Students' Chemical Literacy on Context-Based Learning: A Case of Equilibrium Topic

Students' Chemical Literacy on Context-Based Learning: A Case of Equilibrium Topic

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Abstract. This study was aimed to analyze the students' chemical literacy on context based chemical equilibrium learning. This research used quantitative approach with survey method. A total 92 students of 11th grade from two public high schools in Special Region of Yogyakarta, Indonesia were selected using the purposive sampling technique. The data were collected using open-ended questions namely Chemical Equilibrium Literacy Test (CELT) to analyze the students' chemical literacy ability in the topics of coral reef, hypoxia, teeth enamel, and ammonia production. CELT used 3 indicators of Higher-Order Learning Skills (HOLS) on chemical literacy, namely identifying the information, connecting the information and analyzing information. Data from CELT was analyzed using ideal rating category. The result of this study showed that only one third of the sample that has a good chemical literacy ability on the context-based chemical equilibrium learning. This study suggests that the context-based learning process should be always applied to school in order to improve the students' chemical literacy ability better.

1. Introduction

Scientific literacy is defined by the Programme for International Student Assessment (PISA) as the ability to engage with science-related issues and the ideas of science as a reflective citizen [1]. The PISA result towards the students' scientific literacy that were conducted on 2015 has revealed that the students' scientific literacy in Indonesia were still below the average score, which is 403 out of the average score 493 [1]. Meanwhile, chemistry is a part of science. The low of scientific literacy in Indonesia may indicate that the students' chemical literacy also not good. This was supported by the research conducted by [2] which state that students' chemical literacy is still in medium category. The results of this study were in line with [3] that concluded only some students achieved high levels of chemical literacy. The students aren't be able to relate the chemical learning that they received in the school into daily life activities. For the students, science learning that applied in the school is the separate lessons from life. This caused the students couldn't be able to relate and make a use of the scientific concepts that has been studied to encounter with the problems in their life [4].

Therefore, to overcome that problems, government applied curriculum 2013 as an effort to improve the education quality in Indonesia. The low score of PISA result is one of the rational foundation for curriculum 2013 development. The curriculum 2013 also has a principle that education is not allowed to separate the learner from their environment and the curriculum development should

be based on the principle of relevance of the education that suitable to the needs and the environment of the learner [5]. In other words, curriculum gives another opportunity to the students to learn about the problems in their community environment as the curriculum content and an opportunity to apply the lessons they have studied in the classroom into the daily life. This principle is very closely related to chemical literacy.

According to [6], chemical literacy consisted of 4 domains which are the chemical content of knowledge, chemistry in the contexts, Higher Order Learning Skill (HOLS) and affective aspect. The student who understands the chemistry literacy should be able to comprehend the general ideas of science and the characteristic of chemistry. Contextually, the students who are chemically illiterate should be able to acknowledge the importance of chemical knowledge to explain the phenomenon of daily life and use his understanding in daily life. They also should be able to ask a question, look for the information and explain those phenomenon using the scientific evidences also be able to evaluate the pros and cons of an argument. The students who are chemically illiterate has a fair and rational perspective towards chemistry and showed the interest towards the chemical related issues especially in the non-formal environment like pers.

The students who only taught about the concept usually tend to memorize and comprehend the lesson they've learnt. One of the learning approach that can help the students to relate the learning content and the daily life is the context-based learning. Context-based learning has a purpose to cope with the students less interest in learning science at school and to provide the learning environment that could help the students to understand the relevance of scientific content towards individual life, society or occupation in the future [7]. Context-based learning will be more beneficial for the students since the contents on their learning can be directly related and be applied in daily life. Moreover, in the terms of affective, context-based learning can help to improve the students' positive responses on chemistry [1]. The result of [8] research showed that learning using the context-based approach is better compared to traditional learning to improve the students' chemical literacy on the thermochemical and thermodynamics concepts.

