JPII 6 (2) (2017) 356-364

Jurnal Pendidikan IPA Indonesia

http://journal.unnes.ac.id/index.php/jpii

IDENTIFICATION OF CHEMISTRY LEARNING PROBLEMS VIEWED FROM CONCEPTUAL CHANGE MODEL

I . W. Redhana[1]*, I. B. N. Sudria[1], I. Hidayat[2], L. M. Merta[3]

[1]Department of Chemistry Education, Universitas Pendidikan Ganesha, Indonesia
[2]Department of Mathematics and Natural Science Education, Universitas Sriwijaya, Indonesia
[3]SMA Negeri 4 Singaraja, Indonesia

DOI: 10.15294/jpii.v6i1.9594

Accepted: August 15th, 2017. Approved: September 4th, 2017. Published: October 17th, 2017.

ABSTRACT

This study aimed at describing and explaining chemistry learning problems viewed from conceptual change model and misconceptions of students. The study was qualitative research of case study type conducted in one class of SMAN 1 Singaraja. Subjects of the study were a chemistry teacher and students. Data were obtained through classroom observation, interviews, and conception tests. The chemistry learning problems were grouped based on aspects of necessity, intelligibility, plausibility, and fruitfulness. Data were analyzed descriptively. The results of the study showed that the chemistry learning problems related to the aspect of necessity were that the teacher did not carry out the laboratory work and did not discuss the properties of the buffer solution. The problems related to aspects of intelligibility were the teacher asked successive questions, answered her own questions, gave wrong information, made unclear and wrong analogies, and did not ask student reasons. The problems related to the plausibility aspects were that the teacher had less emphasis on the importance of context and neglected the students' alternative conceptions. The problems related to the fruitfulness aspects were that the teacher was less likely to provide complex problems especially with regard to the application of the buffer solution in everyday life. Students experienced misconceptions on some concepts of buffer solution.

Keywords: conceptual change model; misconceptions; buffer solution

INTRODUCTION

The learning process occurs continuously during the learning process takes places in accordance with the view of constructivism. Based on this view, students actively build their own knowledge based on cognitive maturity. The teacher must be aware that knowledge can not be transferred from the teacher's head to the students' head. In the view of constructivism, the understanding of learning emphasizes on the process rather than results. Students construct or build their understanding of natural events/facts encountered by using experiences, cognitive structures, and beliefs in order to gain understanding or knowledge and cultivate reasoning.

Students attend to the classroom are generally not with empty heads, but rather they bring a number of previously established experiences or ideas when they interact with the environment (Pinker, 2003). This means that before the learning activities take place, students have ideas about the events around them. These ideas are called as prior knowledge, preconceptions, or alternative conceptions that will be the basis for building their next knowledge.

In the conditions of cognitive conflict, students are faced with three choices, namely (1) retaining their original intuition (the ability to understand something without reasons, rationality, and intellect); (2) revising some of their intuition through assimilation; and (3) changing their views and accommodating new knowledge (Santyasa, 2008). The prior knowledge of stu-

*Address Correspondence:
E-mail: redhana.undiksha@gmail.com

dents will turn into scientific concepts only if the teacher's learning becomes more necessary, intelligible, plausible, and fruitful for students (Posner et al., 1982). The conceptual change model is an effective learning model in changing the students' misconceptions into the scientific concepts (Posner et al., 1982; Hewson & Thorley, 1989; Hennessey, 2003; Cetengul & Geban, 2005; Balci et al., 2006; Onder & Geban, 2006; Dilber & Duzgun, 2008; Berber & Sarı, 2009; Trundle & Bell, 2009; Gadgil, Nokes-Malach, & Chi, 2011; Aydin, 2012; Kaya & Geban, 2012; Taslıdere, 2013; Madu & Orji, 2015; Tas et al., 2015; Yumusak et al., 2015).

The conceptual change model is a learning model that describes an interaction between new conceptions and pre-existing conceptions. It is widely used in science subjects. This model was first introduced by Posner et al. (1982) and more than a decade of this model has greatly influenced studies in the field of student conceptions.

Recent studies in the field of education begin to focus on the problems of learning. Orgill & Sutherland (2006) state that teachers tend to focus more on the aspects of calculation rather than those of concepts in the learning to explain chemistry subject. This results in students having difficulties in understanding the chemical concepts correctly. Some students' understanding is inconsistent with the views of the scientific community. It is called misconceptions. Students experiencing misconceptions will have difficulties in relating their concepts with the next concepts. Therefore, the teachers must know the misconceptions of students so that they are able to carry out the teaching and learning process in accordance with the prior knowledge of students.

