faculty of Mathematics and Natural Sciences, Universitas Negeri Jakarta, 10 Pemuda Street, Rawamangun 13220, Jakarta, Indonesia

elsavera@unj.ac.id

Abstract. This study examines the variation of conceptual understanding of students in grade XI MIPA regarding salt hydrolysis through phenomenography. The study, which was conducted at SMA Negeri 58 Jakarta in the 2022/2023 academic year, used qualitative methods and involved 36 students from class XI MIPA A. Data were collected through observation sheets, reflective journals, student worksheets, and interviews, and analyzed using Akerlinds' (2005) phenomenographic approach, which includes transcribing interviews, identifying key phrases, categorizing descriptions, providing examples, and organizing the categories into a hierarchy based on their complexity. The results showed four levels of understanding among the students. At the lowest category A, six students only recognized the reaction between salt and water. In category B, three students understood the reaction between salt ions and water ions. Category C included ten students who understood that not all salt ions react with water ions, although they did not fully understand which ions reacted or did not react. The highest understanding, category D, included three students who knew that only ions of weak acids or bases react with water. Most students were in the C category, which indicates a general level of understanding. This study underscores the importance of prior knowledge and strategic learning approaches in mastering the concept of salt hydrolysis.

Keywords: Variations in Students Conceptual, Phenomenography, Salt Hydrolysis.

1 Introduction

Based on the current state of education in aspects of the learning process, most students consider that chemistry is one of the most difficult materials that is difficult to learn [1]. This can be seen from student learning outcomes are relatively low in chemistry learning [1]. The reason is because students cannot understand the basic concepts of material so that students have difficulty understanding more complicated concepts. Conceptual understanding is an important thing in chemistry learning for students. Understanding conceptual understanding makes students able to solve problems by linking a problem

T. A. Aziz et al. (eds.), *Proceedings of the 4th Science and Mathematics International Conference (SMIC 2024)*, Advances in Physics Research 11,
https://doi.org/10.2991/978-94-6463-624-6_21

with concept that he understands. However, if students lack understanding of the concept, then students will find it difficult to apply the concept to an existing problem.

One of the main factors that influence students' conceptual understanding is because students already have an initial concept of something they have experienced. Students' knowledge is formed based on sensory impressions, cultural environment, peers, media, and classroom learning. Students' understanding of the initial concepts that already exist in a material can be different from the scientific concepts that students obtain during learning. Barriers can arise especially if new information is inconsistent or contradictory with previous knowledge and experience [2].This is because students will combine scientific concepts with their own concepts to form new concepts.

Students bring to school some preconceptions about scientific concepts that may interfere with the correct understanding of scientific terms. Therefore, there is a risk that students will understand some concepts taught in a way that is contrary to existing scientific theories. Coupled with the chemistry curriculum that generally combines various abstract concepts, students find it difficult to understand chemistry [3].

In the current era, the curriculum implemented is an independent curriculum whose programs and additional activities can be developed in accordance with the vision, mission, and available resources. The implementation of this independent curriculum is motivated by learning loss during the pandemic. The legal basis for the implementation of this curriculum includes the Decree of the Minister of Education, Culture, Research and Technology of the Republic of Indonesia Number 56/M/2022 concerning guidelines for curriculum implementation in the context of learning recovery. However, the central government has not yet required schools to implement the Merdeka curriculum. Schools that feel unprepared are still allowed to use the old curriculum, namely the 2013 curriculum in organizing education in their education units. As in SMA Negeri 58 Jakarta, which has just implemented the independent curriculum for grade X and is still using the 2013 curriculum for grades XI and XII.

Students in grade XI SMA are required to be able to learn the various types and properties of a solution and the reactions that occur in it. This solution material is one of the difficult materials for most students, so students need to understand the concept of the material which will later be applied in everyday life. One of the class XI materials related to solutions is salt hydrolysis. According to the results of previous research, students still have difficulty in understanding the concept of acid-base and its reactions, the concept of hydrolysis, salt solutions, and the equilibrium process in solution. Students' difficulties in learning these materials resulted in variations in conceptual understanding among students [2] [4].

