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STUDENTS' CHEMICAL LITERACY PROFILE ON CHEMICAL EQUILIBRIUM MATERIAL: A CASE OF CORAL REEFS TOPIC

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ABSTRACT

Nowadays, chemical literacy is something important to discuss, including the benefits of chemical literacy itself. It can be the main purpose for teachers, experts, and curriculum policymakers. Chemical literacy is necessary for students since it can be a background for them to make a decision, build their critical thinking, and creativity, and help them solve daily problems or natural phenomena based on their knowledge. This research aimed to describe the students' chemical literacy profile on chemical equilibrium materials in coral reef topics. The research question posed in this study is "What is the profile of the chemical literacy level of high school students on the topic of chemical equilibrium on coral reefs?", then this research was designed to determine the chemical literacy profile of high school students on the topic of chemical equilibrium on coral reefs. This research explains the chemical literacy profile from each aspect, chemistry in context, chemistry as knowledge, high-order learning skills, and affective aspect. The type of research is quantitative descriptive research. The research subjects were all students in grade 11th in a senior high school in Magelang who had been taught about chemical equilibrium materials. The sample of the research was 100 students in grade 11th. The research data collection technique used was a questionnaire. The instrument used was the students' four-option close questionnaire sheet, in which the options were SD (Strongly Disagree), D (Disagree), A (Agree), and SA (Strongly Agree). Then, the data were analyzed by ideal criteria assessment. The result showed that the students' chemical literacy profile in chemical equilibrium materials is 61.3125%. It showed that the student's level of chemical literacy profile in chemical equilibrium materials is in a fair category. Therefore, the learning process can be modified to better support the development of high school students' chemical literacy profiles.

Keywords: Chemical Literacy Profile; Chemical Equilibrium; Coral Reefs

INTRODUCTION

Literacy level is one of the parameters of a nation's progress in the field of education (Pratama & Rohaeti, 2023). However, the newest result of the Program of International Student Assessment (PISA) conducted by the Organization for Economic Co-Operation and Development (OECD) in the literacy field showed unsatisfying results for Indonesia. The positions of Indonesia in 2009, 2012, 2015, 2018, and 2022 were 402, 396, 397, 371, and 359 in order. That score is categorized as below the average which is 500 (Pratama & Rohaeti, 2024). From the results of the PISA test, it can be said that the literacy level of students in Indonesia is still relatively low. Some factors causing the low scores of students' literacy in

Indonesia are such as people's perception that the development of reading skills is only taught by language lessons, unsuitable activities, lower-order thinking skill exercises and evaluations, and the lack of library services in the school (Pratama et al., 2024). Therefore, the ongoing teaching and learning activity should be modified. The modification aimed to build the students' science literacy model deeply and in a multidimensional way (Cigdemoglu & Geban, 2015).

One of the parts of literacy is science literacy. Science literacy is defined as the ability to be employed with scientific issues (Pratama et al., 2023). Science literacy then becomes a focus for students to participate in discussions related to science, technology, society, and environmental problems scientifically (Yore et al., 2007). Other opinions state that science literacy is defined as something that should be acknowledged by the students so they can have an effective life in their surroundings (Garner-O'Neale et al., 2013).

Science literacy is the skill to identify problems, employ scientific knowledge, explain scientific phenomena, draw conclusions based on evidence, understand scientific characteristics, acknowledge how science and technology create a natural environment, intellect, and culture, also the skill to involve and pay attention to the issues related to the science (Perry et al., 2020). The sequences of scientific competency needed in science literacy show the combination of social and cognitive ability throughout the entire knowledge (Crujeiras-Pérez & Brocos, 2021).

Science literacy shows the theme sequences which include multi-course (Wei & Chen, 2017). Science literacy can be specified as chemical literacy which includes chemistry knowledge and skill which is necessary for chemistry-based understanding. Chemical literacy consists of three components which are basic chemistry key concepts such as elements, symbols, processes, and models, academic and industrial professional chemistry concepts, and social context (Kohen et al., 2020).