One of the chemistry concept that has a lot of context in daily life is the chemical equilibrium. Fundamentally, the chemical equilibrium is important to comprehend the basic concept of chemistry (the solubility equilibrium and acid-base equilibrium). Chemical equilibrium is a concept learned in high school and present at the national examination. However, compared to the other topics, the chemical equilibrium subject is one of the most difficult topics to learn [9]. There are a lot of contexts that can be used on chemical equilibrium concept, for example the coral reef, the oxygen binding in the blood, the teeth enamel damage and others. The results of the study of [10] revealed that context-based chemical equilibrium learning had a positive influence on student achievement, motivation in learning chemistry and a constructive learning environment. The education for the chemical literacy has been a general purpose to understand the chemistry from any range of age [11]. Hence, the objective of the research is to analyze the students' chemical literacy ability on the context-based chemical equilibrium learning.

2. Research Methods

2. 1. Research design and procedure

This research used quantitative approach with survey method. In this research, the survey method used to analyze the students chemical literacy profile on the chemical equilibrium which consists of various topics of chemical equilibrium in daily life. The test was given after the implementation of the context-based chemical equilibrium learning process. Samples in this study were chosen from two public high schools in the Special Region of Yogyakarta, Indonesia using the convenience sampling. The school that was chosen as the samples have same characteristic i.e have a very good school accreditation and on the middle-categorized for the national chemistry test scores. A total 92 students were randomly selected. They are 16- 17 years old.

2.2. Data collection and research instrument

The data used in this study were obtained from the Chemical Equilibrium Literacy Test (CELT). CELT was open-ended questions which consisted of 4 chemical equilibrium topics (coral reef, hypoxia, teeth enamel, and ammonia production). The researcher developed the chemical literacy ability test by synthesizing the aspects of chemical literacy according to [12] and [1]. There are 3 indicators of HOLS in the chemical literacy ability which are identifying the information, connecting the information and analyzing the information that were used in CELT. Other than that, the students were asked to give an argument on the issues for every topic in the affective aspect questions but discuss in other papers. CELT also adjusts chemical equilibrium concept that was present on syllabus of high school chemistry course. The grid of CELT could be seen on the Table 1.

Table 1. The grid of CELT

Chemical in the context	Chemical content knowledge	HOLS	No
Coral reef (environment)	The dynamic equilibrium	Identifying the information	1a
	The reaction equation of chemical equilibrium	Identifying the information	1b
	Homogeneous and heterogeneous equilibrium	Analyzing the information	1c
	The factors that affecting the friction of equilibrium	Analyzing the information	1d
Hypoxia (health)	The reaction equation of chemical equilibrium	Identifying the information	2a
	The equilibrium constant of Kc and Kp	Identifying the information	2b
	The determination of Kc value	Connecting the information	2c
	The connection between Kp and Kc	Analyzing the information	2d
Teeth enamel (health)	The factor that affecting the friction	Connecting the information	3a
	of chemical equilibrium	Connecting the information	3b
Ammonia production (industry)	The reaction equation of chemical equilibrium	Identifying the information	4a
	The determination of Kc value	Analyzing the information	4b
	The factor that affecting the friction	Connecting the information	4c
	of chemical equilibrium	Connecting the information	4d

CELT has been tested for its validity and reliability. The validation has been done theoretically and empirically. The theoretical validation has been done by asking for the expert judgement namely 2 expert lecturers who are majoring in chemistry. According to the expert judgement, the instrumental was stated as the decent instrumental materially, constructively and by the language.

Furthermore, CELT has been empirically tested to 110 students. Based on the result of the empirical validity analysis, there were 5 items that were not accordance with the Partial Credit Model (PCM) out of the 19 item questions that has been tested. This showed that there were 14 item questions (consists of 4 topics) that can be used on CELT. Cronbach Alpha reliability from CELT was 0,92. It was concluded that the CELT can be used to collect the data.

2.3. Data analysis

The collected data from CELT was analyzed using the descriptive quantitative method with categorization. The score was categorized based on the ideal rating category suggestion by [13] with ideal maximal score is 34 and ideal minimal score is 14. It divided into 5 categories, namely very good, good, quite good, less good, and bad. The score of the ideal rating category can be seen in Table 2.

