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The Students' Critical Thinking Skill in Exploiting Covalent Bond Material

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This study aims to analyze students' critical thinking skill in exploiting covalent bond material. The method applied in this study was descriptive qualitative with a case study approach. It was conducted at one of high schools in Bandung were the participants were the tenth grade students'. The instruments used for data collection were audio, video and observation sheets. The collected data were analyzed using Transcript Based Lesson Analysis (TBLA). The results indicated that three out of twelve indicators of critical thinking skill had been identified in learning covalent bonds. The three indicators are formulating questions, answering the "why" questions, and identifying differences. The low achievement of critical thinking indicators was due to the method used in teaching which is still informative or transferring knowledge from teacher to student (teacher-centered) without giving sufficient time for students to reflect the material presented, link it with prior knowledge, or apply it in real life situations.

1. Introduction

The significance and rapid progress of science and technology in the 21st century demands students to have thinking skills to compete in a worldwide level The dominant thinking skill required in the 21st century is critical thinking skill (Fuad, Zubaidah, Mahanal, & Suarsini, 2017). Critical thinking skill promotes the emergence of new ideas and inventions as the basis for comparative and competitive excellent product creation in global competition (Martincova & Lukesova, 2015). The learning process in schools must facilitate students to develop 21st century skills, namely creative, innovative, collaborative, and communicative skill together with critical thinking and problem-solving skill to welcome the industrial revolution 4.0 era (Permendikbud, 2018).

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Various studies revealed that Indonesian students' critical thinking skill is still low. Some of them report of Program for International Student Assessment (PISA) in 2018 and Trends in Mathematics and Science Study (TIMSS) in 2011 placed Indonesian students' performance in scientific literacy below the international average (OECD, 2019; Kemendikbud, 2011). Science literacy is viewed as an understanding of scientific knowledge and higher order thinking ability (OECD, 2009).

There are a lot of education experts defined critical thinking skill, one of them is Yu who specified critical thinking as a type of high-level cognitive activities involving skills related to logical learning and problem solving (Yu, Lin, & Fan, 2015). Magno gave another point of view of critical thinking which based on four factors: conclusion (the ability to distinguish correct and wrong), deduction (the ability to think deductively), interpretation (the ability to distinguish between incorrect data generalization and unnecessary data), and arguments evaluation (the ability to distinguish relevant and irrelevant arguments) (Magno, 2010). According to Dwyer et al, critical thinking is part of the metacognitive process used to construct logical solutions to the problems (Dwyer et al., 2014). Critical thinking skill according to Lai includes ability to analyze arguments, make conclusions using inductive or deductive reasoning, assess or evaluate, and make decisions or solve problems (Lai, 2011). According to Liu et al, critical thinking is an agreement within cognitive dimensions which involve interpretation, evaluation, analysis, explanation and self-regulation (Liu et al., 2014). Ennis expresses critical thinking skill as a reasonable and reflective thinking that focuses on deciding what to believe or do (Fisher, 2009).

Ennis classified critical thinking into five aspects consisting of: (1) elementary classification, (2) basic support, (3) inference, (4) advanced clarification, and (5) strategies and tactics. Each of these aspects is further elaborated into several indicators of critical thinking (Ennis, 2001). The indicators are specified according to natural science learning by Liliasari namely: (1) formulating questions; (2) answering the why question, question asking the main reason, and question about facts; (3) identifying conclusion and reason, classifying similarities and differences, selecting relevant things, and summarizing; (4) adjusting with the source, giving reasons, and possessing cautious habits; (5) reporting based on observations, reporting generalization of experiments, reinforcing thoughts, good conditioning; (6) interpreting questions; (7) generalizing and researching; (8) applying acceptable principle and considering alternatives; (9) determining the definition of the strategy and the subject matter; (10) identifying assumptions from the unstated reasons and constructing questions; (11) formulating the problem, choosing criteria for the solution, formulating alternative solutions, determining things to do tentatively, summarizing by considering the situation and then making decision; (12) using logical strategies (Liliasari, 2002).

Critical thinking skill will not develop properly without conscious effort to develop them during learning (Zohar, Weinberger, & Tamir, 1994). Practicing critical thinking skill is very important to equip students to develop the abilities they have in solving problems and explaining the phenomena existed in daily life

(Erna et al., 2018). An area of study which contributes in developing students' critical thinking skill is chemistry.

The chemistry instruction in schools nowadays mostly uses teacher-centered learning. The chemistry learning in school tends to be informative or only in the form of transfer of knowledge from teacher to student without involving activities to recognize why the knowledge is important to be learnt. Conventional learning emphasizes on the content recitation, without giving students sufficient time to reflect on the material presented, connecting it to prior knowledge, or applying it to real life situations (Burrowes, 2003).

Based on interviews with several chemistry teachers, conventional learning is still the most popular method among the teachers since they still hold the believe that conventional method is the easiest method to be implemented, does not require a lot of media, and can save the time as it does not require excess preparation. Based on the problems aforementioned before, the researcher conducted a case study which aims to find out how students' critical thinking skill in conventional learning.

