Analysis of students’ mental model of salt hydrolysis concepts at Klaten, Central Java

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Abstract. This paper describes students’ mental model of salt hydrolysis concepts. The subjects of this study were the best science class of public senior high school at Klaten, Central Java. This research employed ethnography as a research methodology. Data were collected through in-depth interview, classroom observation, and reflective journals. The result showed that students built their mental model based on their understanding and experience that influenced by their ethics and values. The values of politeness, empathy communication, and respectful influence their classroom interaction. The students’ mental model in salt hydrolysis concepts were divided into understanding and misconceptions. Students’ misconceptions were the concept which states that salt hydrolysis is the salts decomposition in water. Students were not considered about dissociation and equilibrium of acid and base to explain about salt hydrolysis. In addition, the students also determined salt’s characteristic of acid and base by the origin of ions in the salts, not based on hydrolysis reaction of the salt. Teacher’s understanding of students’ mental model will help the teacher to developing meaningful learning experiences.

1. Introduction

Chemical concept was described in three different representations, there are microscopic, submicroscopic, and symbolic representation [1]. Most of students considered that chemistry is difficult to understand because of their lack in understanding about three levels of representative in chemistry. Salt hydrolysis is one of the difficult concept for students. That was supported by the result of research which stated that 44.4% students have difficulty in understanding salt hydrolysis concept [2]. The same statement also known by the interview with chemistry teachers in public senior high school in Klaten. Most of students in Klaten stated that salt hydrolysis concept is one of chemical concept that difficult to understand. Hydrolysis concept considered as a difficult concept because hydrolysis concept requires students’ understanding in three levels of representative in chemistry (macroscopic, submicroscopic, and symbolic level). Mental model is the one of ways to know students’ understanding. Mental model is students’ representation that showed students’ understanding [3]. By studying and analyzing the students’ mental model makes teachers have an opportunity to understand how students construct the concept in learning process [4]. Students construct their understanding in different ways. Students built their mental models as a result of learning process [5]. Students built their mental models and they tried to understand the knowledge [6]. In learning process, students constructed their understanding based on their experience or their understanding. Mental models can be used by students to explain and predict about phenomena, processes, or scientific systems. External factors beside the learning process that
influence the students’ mental model are the characteristics of the students, social environment, and students’ cultural background [7].

Culture has an important role in construct mindset, social aspect, and personality of a society [8]. People’s intelligence has come from the society, environment, and culture [9]. Teachers need to be aware of the diversity in cultural backgrounds of students and understand how students build their mental models. Students in classroom have different cultural backgrounds and this cultural background influences students’ way of thinking. Culture in science will help teachers to engage students in their personal worlds. However, in an Indonesia context, beside the challenges of losing cultural identity [10], there is the challenge of addressing the needs of a population that consists of more than 17.000 islands with 300 ethnic groups that speak more than 250 dialects [11]. These ethnic groups have different cultural which influence their values, beliefs, and practices. Therefore, Indonesia students grow up with different cultural backgrounds which influence the set of values and beliefs they hold, including beliefs about learning.

2. Method

This research conducted in 11th grade of senior high school in certain public school in Klaten, Central Java on December 2015 to June 2016 which involved 40 students. This research employed ethnography as a research method with interpretative paradigm. Ethnography was used to understanding students’ mental model which mostly have the character of Javanese culture. Data collecting was carried out using classroom observation, in-depth interview, and reflective journal. Researcher interpreted students’ mental model by depth-interview using open-ended question with writing-drawing technique, free word association, and concept mapping. Data analysis carried out using data reduction, data display (coding), conclusion and data verification. Quality standards that used in this study are trustworthiness and credibility through prolonged engagement, persistent observation, progressive subjectivity, and member checking.

3. Result and discussion

3.1. Students’ characteristics

Students’ characteristics in grade 11 at public senior high school in Klaten was known by observation, teacher interview, and in-depth interview. All the students in grade 11 were Javanese. This leads to the daily life of students that influenced by values in Javanese culture. Based on the results of research, the characteristics of students in grade 11 at public senior high school in Klaten are politeness, empathy, communication, and respectful.

Students’ politeness can be seen from students’ attitudes. Students’ attitudes in communication was affected by with whom students were talked. Javanese people have a communication rules in the use of language, words, and ethics. Thus, Javanese people have a normative rules of social and psychological behavior [12]. The normative rules manage Javanese people to make a good relation with other people, such as politeness, manner, ethics, and daily interaction to maintain their harmony of life.

Empathy communication of students in public senior high school in Klaten is an attitude of students that not accustomed to conveyed criticism directly when looking at something which not accordance with their value. Based on the research, empathy communication can be seen when there were mistake that made by their friends or others, students did not conveyed criticism directly. Criticism as one of social control in Javanese society tends to only from top to bottom [13]. In Javanese culture, Javanese people speak slowly or subtly and as much as possible hide the feelings of the students as the embodiment of the principle of shame and hesitate [14].