SMA Negeri 1 Singaraja as a part of the educational institution is in charge of preparing graduates who are intelligent, having life skills, cautious to God Almighty, having the noble character, and so on. It is a favorite school in Buleleng regency of Bali. Students' academic achievements in the event of such olympic competitions are quite proud. Likewise, the number of graduates of SMA Negeri 1 Singaraja received at the favorite colleges is quite a lot. However, the results of observations on the chemistry learning showed that chemistry the teachers applied traditional learning. In this traditional learning, the chemistry teachers used more lecture and question and answer methods as well as group discussions. Observation results also showed that some chemistry teachers provided many tasks to the students so that they were able to solve problems given by the teachers. Given these tasks, the teachers hoped that students actively learnt. This actually caused students to experience difficulties due to lack of guidance from the teachers.

The study aimed at describing and explaining the problems of chemistry learning conducted by the chemistry teacher on buffer solution in terms of the conceptual change model of Posner et al. (1982). The study results of Orgill & Sutherland (2006) found that students experienced misconceptions on the topic of buffer solution. Students considered that the stronger the acids and bases form a buffer solution, the greater the capacities of the buffer solution are. In addition, students were convinced that the buffer solution could be made from mixtures of acids and bases regardless of acid or base strength. The teacher-centered teaching that emphasizes the calculation aspects enables low comprehension and misconceptions among students. de Jong et al. (1995) reported that, in fact, the chemistry teachers who taught redox reactions had a lot of learning problems related to the conceptual change model. These learning problems included they presented the unsuitable problems, presented the unnecessary explanations, explained the conceptions prematurely, used the confusing terms, taught the less context, ignored the alternative conceptions of students, discussed the less application of concepts (especially in industry), and explained too many procedures from experts. Based on these descriptions, the studies on the problems of chemistry learning on other concepts were very important to do.

The studies involving the students' misconceptions in relation to the conceptual change model has been reported on the electrochemical concept in the Netherlands (de Jong et al., 1995). These studies were forwarded to other countries, such as the United Kingdom (Bojczuk, 1982), the North America (Finley et al., 1982), and Australia (Butts & Smith, 1981). The studies of the conceptual change model related to the concepts of electrochemistry were reported in the United Kingdom (Allsop & George, 1982), Spanish (Barral et al., 1992), and Australia (Garnett & Treagust, 1992a; 1992b). Meanwhile, Redhana (2011) has investigated the students' misconceptions on the topic of hydrocarbons.

METHODS

This study was a qualitative research with case study type. The study was conducted at SMAN 1 Singaraja from February to April 2014. The subject of the study was a chemistry teacher and students consisting of 28 people coming from one class. This case study was done on the buffer solution topic. The focus of the study was the process of teaching and learning and conceptions of students. Data were collected from the learning processes and student's conception through observation, interview, and test. The observations were conducted to the teaching and learning process that took place in the classroom. The observation results, all drawings, and notes on the board either made by the teacher or students were copied into a field notebook. In order for the observations obtained more accurately, the ongoing chemistry learning process was recorded with video and voice recorder.

Results of recording of video and voice recorder were combined and then transcription was made by researchers. After the topic of the buffer solution has been taught, the researchers carried out a conception test to the students. The conception test was made based on the findings of the problems in the learning process after the transcription was made. This conception test was a two-tier test, which was an objective test with reason. The test consisted of 15 items of questions.

Based on the transcription, the researcher identified the problems of chemistry learning done by the teacher. These problems were grouped into aspects of the conceptual change model of Posner et al. (1982), which included necessity, intelligibility, plausibility, and fruitfulness.

RESULTS AND DISCUSSION

The results of the study were the problems of chemistry learning viewed from the conceptual change model of Posner et al. (1982) and the students' misconceptions. Data of the problems of chemistry learning were presented in Table 1. As a result of these learning problems, students experienced misconceptions as shown in Table 2.

Table 1. The problems of chemistry learning in one class of SMAN 1 Singaraja.