Bussey et al. reported the fact that two students sitting in the same class and accessing the same material can understand certain chemistry concepts differently which continues to confuse teachers. If teachers only focus on students' learning difficulties without paying attention to variations in conceptual understanding, it will be difficult to achieve learning objectives. Teachers can organize the learning process, plan learning steps, develop, and introduce learning models so that students can achieve conceptual understanding well [5].

Students can describe the concepts of a material on a phenomenon studied in chemistry concepts and the depiction of the concept of the phenomenon will be different for each student. Students' conceptions can be considered as an alternative way to understand the phenomena presented. Phenomenography can see a variety of different views in interpreting a phenomenon that can be useful for teachers in designing effective learning in the classroom [6].

In the phenomenographic perspective, learning is seen as a change in students' conceptions related to a phenomenon [7]. That is, conceptions differ qualitatively according to different levels of complexity derived from different ways of experiencing a phenomenon. Variations in conceptions are caused by different aspects of the phenomenon that students can perceive. With variation established, phenomenographic research leads to a hierarchical set of increasingly complex categories of conceptions. Differences in conceptions are not only among different individuals, but also in different contexts within a person. Based on this background, chemistry research was conducted in obtaining an overview of variations in students' conceptual understanding of salt hydrolysis material analyzed using phenomenography.

2 Method

The research method used is a qualitative method with the research subjects are students of class XI MIPA A SMA Negeri 58 Jakarta, totaling 36 people. This research consists of several stages, namely: problem formulation, data collection, data analysis, and data reporting. The analysis in the study followed Akerlind's phenomenographic research stages, namely collecting interview data using the questions in Figure 1, transcribing interviews, identifying meaningful words or sentences, grouping descriptions into categories, giving examples of statements in each category, arranging categories into a hierarchy based on students' level of understanding [8].

Q1: Can you explain salt hydrolysis in your own words?

Q2: What types of salt hydrolysis do you know? Try to explain each type of salt hydrolysis.

Q3: Can you give an example of a salt that can undergo hydrolysis?

Q4: Why can the salt be hydrolyzed? (refer to Q3)

Q5: What do you think happens to the water molecules during salt hydrolysis?

Q6: When sodium chloride salt is put into water, does the solution change the color of litmus paper? If it happens, why does this happen?

Q7: Would OH^- ions and H^+ ions form when acetic acid solution is reacted with sodium hydroxide solution?

Fig. 1. List of Questions in the Interview

3 Result and Discussion

Phenomenography is used to analyze variations in student understanding. In the phenomenographic point of view, learning is considered as a process of changing students' conceptions related to a situation. The results of the analysis are then described qualitatively to provide an overview of the aspects of the research study.

Learning salt hydrolysis material is carried out using the Student Teams Achievement Division (STAD) learning model in which students analyze and predict answers to problems or salt hydrolysis phenomena that exist in everyday life and develop group thinking skills.

3.1 Interview

Semi-structured interviews were conducted online through zoom meetings in several meetings at times determined by the students. The interviews were conducted after the students had done the questions on salt hydrolysis. All interviews conducted were recorded and then transcribed in word form. The results of the interview transcripts that have been completed are given to the students concerned to check the suitability of what the students mean (member checking). After the transcript was appropriate, the next step was to identify students' meaningful words or sentences. The meaningful words and sentences formed the initial codes that were compiled.

3.2 Categories Description

The data generated from students' responses to the interview questions were formed into categories of students' concepts about salt hydrolysis. There are several characteristics that can be used for the basis of categorization. The category descriptions formed were the researcher's interpretation of the students' concepts. The category descriptions were accompanied by examples of the most typical student statements for each category to support the category.

The results showed variations among students' conceptions. The categories of students' concepts on salt hydrolysis are shown in Table 1.