Respectful characteristic of students can be seen from interview. During the interview process, most students said what the teacher has taught to them. Students assumed that teachers’ thought were always right, so students always received the explanations from teachers and made explanations from teachers’ explanation as the main source of knowledge in learning. There are five things that should be respected in the Javanese culture. The five things were honoring parents, respecting parent’s in-laws, the eldest brother or sister, the teachers, and honoring God [15].
3.2. Students’ mental models

Based on the results of research that conducted with the question about salt hydrolysis, observation, and in-depth interview of salt hydrolysis concept, obtained some mental models of students. Students’ mental models of salts hydrolysis were about salt hydrolysis concept, salt hydrolysis process, analogies, hydrolysed salts, and salts’ characteristics.

3.2.1. Salt hydrolysis concept. The student’s mental model of salt hydrolysis concept was known by through in-depth interview to students on the concept of salt hydrolysis. Based on the interview results, some students have been able to explain the salt hydrolysis well, as the following students’ answers:

"Hydrolysis is a cation / anion reaction of salt with water. The cation which can be hydrolyzed is a conjugate acid of a weak base and anion which can be hydrolyzed is a conjugate base of a weak acid" (Interview on Student 01, March 2nd 2016)

The student’s answer about salt hydrolysis concept above obtained from students’ chemistry book. That answer in accordance with salt hydrolysis definition from the text book, which stated that hydrolysis as a reaction of anion or cation or both from a salt with water [9]. In addition to appropriate concept of salt hydrolysis concept, there are some students who have an alternative mental model in hydrolysis concept that built by student. The alternative mental models can be identified based on the following students’ answer:

"Hydrolysis is a reaction between a neutral salt then dissolved in water and become ions. All the ions react with water to produce H+ or OH-" (Interview on Student 03, February 29th 2016)

"Hydrolysis is a decomposition of salt with water" (Interview on Student 09, March 1st 2016)

"Hydrolysis is an acid-base reaction with H2O" (Interview on Student 25, March 2nd 2016)

The first answer above showed that students generalized about hydrolyzed ions. Students understand that all ions that produced when salt dissolved in water can be hydrolyzed to formed H+ and OH-. The second answer above was formed because students know that “hydrolysis” derived as hydro which means water and lysis which means decomposition. This alternative mental model was formed from teacher’s explanation in the class. The third answer above indicated another alternative mental model, where student assumed that hydrolysis is an acid-base reaction with water molecules. Alternative mental model can be formed because students did not have a good understanding about salt hydrolysis, so students built their alternative mental model.

In addition to the concept of salt hydrolysis, students’ mental model about the process of salt hydrolysis was known in this research. Based on the result, students’ mental model of salt hydrolysis process are: (a) Salt hydrolysis process occurs due to salt dissociation in water. Then a cation which is a conjugate acid of a weak base or anion which is a conjugate base of a weak acid or both reacts with a water molecule to form an acid-base equilibrium. Then a cation which is a conjugate acid of a weak base or anion which is a conjugate base of a weak acid or both reacted with water and form an acid-base equilibrium system. This statement was accordance with the concept of salt hydrolysis [16]. (b) Salt hydrolysis process occurs due to the salt dissociation in water. Then a cation or anion reacted with H2O through irreversible reaction. This students’ answer can be given because students applied the knowledge provided by the teacher in their class. The students felt that the teacher’s explanation was always true so that what is explained by teacher would be directly accepted by the students.

Some students explained the dissociation process of salt hydrolysis using a picture. Figure 1 and 2 showed the representation of students’ mental models in dissociation process. Based on figure 1, some students explains the decomposition process of salt into anion and cation occurred when the salt dissolved in water. Students stated that was an ionization process which is a decomposition process of neutral compound to ions in water. Figure 2 showed that some students used round symbol to explain
the salt decomposition concept in ionization process and some students used name of the compounds and ions directly. The students that represented with round symbols caused by the student’s prior knowledge that atoms were spherical [17].

Figure 1. Salt hydrolysis process.