Characteristics of New Conceptions	Descriptions
Necessity	Most materials presented by the teacher were in accordance with the curriculum requirements (content standards: competency standards and basic competencies), such as analyzing buffer and non-buffer solutions through experiments, calculating the pH or pOH of buffer solution, calculating the pH of the buffer solution with the addition of slight acids or bases, or by dilution, and explainig the function of buffer solutions in the body of living things. However, there were some problems of chemistry learning in relation to the aspects of necessity presented as follows. 1. The teacher did not conduct laboratory work to analyze buffer solutions and non-buffer solution through experiments, but she only presented the experimental data. 2. The teacher did not discuss the properties of the buffer solution which was capable of maintaining the pH of the solution if it was diluted. On the other hand, she discussed more the properties of the buffer solution when added by slight acids or bases. 3. The teacher did not fully discuss the function of the buffer solution in the living things.
Intelligibility	Some of the problems of the chemistry learning related to aspects of intelligibility were as follows. 1. The teachers asked successive questions to students. One question asked by the teacher had not been answered by the students, she asked other questions. This could be seen in the following description. The teacher asked: "What does it mean of conjugation? Who states the concept of the conjugate of acid-base? Why is CH_3COONa called the conjugate base? Because of what? Do you remember the Bronsted-Lowry acid-base concept?" The teacher wrote the equilibrium reaction of CH_3COOH CH_3COO^- + H^+. She asked: "How is the ion concentration of CH_3COO^- if the pH of the solution is increased? What happens to the equilibrium reaction? Who overcome this shortcoming?" 2. The teacher answered her own questions. The teacher wrote the reaction of CH_3COOH formation of CH_3COO^- and H^+ ions. She asked: "If HCl solution is added to the buffer solution, to which the equilibrium shifts?" She then answered her own question: "The shift goes to the formation of CH_3COOH." The teacher asked: "Why can not the weak acid of CH_3COOH form a buffer solution with the NaCl salt?" She then answered her question: "Because the definition of the buffer solution is a mixture of weak acids and their conjugate bases or between weak bases and their conjugate acids."

	3. The teacher gave wrong information. The teacher said: "If the buffer solution of CH_3COOH and CH_3COO^- is added by the slight bases, then the OH^- ions will bind the H^+ to form CH_3COOH." Supposedly, the OH^- ions bind the H^+ ions to form H_2O. The teacher described the formation reaction by stating: "CH_3COOH molecules were formed from CH_3COO^- ions and H^+ ions." She mistakenly understood about the formation reaction. 4. The teacher made unclear and wrong analogies. The teacher explained: 'The buffer solution can maintain pH when it is added by the slight acids, the slight bases, or diluted. Still, remember? A bit acid, a bit base.'Just like "If you eat excessively, then you can get dizzy. Therefore, you should eat sufficiently." The analogies made by the teacher was not related to the statement described earlier. 5. The teachers did not ask students' reasons. Students stated: "CH_3COOH becomes CH_3COO^- ions by removing and CH_3COO^- ions becomes CH_3COOH by receiving." She did not ask the students' reasons about what was removed and what was received? The teacher asked: "Is mole or molar used in the pH calculation of buffer solution?" Student answered: "Mol." She did not ask the students why the mole is used in the calculation of pH of buffer solution instead of the molar.
Plausibility	1. The teachers did not emphasize the importance of context. This could be seen from less explanation of the teacher about the role of buffer solutions in the living things, which included a blood buffer system and body fluid support system. She did not discuss the working mechanism of buffer solutions in the body. 2. The teacher ignored the students' alternative conceptions. The teacher asked: "What happens after the H^+ ions from HCl combine with CH_3COO^- ions?" Students replied: "Binding." She did not further explore about "binding." The teacher asked: "What is the properties of the CH_3COOH solution?" The student replied: "Strong acid." The teacher then explained another topic. The teachers should ask students why the CH_3COOH solution was strongly acidic.
Fruitfulness	The teachers were less likely to provide complex problems especially with regard to applications of the concept of buffer solutions in everyday life, such as the use of buffer solutions in the pharmaceutical industry (in the manufacture of drugs).

2. The students' misconceptions on the buffer solution

Based on Table 2, it seemed that there were many problems of chemistry learning which had not met the criteria of conceptual change model of Posner et al. (1982). Even though the conceptual change model of Posner et al. (1982) has long been developed, but the model is still highly relevant to the current and future learning process. This is due to the conceptual change model of Posner et al. (1982) accommodates the theory of scientific revolution of Khun (1970) and the theory of cognitive development of Piaget (Santrock, 2011). In the theory of scientific revolution (Khun, 1970), the old paradigm will be partially or completely replaced by a new paradigm if it is contradictory. On the other hand, in Piaget's cognitive development theory, students must change their schemes if the new knowledge being studied does not match to the pre-existing scheme. This process is called the accommodation according to Piaget.