Table 2. Ideal rating category

No.	Score Range	Category
1	$X > 30.50$	Very good
2	$26.83 < X \leq 30.50$	Good
3	$23.17 < X \leq 26.83$	Quite good
4	$19.5 < X \leq 23.17$	Less good
5	$X \leq 19.5$	Bad

3. Result and Discussion

3. 1. The level of students' chemical literacy

The chemical literacy profile data was obtained from CELT that has been done on the 92 samples. The result of the chemical literacy profile that has been analyzed based on the ideal rating category on this research could be seen on the Figure 1.

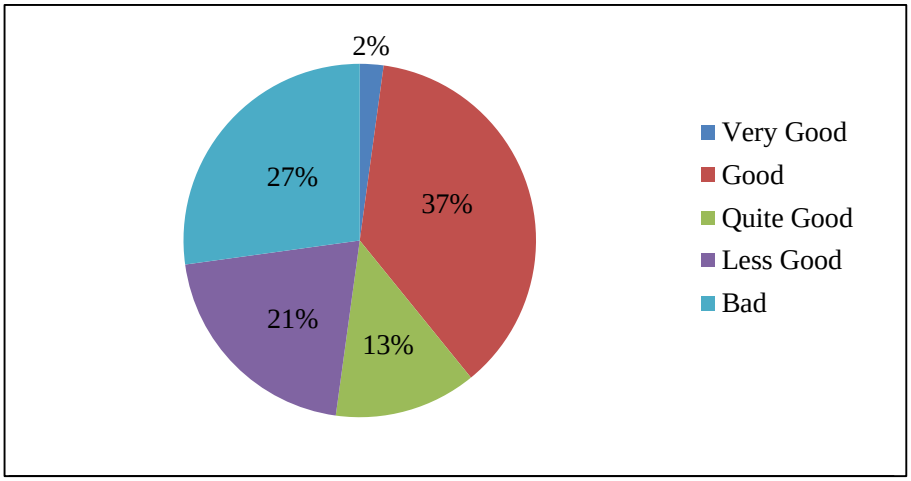

Figure 1. The level of students' chemical literacy.

Based on the Figure 1, it could be seen that the students' chemical literacy ability in good category was highest (37%). However, students' chemical literacy in bad (21%) and less good (27%) also had a high percentage. The students with chemical literacy category were very good only 2%. It can be concluded that there were many students who had low chemical literacy. This is supported by [14] research which stated that students' chemical literacy levels were low, students also lacked high order thinking skills in analytical thinking and reasoning to applied their knowledge for solving everyday life problems related to chemistry. Students' chemical literacy was still low because students were not familiar with context-based learning. Students were less active and less collaborative when context-based chemical equilibrium learning was carried out. However, some of students were interested with context-based chemical equilibrium learning because they could learn chemistry based on real life.

According to the students' chemical literacy profile on the context-based chemical equilibrium learning, there should be a reconstruction that can improve the chemical literacy ability. Learning concept with the daily life problems is very necessary. The chemical learning was introduced to the students with the chemical aspects that relatively restricted and unnecessary theoretical concept that can't be used in their future life [3]. The research that conducted by [8] revealed that learning using the context-based approach is better to improve the students' chemical literacy than traditional learning on the thermochemical concept. This learning allows the teacher to connecting the context that is used and the other relevant contexts in order to stimulate the students' way of thinking. Furthermore, context-based learning can be integrated with multiple representation approach that facilitate students' creative thinking skills [15]. It will give more chance to improve students' chemical literacy.

3. 2. Students' chemical literacy on each topic

The analysis of chemical literacy profile has been done by counting equally each scores topic on CELT which consisted of coral reef, hypoxia, teeth enamel, and the industry of ammonia production which is categorized into the very good, good, quite good, less good, and bad. The analysis result of the students' chemical literacy profile on the chemical equilibrium concept showed that there were still a lot of students on the less good and bad categories.

3.2.1. Topic 1: Coral reef (environment). The students' chemical literacy profile was reviewed based on the category percentage on the topic 1 could be seen on the Figure 2.