Chemical literacy consists of four aspects which are chemistry as knowledge, chemistry as a context, High-Order Learning Skills (HOLS), and affective aspect. Chemistry as knowledge describes how students who are literate in chemistry must understand general chemistry ideas, key ideas, or chemical characteristics so that students can explain general chemistry problems. Chemistry in context is an explanation of real-life situations involving chemistry and technology so that students can recognize the importance of chemical knowledge, use their understanding of chemistry, and understand the relationship between chemical innovation and social and cultural processes. High-order learning Skills (HOLS) indicators in general are asking questions, investigating relevant information, and being able to evaluate the pros and cons of a phenomenon in everyday life that is integrated with the understanding of chemistry that is already owned. The affective aspect describes students' interest in learning chemistry in everyday problems related to chemistry, especially in non-formal environments (Wiyarsi et al., 2020; Wiyarsi et al., 2021). The students need to get chemical literacy so it can be a background for them to make decisions (Wiyarsi et al., 2020), make them think critically and creatively, and also help them to solve daily problems or phenomena based on their knowledge (Rahmawati et al., 2024; Yuendita & Dina, 2024), and they can respect the nature using the science and technology (Pratama et al., 2024).

However, the results of observing chemical literacy profiles for the same respondents but with different materials showed less than satisfactory results. Observations made on hydrocarbon material on the topic of dangerous fried foods resulted in a percentage of less than 70% (Pratama & Rohaeti, 2023). Similar research with electrochemical materials also produces less encouraging percentages (Prastiwi et

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al., 2017). Therefore, research is needed on further chemical materials, one of which is chemical equilibrium. Chemical equilibrium was chosen as the chemical concept discussed in this study because chemical equilibrium is one of the chemical concepts that has many contexts in everyday life (Eny & Wiyarsi, 2019). Another reason is that the concept of chemical equilibrium is complex and difficult to learn (Kousathana & Tsaparlis, 2002; Prastiwi & Laksono, 2018). This is thought to be related to the characteristics of this topic which include defined concepts, abstract concepts, mathematical calculations, and graphs (Shwartz et al., 2006). These characteristics make students tend to have difficulty understanding concepts and think that the topic of chemical equilibrium has no relation to everyday life (Shwartz, 2006). Whereas if explored more deeply, many phenomena or events in everyday life can be developed from the concept of chemical equilibrium. Examples of phenomena or events in everyday life that involve the concept of chemical equilibrium include dental health (tooth enamel), coral reefs, hypoxia, ammonia production, atmospheric pollutant gases, ocean acidity, and cutting vegetables (Eny & Wiyarsi, 2019; Sadhu et al., 2019; Fadly et al 2022).

Research related to chemical literacy profiles on chemical equilibrium material is rarely carried out. In comparison, research conducted in Gowa Regency also produced unsatisfactory percentages (Syamsidar & Suyanta, 2024). Therefore, in-depth research results are needed to determine the profile of chemical literacy in chemical equilibrium material. Appropriate topics must also be considered so that students can feel the correlation between the cases presented and the chemistry material.

This research takes the topic of forming coral reefs for several reasons such as coral reefs are one of Indonesia's natural wealth and the concept of chemical equilibrium in the formation of coral reefs is easy for students to imagine and understand (Watt-Primgle et al., 2024; Pratama & Rohaeti, 2024). Therefore, linking the relationship between chemical material and the case of coral reefs will produce students' chemical literacy. Based on the description, the research question posed for this research is "What is the level of chemical literacy profile of high school students on chemical equilibrium material in coral reef topic?". This study aimed to determine the profile of high school students' chemical literacy in chemical equilibrium material. This research will show the basic view of students' chemical literacy profile at the level of senior high school.

RESEARCH METHOD

This research is descriptive research using a quantitative approach which is done in one of the senior high schools in Magelang City. The subjects of the research are based on the description of the data (Gay et al, 2014). The subject of quantitative research should be in a representative way so that the chosen individual could represent the whole population (Creswell, 2012). A population is a group of individual who has the same characteristic. The population of this study was all 11th-grade students at three state high schools in Mageang city, totaling 300 students. By using simple random sampling, researchers selected respondents. The number of respondents included was 100 students.