Based on the transcription of learning that has been made, it appeared that the learning that took place was centered on the students. The teacher provided more information or transfer knowledge to students. The chemistry learning problems being found were as follows. Firstly, from the aspect of necessity, the teacher did not conduct chemistry laboratory work to study the properties of the buffer solution, but she only presented the hypothetical experimental data. Although such learning was not entirely wrong, but students could not directly observe the natural phenomena associated with the properties of the buffer solution. Likewise, students did not have the opportunity to develop skills, especially the skills of using laboratory tools.

In addition, aspects of student attitudes that were the nurturing effects of the learning process also could not develop optimally. Sciences including chemistry are developed from the experimental results. The chemistry learning without laboratory work was like history learning. This resulted in low students' memory. Secondly, the teacher did not discuss the properties of the buffer solution if dilution is performed. She discussed the buffer properties more about the effect of the addition of slight acids or bases to pH change. In short, in this necessity aspect, the teacher presented incomplete buffer topic.

Table 2. Students' Misconception on Buffer Solution Materials

The Students' Misconceptions
CH_3COONa is an acidic salt.
HCOONa is an acidic salt.
CH_3COONa is a weak acid.
CH_3COOH is a strong acid.
CH_3COONa is a conjugate acid of NaOH.
A mixture of weak acids with salts may form a buffer.
The mixture between HCN and NaCl forms a buffer solution.
Strong acids react with salts to form salt hydrolysis.
The reaction product between NH_4Cl and KOH is KNH_4.
If the buffer solution is mixed with a strong acid or strong base solution, the mixture can still maintain the pH.
The buffer solution is formed of acids and weak bases.
NaCl is a salt without pH.
Buffer solutions can be formed from weak acids and salts.
The chemical formula of nitric acid is NHO_2.
The chemical formula of cyanide acid is HNCN.
If the buffer solution is added by acids or bases, pH will not change.
The buffer solution is a solution whose pH does not easily change if it is droped gradually with acids, or bases, or was diluted with water even in large quantities.
In the buffer solution, the remaining is strong bases so that the buffer solution is alkaline.
The reaction between acetic acid and barium hydroxide is $2CH_3COOH + Ba(OH)_2 \rightarrow 2CH_3COOBa + 2\ H_2O$.

The chemistry learning problems related to the aspect of intelligibility are as follows. Firstly, the teacher asked successive questions to students. Asking questions is important, but students should be given the opportunity to think about the answers of the questions. Students had not answered the first question, even still thinking, the teacher directly asked the students with the next question. This could be seen from the following transcription of learning. The teacher asked: "Remember what does it mean by conjugation? Who declares the concept of conjugate acid-base? Why is CH_3COONa called the conjugate base? Because of what? Do you remember the acid-base concept of Bronsted-Lowry?" This condition could lead to students becoming frustrated in learning chemistry.

In addition, the teacher mistakenly stated that CH_3COONa salt was a conjugate base. Secondly, the teacher answered his own question. This could be seen from the following transcription of learning. She wrote the formation reaction of CH_3COOH from CH_3COO^- ions and H^+ ions. She then asked: "If the HCl solution is added to the buffer solution, to which the equilibrium shifts?" She then answered her own question: "The shift goes to the formation of CH_3COOH." Consequently, students were inactive learners. In other words, the teacher was too active in the learning. Thus, the constructivist learning paradigm that expects students to actively construct knowledge can not take place. Thirdly, the teacher gave wrong information. This could be seen from the following transcription of learning. She said: "If slight bases are added to the buffer solution of CH_3COOH and CH_3COO^-, the OH^- ions will bind the H^+ ions to form CH_3COOH." Supposedly, the OH^- ions bind the H^+ ions to form H_2O. Misinformation submitted by the teacher to the students could cause the students to misunderstand the concepts being studied. In other words, students experienced misconceptions. This meant that teachers could be a source of misconceptions for students.

Fourthly, the teacher made an unclear and wrong analogies. This could be seen in the teacher's explanation as follows. She explained: "The buffer solution can maintain pH if it is added by slight acids, slight bases or diluted. Still, remember? A bit acids, a bit bases. Just like "If you eat excessively, then you can get dizzy. Therefore, you should eat sufficiently." The analogies made by the teacher was not related to the statement described earlier. The unclear and wrong analogies could mislead students. Fifthly, the teacher did not ask the students' reasons. This could be seen from the following transcription of learning. The teacher asked: "Is mole or molar is used in pH calculation of buffer solution?" Students answered: "Mol." She did not ask the student why mol is used in pH calculation of buffer solution instead of the molar. She did not explore further the students' answers what reasoning is. If this was allowed, they would not know which concept is correct.