Table 1. Category Description of Students on Salt Hydrolysis Concept

Category A Salt hydrolysis is the reaction of salt in water	**Example** - Salt substances that undergo a mixing process with water - Salt hydrolysis is the dissolution of salt by water
Category B Salt hydrolysis is the reaction of salt ions with water molecules	**Example** - Salt hydrolysis is the decomposition of salt by water - Water breaks down in the process of hydrolysis of salt into its ions

Category C Salt hydrolysis is the reaction of the decomposition of a water molecule by salt ions to produce a solution that is acidic, basic, or neutral	**Example** - Salt hydrolysis is the reaction between one of the salt ions and water - Neutral nature of salt because it is formed from strong acids and strong bases
Category D Salt hydrolysis is the decomposition of a water molecule by a cation or anion of a salt that is the conjugate of a weak acid or base resulting in a solution that is acidic, basic, or neutral	**Example** - Reaction of salt ions of weak acids or bases with water - Salt properties formed from water ions that do not react with salt ions

Category A

In this category, students can recognize the reaction of salt in water. However, students do not know the actual reaction between salt and water in the process of salt hydrolysis. Some students think salt hydrolysis is the decomposition reaction of salt caused by water and some think salt hydrolysis is the dissolution reaction of salt. For example, when students were asked to explain the meaning of salt hydrolysis in Q1, some students explained it as follows.

Student 1: The definition of salt hydrolysis is a salt that is mixed with water to form an acid-base solution.

Student 4: The definition of salt hydrolysis is a reaction that is dissolved with water to produce acidic and basic solutions.

Students' knowledge of the types of salt hydrolysis in this category is also limited to memorizing the names of the types of salt hydrolysis. However, students are less able and even tend to be wrong in explaining the meaning of each type of salt hydrolysis that has been mentioned.

In this category, students still find it difficult to distinguish between acids, bases, and salts. This can be seen when students answer questions on Q3 about giving examples of salts that can be hydrolyzed. The students' answers are listed in Table 2.

Table 2. Student Responses to Examples Salt that Can Be Hydrolyzed

Example of salt	Student	Frequency (%)
NH_4CN	Student 1, Student 9, Student 21*, Student 6	18%

NH_4Cl	Student 17*, Student 18, Student 2, Student 10, Student 3, Student 13, Student 7, Student 15, Student 16	41%
CH_3COONa	Student 18, Student 9, Student 20, Student 12, Student 21, Student 8, Student 14, Student 22	36%
CH_3COONH_4	Student 9, Student 5, Student 6	13,6%
NaCN	Student 11, Student 14	9%
$AgNO_3$	Student 4	4,5%

*Some students give more than one example.

Category B

In category B, students not only know what they know in category A. However, students' understanding of the hydrolysis reaction of salt also develops into the reaction that occurs is the reaction between salt and water molecules. Students have developed a partial understanding of ionization in salt, that is, students know that salt in water will become ions and react with water molecules. However, students do not know how this happens.

For example, when students were asked about the definition of salt hydrolysis in Q1, two students gave similar answers as follows.

Student 16: Hmm... salt hydrolysis is the decomposition of salt compounds in water into cations or anions.

Student 22: Salt hydrolysis is the decomposition of salt anion cations with water.

In this category, students also knew that water would also become ions. However, they did not show an understanding of the reaction between the salt ions and the decomposed water. An interview with one of the students in response to question Q5 is taken as an example.

Student 21: What happens to water during salt hydrolysis is that hydrolysis will break down the water molecule H_2O into hydrogen cations H^+ and hydroxide anions OH^-.

Category C

In category C, students do not only know what is known in category B. They also develop a deeper understanding of the reactions that occur in the salt hydrolysis process. However, students also develop a deeper understanding of the reactions that occur in the salt hydrolysis process. Students understand that not all salt ions can react with water. In addition, students also understand that the reaction that occurs is salt ions with water ions. An interview with one of the students is taken as an example.