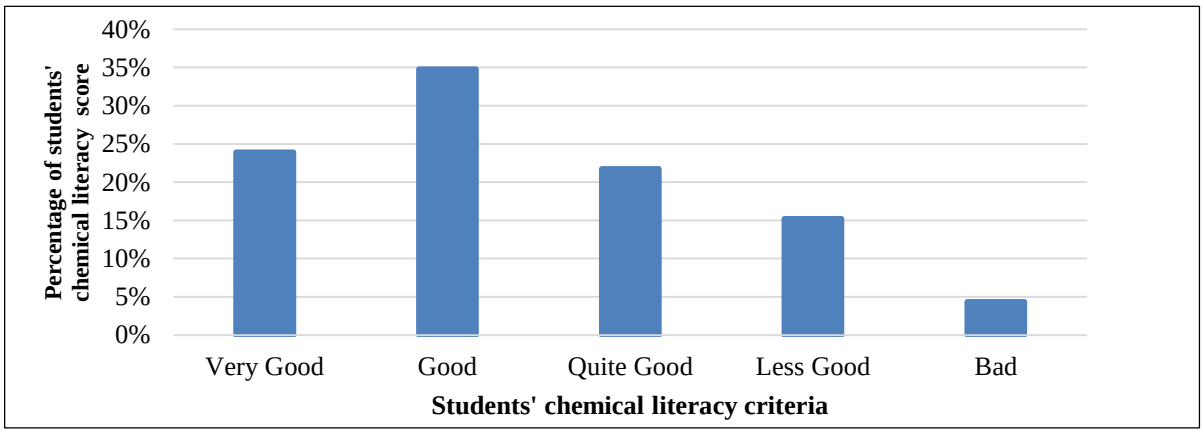

Figure 2. The students' chemical literacy percentage on the topic 1

Based on the Figure 1, it could be concluded that the most dominant students have the good criteria of the chemical literacy (34.78%). Meanwhile, the percentage of the students with very bad category was the very low (4.35%). This showed that mainly the students on the topic 1 already has the good chemical literacy ability.

This topic discussed about the coral reef which is one of the examples of the dynamic equilibrium in daily life. The students were asked to identify the definition of chemical equilibrium based on the coral reef concept that has been explained on the question. Mainly the students were only able to identify the equilibrium dynamic concept generally without related it to the dynamic equilibrium that happened on the coral reef. [16] stated that the equilibrium on the closed system usually is explained rapidly. The teacher should use some relatable examples in order to help the students understand the concept easily. On this topic, the students also were asked to make a chemical equilibrium reaction that happened on the coral reef and also tried to differentiate homogenous and heterogenous equilibrium. On this part, some of the students were already able to distinguish it very well. Before this test, students have been taught with context-based chemical equilibrium learning, so students are accustomed to associating the concept of chemical equilibrium with everyday life. Most students could answer questions well by identifying information and linking information. Based on the test results on topic 1, most students have reached HOLS.

3.2.2. Topic 2: hypoxia (health). The students' chemical literacy profile on the chemical equilibrium context-based learning on the topic 2 (hypoxia) could be seen on the Figure 3.