The chemistry learning problems related to aspects of plausibility were as follows. Firstly, the teacher did not emphasize the importance of context. This could be seen from teacher's explanation. She discussed the less role of buffer solutions in living things, which included blood buffer systems and body fluid support systems, and the application of buffer solutions in everyday life. This could result in students not knowing the link between the concepts being studied and their application in everyday life. Students felt the concepts they were learning were useless to their life. The importance of linking the concepts learnt with their application in everyday life has been the goal of sciences lately because sciences including chemistry have a high application in everyday life. Therefore, the contextual teaching and learning is a teaching and learning that is suitable to teach science, including chemistry (Brist, 2012). Secondly, teacher ignored the alternative conceptions of students. This could be seen from the transcription of learning as follows. She asked: "What is the properties of the CH_3COOH solution?" The students answered: "Strong acid." She should ask students why the CH_3COOH solution is the strong acid. Before learning, students actually have had a number of conceptions. This alternative conception should be considered by the teachers in designing learning strategies that will be applied. Likewise, any alternative conceptions that arise during the learning processes should be of concern to teachers. If they are misconceptions, then she must turn them into scientific conceptions.

The problems of chemistry learning related to the fruitfulness aspect were that teacher did not provide complex problems especially those related to the application of buffer solution in everyday life. The complex problems are ill-structured and open-ended problems and contextual issues. Solving these problems requires higher-order thinking. The higher-order thinking was the goal of all educational curricula. The description above showed that the ongoing learning was the teacher-centered teaching. This kind of teaching failed to improve students' understanding of the concepts being studied. Even the results of this study indicated that the teaching applied by the teacher was not able to make changes to the conceptions of students significantly. This was apparent from the students' misconceptions of the buffer solution. Generally, students experiencing misconceptions may be caused by associative thinking, incomplete or incorrect reasoning, wrong experiences, and conclusions based on what appears on the surface only (Kurniawan, 2012). It could be said that students did not understand the concept completely. The incomplete reasoning of students was caused by incomplete information or data. As a result, students drew a wrong conclusion and this could lead to misconceptions. The findings above were in line with previous study findings. The results of the study showed that teachers who taught hydrocarbon concepts have a lot of learning problems in terms of conceptual change models (Redhana, 2011). These learning problems included presenting erroneous questions, presenting less structured information, providing incomplete information, misinformation, and making unclear analogies.

The results of the study above confirmed previous findings related to misconceptions (de Jong, 1982; de Jong et al., 1995; Nahum, Hofstein, Mamlok-Naaman, & Bar-Dove, 2004; Chiu, 2005; Barke, Hazari, & Yitbarek, 2009). The students' misconceptions were found on almost all chemistry topics, such as atomic structures, periodic systems, and chemical bonds (Redhana & Kirna, 2004). Meanwhile, (Banerjee, 1991) found the students' misconceptions on the chemical equilibrium topics, namely: (1) rainwater was neutral; (2) for the same concentration, the pH of acetic acid solution was less than or equal to the pH of the hydrochloric acid solution; and (3) there was no hydrogen ions in the sodium hydroxide solution. Ross & Munby (1991) reported the students' misconceptions on acid-base topics, namely: (1) all acids were strong acids; (2) combustible substances were acids; (3) all acids were toxic; (4) fruits were alkaline; (5) strong acids contained more hydrogen bonds than weak acids; (6) all sharp-smelling substances were acids; (7) acids were bitter and spicy; and (8) the soil might not be acidic because something was impossible to grow in acids. Bradley and Mosimege (1998) reported the students' misconceptions on the topics of acids and bases, namely: (1) all salt solutions were neutral; (2) indicators were used to test whether a substance was a strong or weak acids; and (3) an indicator neutralized the acidity of the solution. On the other hand, Redhana (2011) reported the students' misconceptions on the topics of hydrocarbons, including: (1) isomers of hydrocarbon compounds had different relative masses; (2) isomers of hydrocarbon compounds had similar physical and chemical properties; (3) in molecules ethene, one C atom was positively charged and another C atom was negatively charged; (4) the most volatile compounds were compounds having the highest boiling point and the highest molar mass; (5) in a methane molecule, all hydrogen atoms were positively charged; (6) in the Cl_2 molecule, one Cl atom was more positively charged and another Cl atom was more negatively charged; (7) at the substitution reaction of methane by HCl, the H atoms of methane could be replaced by the H atom of HCl because the H atom of HCl had higher degree; (8) gasoline was explosive and flammable because it had a high boiling point; (9) a branched carbon skeleton was more easily broken down by microorganisms than that of a straight carbon; and (10) air crafts used kerosene fuel. Khasanah et al. (2016) reported that students' misconceptions generally occurred in low mental models. Mental models can be grouped into three categories, namely low, medium, and high mental models.