Student 17: Salt hydrolysis is hmmm... from the word hydrolysis, it does a decomposition, meaning that salt hydrolysis is a reaction between salt ions, namely cations or anions, and water and will make the water into an acidic or basic solution. What decomposes is the water into cations and anions. The salt also decomposes.

Student 17 also understands that the neutral nature of a salt is due to the salt being formed from a strong acid and a strong base. The neutral salt also cannot undergo hydrolysis. However, Student 17 did not explain how this could happen.

Another understanding in this category is about the function of water. Some students thought that water would restore the acid-base compounds that form the salt. . Here is one student's response to this statement.

Student 14: It hydrolyzes like it makes a reaction; I think. Like ... NaCl is salt, right. So later if it is broken down it is like producing bases and acids like that.

Category D

In this category D, students do not only know what is known in category C. However, students also develop an understanding of the characteristics of salt ions that can react with water ions. Students understand that salt ions that react with water in salt hydrolysis are cations and anions derived from weak acids and weak bases.

In this category, students' understanding of the nature of a salt solution in salt hydrolysis also develops. Students understand that the nature of a salt solution results from water ions that do not react with salt ions. Here is an example of student responses.

Student 19: Sodium acetate is CH_3COONa from Na^+ plus CH_3COO^-. Na^+ is a strong base and CH_3COO^- is a weak acid. If it is hydrolyzed or reacted with H_2O water, CH_3COO^- plus H_2O is hydrolyzed to CH_3COOH plus OH^-. If the Na^+ is not hydrolyzed because it is from a strong base. So, if CH_3COONa is also called a basic salt. So only OH^- is formed.

3.3 Hierarchy Category Description

The final stage of analysis using phenomenography is to form a hierarchy.A series of description categories were analyzed, and the categories were sorted into a hierarchy based on complexity to logical progression. The four description categories that were previously formed were sorted into a hierarchy with respect to logical progression among the students. As seen in the description categories, students' understanding of salt hydrolysis was arranged from category A to category D ranging from less than perfect understanding to the most precise. Category A is part of category B, category B is part of category C, and category D includes all categories of students' understanding of salt hydrolysis. This hierarchy does not indicate that all the categories formed are completely correct or incorrect. It only shows the differences in learning outcomes found when students learn the salt hydrolysis material.

The four categories of descriptions formed, represent four qualitatively different ways of understanding a phenomenon which in this case is salt hydrolysis. These four different ways of understanding salt hydrolysis material can be seen as a sequence in a hierarchy in a logical relationship between the categories.

Based on the hierarchy of description categories that have been formed, the possible pathways that students may take in learning salt hydrolysis can be predicted across classes or within individual students at different times or in different contexts. Figure 2 shows the possible pathways of students' conceptual development in salt hydrolysis. The relationships between frames are labeled with lines created when the same person is in two different frames.