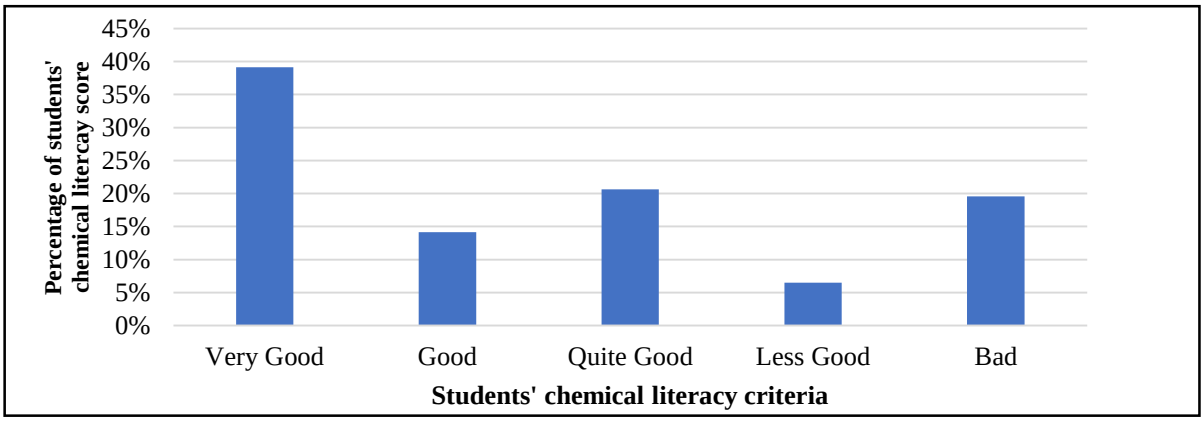

Figure 3. The students' chemical literacy percentage on the topic 2

Based on the Figure 3, it could be seen that the students' chemical literacy percentage on the topic 2 with very good category has the biggest percentage (39.13%) and the smallest percentage (6.52%) on the bad category. This could be concluded that on this topic, some of the students had already has the good chemical literacy ability.

This topic discussed about the hypoxia phenomenon that usually happened when someone climbed the mountain. Almost all the students could wrote down the right chemical equilibrium reaction that was happened between the hemoglobin and the oxygen on blood. However, some students still face the difficulty to determine the value of Kc when the blood pressure was known on the connected part of Kp and Kc. There were still lot of the students that made a wrong analysis of the questions that was why they answered it wrong too. [17] on his research showed that the students still has the limited ability when being asked to count the equilibrium constants. On this topic, the students were also asked to give an argument about the necessary preparation to do in order to avoid experiencing hypoxia. Some of the students were already gave the right arguments even though the others were still confused about the answer. This was because in the some areas around Yogyakarta, there are lot of mountains that could be climbed, so most of the students has done climbing the mountain and had some good experience about hypoxia phenomenon.

3.2.3. Topic 3: teeth enamel (health). The students' chemical literacy profile on the context-based chemical equilibrium learning on the topic 3 (teeth enamel) could be seen on the Figure 4.

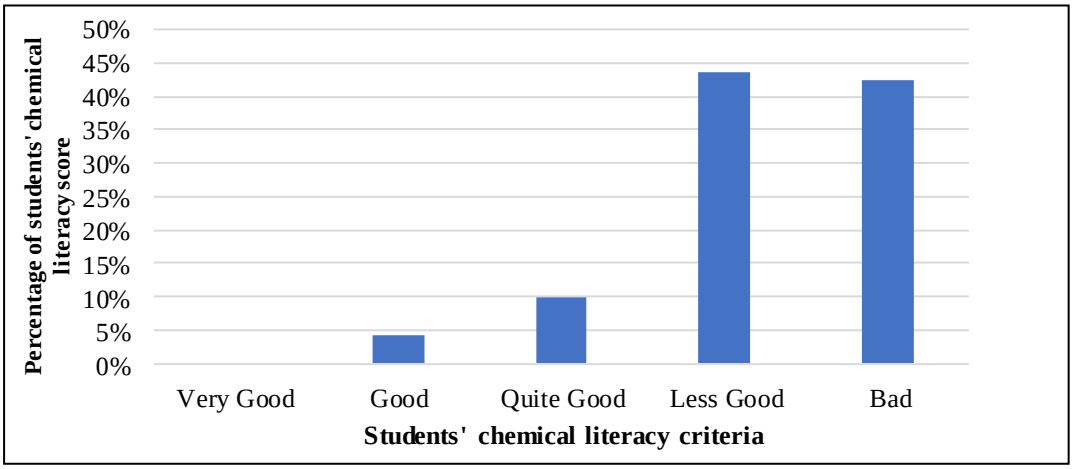

Figure 4. The students' chemical literacy percentage on the topic 3.

Based on the Figure 4, it could be seen that the students' chemical literacy percentage on the less good category (43.48%) and bad category (42.39%) were the biggest. The students on the good chemical literacy category was very small (4.35%). In short, the students' chemical literacy on the topic 3 was still low.