Teachers need to devise the conceptual change strategies to remediate students' misconceptions. The various conceptual change strategies have been developed to remediate student misconceptions, including: (1) the conceptual change texts (Tsai & Chou, 2002; Cetengul & Geban, 2005; Onder & Geban, 2006; Balci et al., 2006; Berber & Sarı, 2009; Sinatra & Broughton, 2011; Aydin, 2012); (2) the web-based conceptual change texts (Calik et al., 2011; Tas et al., 2015); (3) the computer simulations (Trundle & Bell, 2009); (4) the computer-based learning (Kose, Kaya, Gezer, & Kara, 2011; Yumusak et al., 2015); (5) ECIRR model (Elicit, Confront, Identify, Resolve, and Reinforce) (Wenning, 2008); (6) the cognitive conflict learning strategies (Baser, 2006; Madu & Orji, 2015); (7) the conceptual change-oriented learning (Baser, 2006; Kaya & Geban, 2012; Taslıdere, 2013); (8) analogies (Dilber & Duzgun, 2008); (9) the holistic mental model confrontation (Calik et al., 2011); (10) problem posing (Rufaida & Sujiono, 2013), and (11) multiple representations (Widarti et al., 2016).

CONCLUSION

The identification of chemistry learning problems is very important. By knowing the learning problems that arise, the chemistry teacher can design the effective learning strategies. The chemistry learning problems viewed from the conceptual change model of Posner et al. (1982) were as follow. The chemistry learning problems that related to the necessity aspects included: (1) the teacher presented incomplete concepts; (2) the teacher did not discuss the properties of the buffer solution; and (3) the teacher did not discuss completely the function of the buffer solution in the living things. The chemistry learning problems that related to aspects of intelligibility included: (1) the teacher asked successive questions; (2) the teacher answered her own questions; (3) the teacher gave wrong information; (4) the teacher made an unclear and wrong analogies; and (5) the teacher did not ask the students' reasons.

The chemistry learning problems that related to plausibility aspects included the teacher did not emphasize the importance of the context and the teacher ignored the alternative conceptions of students. The chemistry learning problems that related to fruitfulness aspects included teacher gave less complex problems in term of the application of the concepts of buffer solutions in everyday life. On the other hand, the misconceptions that were experienced by students included: (a) CH_3COONa was an acidic salt; (b) CH_3COOH was a strong acid; (c) CH_3COONa was the conjugate acid of NaOH; (d) the mixture of HCN and NaCl formed the buffer solution; (e) NaCl was the salt without pH; (f) the buffer solution might be formed from weak acids and salts; and (g) the buffer solution was the solution having the unchanged pH even though it was dropped by slight acids, slight bases, or was diluted with water even in large quantities.

Based on the results of the study it could be suggested that the teachers, especially problems related to the students' misconceptions. They can design effective lesson plans to improve students' understanding toward the chemistry concepts learnt and to remediate the students' misconceptions.

REFERENCES

Allsop, R., & George, N. H. (1982). Redox in Nuffied Advanced Chemistry. *Education in Chemistry*, *19*, 57–59.

Aydin, S. (2012). Remediation of Misconceptions about Geometric Optics Using Conceptual Change Texts. *Journal of Education Research and Behavioral Sciences*, *1*(1), 1–12.

Balci, S., Cakiroglu, J., & Tekkaya, C. (2006). Engagement Exploration, Explanation, Extension, and, Evaluation (5E) Learning Cycle and Conceptual Change Text as Learning Tools. *Biochemistry and Molecular Biology Education*, *34*(3), 199–203.

Banerjee, A. C. (1991). Spontaneity, Reversibility, and Equilibrium. In *the Eleventh International Conference on Chemical Education*. London, UK.

Barke, H. D., Hazari, A., & Yitbarek, S. (2009). *Misconceptions in Chemistry*. Heidelberg: Springer-Verlag.

Barral, F. L., Fernandes, E. G. R., & Otero, J. R. G. (1992). Secondary Students' Interpretations of The Process Occurring in An Electrochemical Cell. *Journal of Chemical Education*, *69*, 655–657.

Baser, M. (2006a). Effect of Conceptual Change Oriented Instruction on Students' Understanding of Heat and Temperature Concepts. *Journal of Maltese Education Research*, *4*(1), 64–79.

Baser, M. (2006b). Fostering Conceptual Change by

Cognitive Conflict Based Instruction on Students' Understanding of Heat and Temperature Concepts. *Eurasia Journal of Mathematics, Science and Technology Education*, *2*(2), 96–114.