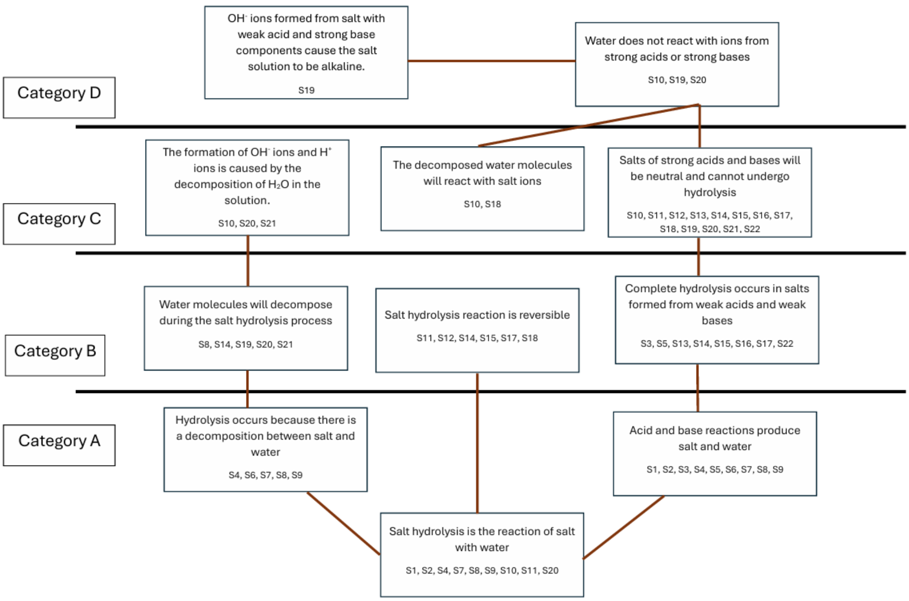

Fig. 2. Possible Pathways of Potential Student Thinking on Salt Hydrolysis

Students who are in category A are only limited to knowing that there is a reaction that occurs between salt and water in solution. Students understand that in the solution, water and salt will decompose. However, students do not understand how the reaction occurs between the two. Students are only limited to memorizing the types of salt hydrolysis that exist. Finally, students have not connected the nature of salt with the concept of hydrolysis.

Students in category B understand the reaction that occurs in salt hydrolysis is salt that breaks down with water into ions and then react. Students understand water will decompose and later the solution will be acidic or alkaline. Students in this category have sufficiently able to distinguish the weak or strong acid-base compounds, also understand if salt is neutral, it does not change the color of litmus paper. the color of litmus paper. However, they still do not connect it with concept salt hydrolysis.

Students in category C understand that not all decomposed salt ions will react with water. Students understand the salt component that comes from weak acids or bases that can react with water. Students understand water will break down into its ions and later the solution will be acidic, basic, or neutral when it has reacted with salt ions. However, it is not enough to understand the reaction between salt ions and water because they think that salt with a strong acid or base component that has decomposed can return to form its acid-base compound again.

Students in category D understand that salt and water will decompose together in solution. Students also understand that only salt anions or cations from weak acids or bases react with water ions. Meanwhile, salt anions or cations from strong acids or bases will remain as ions in the solution. Students understand a salt solution will be acidic, basic, or neutral depending on the water ions that do not react with the salt ions.

Percentage of students in each category formed from a total of 22 students can be seen in Table 3.

Table 3. Percentage of Students in Each Category Formed

Category	Students	Percent
A	6	27,3%
B	3	13,6%
C	10	45,5%
D	3	13,6%

Four different categories of descriptions were created for grade 11 showing variations in how students learned the concept of salt hydrolysis. By using phenomenography, more was learned about students' understanding of salt hydrolysis.

In this study most students still do not clearly understand the reaction of salt hydrolysis reaction which is included in the submicroscopic level. Students only simply memorize the properties of the acid-base properties of the salt constituents. This result is in line with with research conducted by Suhita which shows that at the submicroscopic level students tend to not understand the concept because it is a level that is more difficult to understand compared to the macroscopic and symbolic levels [9]. This is due to the existence of particles contained in the solution is difficult to imagine as something real.

In this study, it was also found that students have certain understandings that can affect the process of understanding salt hydrolysis. One of them is that although students know that ions will form in the solution, students still have difficulty in understanding how these ions are formed and react with water. This is because students lack a deep understanding of the weak or strong properties of acid-base compounds.

To improve students' ability to understand salt hydrolysis more deeply, students must thoroughly understand acid-base material. The use of Designed Student-Centred

Instruction (DSCI) in the learning process can be a teacher's choice to improve students' abilities in acid-base material. The use of DCSI involves several practicum-oriented activities, inquiry, and cooperation that are connected to environmental problems and daily life experiences [10].

In addition, to improve students' ability to understand the submicroscopic level in a material, learning is needed that can visualize a reaction to students. This is because understanding chemical concepts at the submicroscopic level is considered difficult if only based on memorization. The use of the memorization method is less effective because students will find it difficult to estimate or imagine how the process and structure of a substance when reacting. As research conducted by Eliyawati et al. found that there was an increase in student understanding, especially at the submicroscopic level by using multimedia in learning [11].