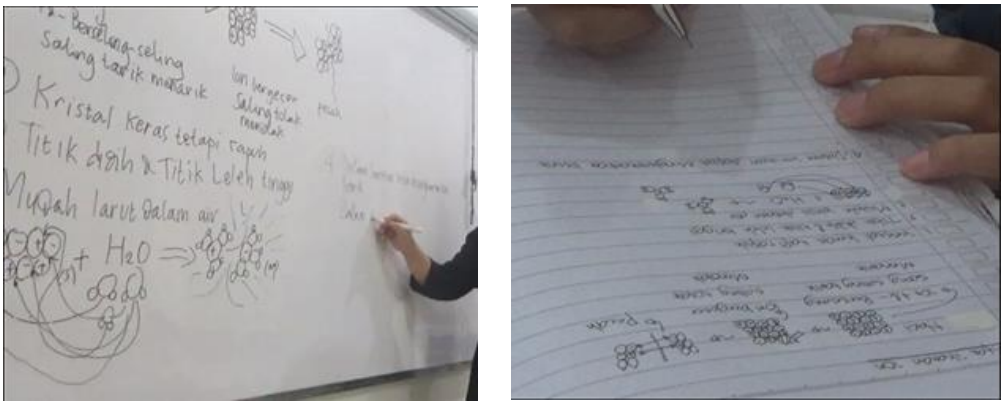
2. Methodology

This is a descriptive research using case study method. It was chosen because the researcher wanted to describe students' critical thinking skill during the conventional learning process. The study was conducted by observing the chemistry instruction of tenth grade students in covalent bond material in one of the high school in the Bandung. The instrument used in the study was an audio, video and observation sheets. Learning analysis was carried out based on Transcript Based Lesson Analysis (TBLA). TBLA aims to investigate the characteristics of learning (Arani, 2017). The students' critical thinking skill was identified using specific critical thinking indicators for learning natural science proposed by Liliasari.

3. Results and Discussion

The Conventional Learning in Covalent Bond Material

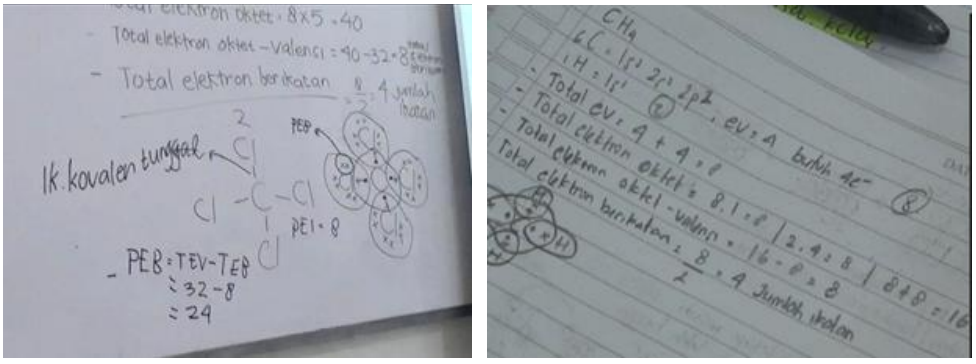
Based on the result of the observation, the learning process was informative. In the preliminary activity during the lesson hour, the teacher used the time to repeat the topics that had been studied previously, namely the nature of ionic bond. To stimulate students' memories about the nature of ionic bonds, the teacher asked students to imagine the form of ionic bond in the kitchen salt compound. The teacher drew the arrangement of the Na+ and Cl- ions from the NaCl crystal on the board, from which the teacher reviewed the ionic bond properties. The students were required to note the teacher's explanation in their notebook.



(a) (b)

Figure 1. (a) Teacher was explaining the ionic bond properties, (b) students were taking notes on teacher's explanation

In the main activity, the teacher focused the learning by dividing it into five stages. The first stage started from the teacher's explanation on the difference between ionic bond and covalent bond. The second stage was the explanation of Lewis's structure of covalent molecules. The third stage was related to bonding pair, lone pairs and single covalent bond. The fourth stage explained the double covalent bond. The last stage was the triple covalent bond material. Each stage was carried out by delivering information to the students. However, the students were given only a chance to practice making the Lewis structure of CH4 molecule.



(a) (b)

Figure 2. (a) the teacher's explanation on bonding pair, lone pairs and single covalent bond, (b) students' practice in making Lewis structure of CH4 molecule

The learning process did not provide sufficient motivation to students. Some students were drowsy, some others used mobile phones, and others joked around when the teacher explained the lesson. Students were not given enough time to reflect on the material presented. They tended to agree and accept the information from the teacher without daring to ask questions and assert their thoughts. Overall, the learning process was not challenging enough and provided less opportunities

for students to think critically to find and solve problems related to the concept being learned.

The Students' Critical Thinking Skill in Learning Process

The results of students' critical thinking skill analysis based on Transcript Based Lesson Analysis (TBLA) and referring to the specific critical thinking indicators for learning natural science proposed by Liliasari, revealed that only three out of twelve indicators of critical thinking skills occurred once during the learning process. The three indicators are explained as followed.