Berber, N. C., & Sarı, M. (2009). The Effect of Understanding the Conceptual Change Texts in Subject Work, Power, Energy. *Journal of Ahmet Kelesoglu Education Faculty*, *27*, 159–172.

Bojczuk, M. (1982). Topic Difficulties in O- and A-level Chemistry. *School Science Review*, 545–551.

Bradley, J. D., & Mosimege, M. D. (1998). Misconceptions in Acids & Bases: A Comparative Study of Student Teachers with Different Chemistry Backgrounds. *South African Journal of Chemistry*, *51*, 137–155.

Brist, H. C. (2012). *The Effect of a Contextual Approach to Chemistry Instruction on Students' Attitudes, Confidence, and Achievement in Science*. Montana State University.

Butts, B., & Smith, R. (1981). What do Students Perceive as Difficult in HSC Chemistry? *Australian Science Teachers Journal*, *32*, 45–51.

Calik, M., Okur, M., & Taylor, N. (2011). A Comparison of Different Conceptual Change Pedagogies Employed within The Topic of Sound Propagation. *Science Education Technolgy*, *20*, 729–742.

Cetengul, I. P., & Geban, O. (2005). Understanding of Acid-Base Concept by Using Conceptual Change Approach. *Hacettepe University Journal of Education*, *29*, 69–74.

Cetengul, I. P., & Geban, O. (2005). Understanding of Acid-Base Concept by Using Conceptual Change Approach. *Hacettepe University Journal of Education*, *29*, 69–74.

Chiu, M. H. (2005). A National Survey of Students' Conceptions in Chemistry in Taiwan. *Chemical Education International*, *6*(1), 1–8.

de Jong, O. (1982). Difficult Topics. *Chemisch Weekblad*, *78*, 90–91.

de Jong, O., Acampo, J., & Verdonk, A. (1995). Problems in Teaching the Topic of Redox Reactions: Actions and Conceptions of Chemistry Teachers. *Journal of Research in Science Teaching*, *32*(10), 1097–1110.

Dilber, R., & Duzgun, B. (2008). Effectiveness of Analogy on Students' Success and Elimination of Misconceptions. *American Journal of Physics Education*, *2*(3), 174–183.

Finley, F. N., Stewart, J., & Yarroch., W. L. (1982). Teachers' Perceptions of Important and Difficult Science Content. *Science Education*, *66*, 531–538.

Gadgil, S., Nokes-Malach, T. J., & Chi, M. T. H. (2011). Effectiveness of Holistic Mental Model Confrontation in Driving Conceptual Change. *Learning and Instruction*, *30*, 1–15.

Garnett, P. J., & Treagust, D. F. (1992a). Conceptual Difficulties Experienced by Senior High School Students of Electrochemistry: Electric Circuit and Oxidation-Reduction Equation. *Journal of Research and Science Teaching*, *29*, 121–142.

Garnett, P. J., & Treagust, D. F. (1992b). Conceptual Difficulties Experienced by Senior High School Students of Electrochemistry: Electrochemical (Galvanic) and Electrolytic Cells. *Journal of Research and Science Teaching*, *29*, 1079–1099.

Hennessey, M. G. (2003). Metacognitive Aspects of Students' Reflective Discourse: Implications for Intentional Conceptual Change Teaching and Learning. In P. R. Sinatra, G. M. & Pintrich (Ed.), *Intentional Conceptual Change* (pp. 103–132). Mahwah, NJ: Lawrence Erlbaum.

Hewson, P. W., & Thorley, R. (1989). The Condition of Conceptual Change in The Classroom. *International Journal of Science Education*, *11*, 541–553.

Kaya, E., & Geban, O. (2012). Facilitating Conceptual Change in Rate of Reaction Concepts Using Conceptual Change Oriented Instruction. *Education and Science*, *37*(163), 216–225.

Khasanah, N., Wartono, & Yuliati, L. (2016). Analysis of Mental Model of Students Using Isomorphic Problems in Dynamics of Rotational Motion Topic. *Jurnal Pendidikan IPA Indonesia*, *5*(2), 186–191.

Khun, T. S. (1970). *The Structure of Scientific Revolution*. Chicago: The University of Chicago.

Kose, S., Kaya, F., Gezer, K., & Kara, I. (2011). Computer Aided Conceptual Change Texts: A Sample Course Application. *Journal of Pamukkale University Education*, *29*(1), 73–88.