This topic discussed about the chemical equilibrium on the teeth enamel. The students were asked to determine the friction of the chemical equilibrium that happened on the teeth enamel based on some familiar factors, like the used of toothpaste that contains calcium and consuming the soft drinks. Most of the students were able to answer the friction question correctly, but some of the students were still confused about how could the friction happened. [18] on his research revealed that on the concentration change factor which could cause the friction in chemical equilibrium obtained the smallest average score. This was because of some students were stuck with the question and it made them solving the question inaccurately. This also supported by the result of [19] research that stated, the most common misconception which is about the interrupted equilibrium system by an increase in concentration has been found.

3.2.4. Topic 4: the industry of ammonia production (industry). The students' chemical literacy profile on the context-based chemical equilibrium learning on topic 4 could be seen on the Figure 5.

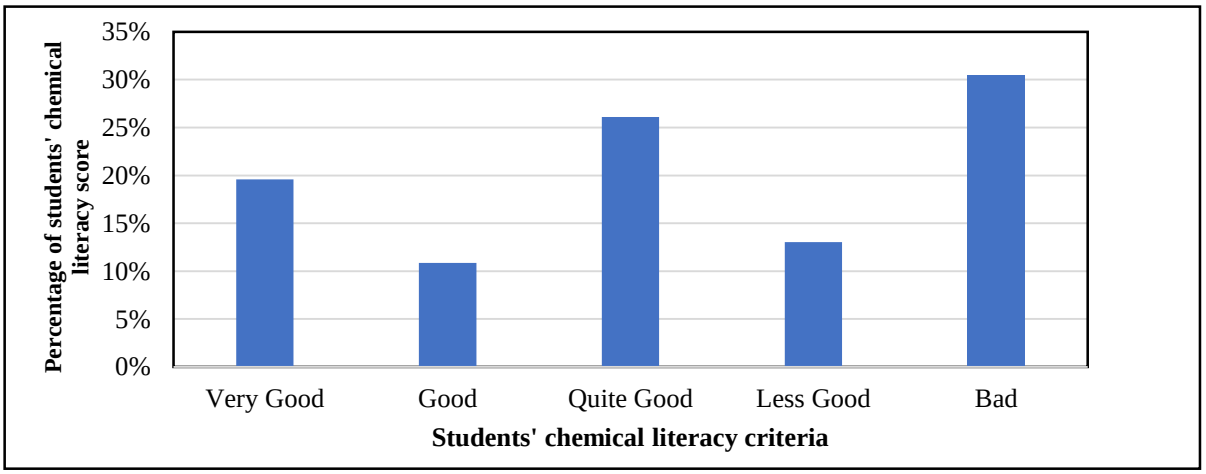

Figure 5. The students' chemical literacy percentage on topic 4.

Based on the Figure 5, it could be concluded that the most dominant of the students' chemical literacy on topic 4 is on the quite good category (26.09%) and bad category (30.43%). This showed that the students' chemical literacy on this topic are low.

Topic 4 discussed about the industry of ammonia production where the students were asked to determine the value of Kc on the ammonia equilibrium reaction and to predict the most on advantage ammonia production based on the factors that affecting the friction of the chemical equilibrium. However, most of the students were still having difficulty on answering the questions. [16] based on the result of his research revealed that not all the students were succeed on making a prediction on the Le Chatelier principle or the equilibrium law. Therefore, the teacher should be more focus on explaining to the students about the changing concentration and temperature against the friction of the equilibrium because those two factors are the main factors. [20] also revealed that the student difficulty on comprehending the chemistry concept related to the learning method that used by the teacher. The topic of ammonia industry was a difficult topic for students because this concept is not close to their lives.

4. Conclusion

Based on the obtained data on analysis of students' chemical literacy in context-based chemical equilibrium learning showed that only one third of students have good categories (2% very good and 37% good). That means there were many students (61%) who had chemical literacy skills in the low category. Context-based learning must often be applied in schools in order to improve students' chemical literacy skills.

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