Formulating questions

An indicator to measure students' critical thinking skill in learning natural science proposed by Liliasari is formulating questions. The indicator appeared at the end of the lesson when the teacher concluded the type of covalent bond based on the number of bonds formed. Students' interpretation of the conclusion stimulated a student's logic to ask questions. However, the teacher did not immediately answer the question and threw it to all students. It can be seen from the following transcript.

Teacher : If there are two bonds, what kind of bond is this?
Student : A pair.
Student : If there are four bonds, is it quadruplicate ma'am?
Teacher : Is there any quadruplicate bond?
Student : No ma'am.
Teacher : Next time we're going to find out more, but for now it is enough to have a bonding pair.

Answering the "why" questions

The students' ability to answer the "why" question indicates that they think critically (Liliasari, 2002). In the second stage of learning Lewis's structure, before the teacher explained how to describe the Lewis structure of the CCl_4 molecule, the teacher asked students to determine the central atom of the CCl_4 compound and one student could answer and give reasons. It can be seen from the following transcript.

Teacher : Now we are going to draw the arrangement of the atoms. Here we have CCl_4. We need to decide which one the central atom is.
Student : C..
Teacher : Why do you think so?
Student : Because it is only one.
Teacher : Yes. To decide the central atom, we need to see the least atom in a compound.

Identifying differences

In the first stage of the learning process, the teacher attempted to construct students' knowledge about covalent bond so the teacher asked the students about the differences between NaCl and HCl compounds. The students did not know the differences at first. Therefore, they answered NaCl was salt and HCl was acid. The teacher affirmed that the differences can be seen from the bond but no one can answer it correctly. Then, the teacher asked one of the students to write the electron configuration of the Na, Cl, and H atoms on the board. Based on the electron configuration, the teacher explained the mechanism of NaCl compound formation and how HCl compound was formed in Lewis structures. After that, the teacher asked the difference between the compounds of NaCl and HCl. Finally, a student managed to identify the differences between the two compounds. It can be seen from the following transcript.

Teacher : Now, I have a question. What is the difference between NaCl and HCl?
Student : HCl is an acid while NaCl is salt.
Teacher : Good. What is the difference from the bond? What should you do if you want to know the bond?
Student : We need to configure the compounds.
Teacher : OK. Who can configure the electron of Na, Cl, and H in front?
Student : Irene ma'am.
Teacher : OK
Teacher : Look at this. How many valence electrons that Na has?
Student : One.
Teacher : Yes. How many valence electrons of Cl?
Student : Seven
Teacher : Yes, now, please explain how do they make the bond?
Student : Na gives an electron to Cl.
Teacher : If Na gave an electron, is it giving up or taking the electron?
Student :Giving up ma'am.
Teacher : So, what do they make?
Student : Na^+.
Teacher : What about Cl?
Student : Take an electron from Na.
Teacher : So, what does it become?
Student : Cl^-.
Teacher : Now, is Na a metal or non-metal?
Student : Metal.
Teacher : What about Cl?
Student : Non-metal.
Teacher : How is the electronegativity? Take a look at the book.
Student : It is big ma'am.
Teacher :From the characteristics mentioned before such as electron giving up, metal with non-metal, big electronegativity difference, what can we conclude about the bond?
Student : It is ionic bonding ma'am.

Teacher : Yes, NaCl is ionic bonding. What about HCl?
Student : H giving up one, how is the electron?
Teacher : It's gone ma'am.
Teacher : Is it stable or not?
Student : No, it does not.
Teacher : If we want to make it stable, how many electrons does it need?
Student : Two ma'am.
Teacher : H needs one and CL also needs one. How can they complete each other?
Student : They can do that alternatively.
Teacher : H used an electron from Cl and Cl also used an electron from H.
Student : Is it possible ma'am?
Teacher : Of course, it is. This is called shared electrons. What do they use together?
Student : The pairs of electrons.
Teacher : What do we call the bond?
Student : Covalent bond ma'am.
Teacher : Great Noval! Have you read this before?
Student : Yes, ma'am.
Teacher : How does its electronegativity compared to NaCl?
Student : It is smaller ma'am.
Teacher :So, what is the difference between NaCl and HCl?
Student : NaCl has ionic bond.
Teacher : Hmm…
Student : HCl has covalent bond.
Teacher : Yes, correct.

4. Conclusion

Based on the results of data analysis and discussion, it can be concluded that three of the twelve critical thinking skill indicators had been achieved in learning covalent bond. The three indicators were formulating questions, answering the "why" questions, and identifying differences. The low achievement of critical thinking indicators was due to the method used in teaching which is still informative or transferring knowledge from teacher to student (teacher-centered) without giving sufficient time for students to reflect the material presented, link it with prior knowledge, or apply it in real life situations. The results also showed that students' critical thinking skill could not only be analyzed based on the pre-test and post-test results but could also be seen from the students' activities that appeared in the learning process. However, as a comparison, further research is needed that measures students' critical thinking skills in conventional learning based on pre-test and post-test results.

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