Kurniawan, A. M. (2012). *Menggali Pemahaman Siswa SMA pada Konsep Larutan Penyangga Menggunakan Instrumen Diagnostik Two-tier*. Malang: UM Press.

Madu, B. C., & Orji, M. (2015). Effects of Cognitive Conflict Instructional Strategy on Students' Conceptual Change in Temperature and Heat. *SAGE Open*, (July-September), 1–9.

Nahum, T. L., Hofstein, A., Mamlok-Naaman, R., & Bar-Dove, Z. (2004). Can Final Examinations Amplify Students' Misconception in Chemistry? *Chemistry Education Research and Practice*, *5*(3), 301–325.

Onder, I., & Geban, O. (2006). The Effect of Conceptual Change Texts Oriented Instruction on Students' Understanding of the Solubility Equilibrium Concept. *Hacettepe University Journal of Education*, *30*, 166–173.

Orgill, M., & Sutherland, A. (2006). Undergraduate Chemistry Students' Perception of and Misconception about Buffer and Buffer problems. *Chemistry Education Research and Practice*, *9*, 131–143.

Pinker, S. (2003). *The blank state: Modern Denial of Human Nature*. New York: Harper.

Posner, G. J., Strike, K. A., Hewson, P. W., & Gertzog., W. A. (1982). Accommodation of a Scientific Conception: Toward a Theory of Conceptual Change. *Science Education*, *88*(2), 211–227.

Redhana, I. W. (2011). Miskonsepsi Siswa pada Topik Hidrokarbon. In *Seminar Nasional MIPA I*. Singaraja, Indonesia: Universitas Pendidikan Ganesha.

Redhana, I. W., & Kirna, I. M. (2004). *Identifikasi Miskonsepsi Siswa SMA Negeri di Kota Singaraja terhadap Konsep-Konsep Kimia*. Singaraja, Indonesia.

Ross, B., & Munby, H. (1991). Concept Mapping and Misconceptions: A Study of High School Students' Understanding of Acids & Bases. *International Journal of Science Education*, *13*, 11–24.

Rufaida, S., & Sujiono, E. H. (2013). Pengaruh Model Pembelajaran dan Pengetahuan Awal terhadap Kemampuan Memecahkan Masalah Fisika Peserta Didik Kelas XI IPA MAN 2 Model Makassar. *Jurnal Pendidikan IPA Indonesia*, *2*(2), 161–168.

Santrock, J. W. (2011). *Educational Psychology* (5th ed.). New York: The McGraw Hill Company, Inc.

Santyasa, I. W. (2008). *Pengembangan Pemahaman Konsep dan Kemampuan Pemecahan Masalah Fisika bagi Siswa dengan Pemberdayaan Model Perubahan Konseptual Berseting Investigasi Kelompok*. Singaraja, Indonesia.

Sinatra, G., & Broughton, S. (2011). Review of Research Bridging Reading Comprehension and Conceptual Change in Science Education: The Promise of Refutation Text. *Reading Research Quarterly*, *46*(4), 374–393.

Tas, E., Gulen, S., Oner, Z., & Ozyurek, C. (2015). The Effects of Classic and Web-Designed Conceptual Change Texts on The Subject of Water Chemistry. *International Electronic Journal of Elementary Education*, *7*(2), 263–280.

Taslıdere, E. (2013). Effect of Conceptual Change Oriented Instruction on Students' Conceptual Understanding and Decreasing Their Misconceptions in DC Electric Circuits. *Creative Education*, *4*(4), 273–282.

Trundle, K. C., & Bell, R. L. (2009). The Use of a Computer Simulation to Promote Conceptual Change: A Quasi-Experimental Study. *Computers & Education*, *54*, 1078–1088.

Tsai, C. C., & Chou, C. (2002). Diagnosing Students' Alternative Conceptions in Science. *Journal of Computer Assisted Learning*, *18*(2), 157–165.

Wenning, C. J. (2008). Dealing More Effectively with Alternative Conceptions in Science. *Journal of Physics Teacher Education Online*, *5*(1), 11–19.

Widarti, H. R., Permanasari, A., & Mulyani, S. (2016). Student Misconception on Redox Titration (A Challenge on The Course Implementation through Cognitive Dissonance Based on the Multiple Representations). *Jurnal Pendidikan IPA Indonesia*, *5*(1), 56–62.

Yumusak, A., Maras, I., & Sahin, M. (2015). Effects of Computer-Assisted Instruction with Conceptual Change Texts on Removing the Misconception of Radioactivity. *Journal for the Education of Gifted Young Scientist*, *3*(2), 23–50.