By directly involving students with the subject matter, students involve more conceptual understanding rather than just memorizing or simply following existing guidelines without really understanding what is being learned.

4 Conclusion

Based on the results of the study, the conceptual understanding of 22 students of class XI MIPA A at SMA Negeri 58 Jakarta was grouped into four description categories. The description categories found in this study describe students' conceptions of salt hydrolysis. The categories are organized based on the addition of students' level of understanding. In category A, which is the category with the lowest understanding, there are six students with an understanding that is only limited to knowing the reaction that occurs between salt and water in the solution. In category B, there are three students who already understand that the reaction that occurs in the solution is the reaction of salt ions with water ions, each of which has decomposed. Furthermore, in category C, there are ten students who understand that not all salt ions can react with water ions. However, they do not understand what characteristics of ions can or cannot react. Finally, in category D, which is the category with the highest understanding, there are three students who understand that only ions derived from conjugates of weak acids or weak bases can react with water ions. It can be concluded that most students' understanding is in category C.

In this study, a hierarchical structure was also formed between these categories. The hierarchy illustrates the potential pathways of students' thinking that can be used to improve their conceptual understanding. The four description categories represent different levels of understanding on salt hydrolysis. The hierarchical structure can be used by teachers to design and implement lessons that can help students develop a deeper conceptual understanding of salt hydrolysis.

References

1. Hutahaean, E., Pardiana, P., & Hadiyati, Y. Identify Students' Misconceptions on Electrolysis using Two-Tier Diagnostic Test. Journal of Research in Environmental and Science Education, 1(1), 1-11. (2024)
2. Orwat, K., Bernard, P., and Migdał Mikuli, A. Alternative Conceptions of Common Salt Hydrolysis Among Upper-Secondary-School Students. Journal of Education. 16(1), 64-76. (2017)
3. Taber, K. S. Progressing Science Education: Constructing the Scientific Research Programme into the Contingent Nature of Learning Science. Springer Dordrecht, NewYork (2009)
4. Agustin, G. P. Analysis of Students' Critical Thinking Abilities Through the Numbered Heads Together (NHT) Cooperative Learning Model on the Topic of Buffer Solutions. Journal of Research in Education and Pedagogy, 1(1), 1-10. (2024)
5. Bussey T. J., Orgill M. K., and Crippen K. J. Variation Theory: A Theory of Learning and A Useful Theoretical Framework for Chemical Education Research. Chem. Educ. Res. Pract. 14(1), 922. (2012)
6. Jan Larsson and Inger Holmström. Phenomenographic or Phenomenological Analysis: Does It Matter? Examples From a Study on Anaesthesiologists' Work. International Journal of Qualitative Studies on Health and Well being. 2:1, 55-64. (2007)
7. Kaur, J., & Bhatia, R. Synchrony in Learning: Investigating the Connection between Student Adjustment and Academic Performance. Journal of Research in Education and Pedagogy, 1(2), 132-139. (2024).
8. Group. Akerlind, Gerlese S. Variation and Commonality in Phenomenographic Research Methods. Higher Education Research & Development. 24:4, 321 334, 24:4, 321334. (2005)
9. Suhita, Delpima. Understanding Students' Concept of Salt Hydrolysis Material at Three Levels of Chemical Representation at Senior High School (Sman) 2 Padang Panjang, West Sumatera. International Journal of Multi Science. Vol. 2, No. 5. (2021)
10. Rahayu, S., et a. Understanding Acid–Base Concepts: Evaluating the Efficacy of a Senior High School Student Centred Instructional Program Indonesia. International in Journal of Science and Math Educucation. 9, 1439 1458. (2011)
11. Eliyawati et al. The Effect of Learning Multimedia on Students' Understanding of Macroscopic, Sub Microscopic, and Symbolic Levels in Electrolyte and Nonelectrolyte. Journal of Physics: Conference Series. 1013. (2018)