Figure 2. Salt decomposition into anion and cation.
3.2.2. Hydrolyzed Salt and Salt Characteristics. All students answered correctly when they decided which salt can hydrolyzed. The salts were $K_2SO_4$, $(NH_4)_2SO_4$, and $NH_4HCO_3$. When student was interviewed with in-depth interview technique, there are some reasons from students to decided salt characteristics. It can be known by the various types of answer: (a) In determination of hydrolyzed salts, students looked directly at salt compounds and predicted the origin of anions and cations. For example, $K_2SO_4$, students assumed that $K$ is derived from KOH which is a strong base and $SO_4^{2-}$ derived from $H_2SO_4$ which is a strong acid. Because the compound of salt consists of strong acids and strong bases, the salt cannot hydrolyzed. Students with this mental model built alternative concepts by simplifying the appropriate concepts to make it easier. (b) In determination of hydrolyzed salt, students made an ionization reaction, then the student assumed that hydrolyzed salts contain weak acids, weak bases, or both. Students considered that a weak acid, a weak base, or both were present in the salt, not from the hydrolysis reaction. Students’ answers were obtained from students’ understanding by their own perceptions. Students quickly determined whether a salt can hydrolyzed or not and acid-base properties of salt. However, this student’s answer showed the lack of students’ mental model. (c) In determination of hydrolyzed salt, students made an ionization reaction. A conjugate base anion of a weak acid or a conjugate acid cation of a weak base can hydrolyzed with water. Students were not directly determine that the ions of the salt were derived from certain basic or acidic compounds, so students need to react it first to determine whether from the reaction there is a conjugate base anion of a weak acid or a conjugate acid cation of a weak bases that can be hydrolyzed.

In salt’s characteristics of acid and base, all students answered correctly that sodium stearate ($C_{17}H_{35}COONa$) was an alkaline salt. However, there are two types of reasons students answer that the sodium stearate salt ($C_{17}H_{35}COONa$) was a base: (a) The sodium stearate ($C_{17}H_{35}COONa$) was derived from the $Na^+$ cation which is a conjugate acid of strong base NaOH and $C_{17}H_{35}COO^-$ which is the conjugate base of the weak acid $C_{17}H_{35}COOH$, so students assumed that sodium stearate was a base. Students directly determined the nature of the salt that can be hydrolyzed without make a reaction. This answer showed a mental model of an alternative concept of students which not inappropriate with the actual concept. (b) Students assumed that to determine the characteristic of salt, they needed to make a hydrolysis reaction to see if there is $OH^-$ or $H^+$ from the reaction. Students not directly determined that the ions in the salt were derived from basic or acidic compounds. However, there was a lack in chemical reaction that written by students. The students wrote the reactions without the actual concept. Figure 3 showed that student did not make an ionization and hydrolysis reaction to determine the salt’s properties. That concept was inappropriate with the actual concept, and it’s indicated that students had an alternative concept in determined the salt’s properties.

![Figure 3. Chemical reaction to determined salt properties of sodium stearate.](image)

3.2.3. Analogies. Analogy was used to explain the concept of salt hydrolysis. There are four analogies which is students used to describe the hydrolysis process. The analogies are fish analogy, padusan analogy, seesaw analogy, and weaving analogy. Fish analogy described by students for ionization process and influenced by their environment. Some students described ionization process with fish that can swims freely.
Figure 4 showed the ionization analogy. Fish analogy explained that some fishes in small place were hard to swim, then the fishes replaced into a pound, the fishes can swims freely like ions in solution. In addition to fish analogy, there are some students that have padusan analogy to described ionization process. *Padusan* means *adus* in Javanese and it means take a bath. *Padusan* is a bathing together tradition in spring before Ramadhan. Students stated *padusan* analogy because they felt *padusan* analogy can made them easier to understand about ionization process that they could not see. Students felt easier and more understand about the process and the concept of ionization if they use analogy that exist in their life.

In addition to ionization process, there was also equilibrium analogy. Students had two analogies about equilibrium process in salt hydrolysis process, there were see saw analogy and weave analogy. Figure 5 showed the equilibrium analogies. The seesaw analogy (left) showed that students described equilibrium reaction like a see saw with reactants and product in each sides. When there was a change in one side, there will be reaction to maintain the equilibrium, like a seesaw. In addition to seesaw analogy, some students also have weaving analogy (right). This analogy was obtained by students because student see weaving activities. Students tried to make a connection from the concept they learned with their experience in life.
4. Conclusion

Based on the results and discussion, it can be concluded that students in public senior high school in Klaten built their mental model based on their understanding and experience that influenced by the characteristics of students and the environment around the students. Characteristics of students in public senior high school in Klaten are politeness, empathy communication, and respectful. The analogy that used by students in public senior high school in Klaten can improve students’ understanding about salt hydrolysis concept. That analogy comes from the culture and the environment around the students, such as fish, padusan, and weaving activities. The students’ mental models of salt hydrolysis concept consisted of the appropriate and inappropriate mental model. The appropriate mental model of salt hydrolysis were the salt hydrolysis concept, hydrolysis process that involved by the decomposition of the salt in water and the acid-base equilibrium, the determination of the salt which can be hydrolized based on the conjugate base or conjugate acid from the decomposition of the salt in water, and salt characteristic of acid and base based on H+ or OH- from hydrolysis reaction. The inappropriate mental models of salt hydrolysis concept were hydrolysis concept which stated that hydrolysis is the decomposition of salt by water, hydrolysis process that involved by the decomposition of a salt in water, the determination of a salt’s characteristic which not based on the conjugate acid and conjugate base of the salt hydrolysis reaction, and determination of salt properties by looked at the origin of ions in the salt.
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