Descriptive research aims to give the image of a population characteristic based on the collected data from the samples (Lochmiller & Lester, 2017). In this research, the data were collected from the result of questionnaires given to the students of grade 11th who had the chemical equilibrium materials. The data then were analyzed quantitatively using descriptive statistics by counting the average of the result. It was

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made in the form of a percentage (%) and then described in the form of a table and graphic to help the decision-making.

The data collection technique in this research was using questionnaires. The instrument used was divided into two instruments which are the research instrument and the data collecting instrument. The research instrument used was the chemical literacy discourse sheet with the topic of coral reefs. While the data-collecting instrument used students' questionnaires. The students' questionnaires contain the students' understanding of chemical literacy about chemical equilibrium materials.

The questionnaires used measured four aspects of chemical literacy which are chemistry (chemistry content), chemistry in a context, High-Order Learning Skill, and affective aspect. Each of the aspects is described into five statements so the total of the statements was 20, which should be answered by the students. The scale used in the questionnaire was the Likert scale with four alternative options. The scales were arranged in the form of a statement and followed by the responses in which the level was shown. The response options are SD (Strongly Disagree) has 1 point, D (Disagree) has 2 points, A (Agree) has 3 points, and SA (Strongly Agree) has 4 points. There was no negative statement so the reversal of the score is not necessary. The final version of the questionnaire is shown in Table 1.

Table 1. The Final Version of the Questionnaire

Aspect	Indicator	Statement	Statement Code
Chemistry as Knowledge (CK)	Recognize the importance of chemical knowledge in explaining a phenomenon and determining chemical theories, models and concepts	I am interested in the phenomena related to the chemical equilibrium concept.	CK 1
		I am able to understand the phenomena related to chemical equilibrium materials.	CK 2
		I am able to explain the relation of phenomena with the chemical equilibrium concept.	CK 3
		I believe that natural phenomena happen because of the chemical equilibrium role.	CK 4
		I believe that the concept of chemical equilibrium takes an important role in a phenomenon.	CK 5
Chemistry in a Context (CC)	Understanding of the phenomenon related to the chemical equilibrium	I am able to define the type of chemical equilibrium that happened in the phenomenon of coral reef formation.	CC 1
		I am able to determine the equation of the reaction in the phenomenon of coral reefs formation.	CC 2
		I am able to determine the direction of chemical equilibrium shift if one of the concentrations from the reactant or product in the coral reefs phenomenon decreases.	CC 3
		I am able to define the direction of chemical equilibrium shit if one of the concentrations from the	CC 4

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Aspect	Indicator	Statement	Statement Code
		reactant or product in the coral reefs phenomenon increases.	
		I am able to understand the application of the chemical equilibrium concept in the phenomenon coral reefs phenomenon.	CC 5
HOLS	Integrating chemical concepts with everyday phenomena to stimulate students' higher-level thinking	I always use chemistry related to the chemical equilibrium in solving daily problems.	HOLS 1
		I am able to reconstruct the process of coral reef formation based on the chemical equilibrium theory which had been taught.	HOLS 2
		I am able to predict the direction of chemical equilibrium shift if in the compound concentrations both reactant and product.	HOLS 3
		I am able to integrate the understanding of shifting equilibrium concept affect the amount of the coral reefs.	HOLS 4
		I am able to integrate the understanding of chemical equilibrium materials with the process of coral reef formation.	HOLS 5
Affective Aspect (AA)	Support the real action as a form of concern for a phenomenon	I like reading and learning about efforts to maintain the sustainability of coral reefs.	AA 1
		I criticize all actions which can destroy the sustainability of coral reefs.	AA 2
		I will participate in the social activity to maintain the sustainability of coral reefs if I am invited.	AA 3
		I have ideas and alternative ways to maintain the sustainability of coral reefs.	AA 4
		I believe that the sustainability of coral reefs will bring positive impacts to its area in many fields.	AA 5

The data analysis technique used was to determine the chemical literacy ability of senior high school students based on their questionnaire result. The analysis steps done in the research are counting the score collected by the questionnaire calculation, counting the average score of students' chemical literacy ability, and deciding the percentage of chemical literacy ability using ideal assessment criteria (Kellaghan, et al., 2003). If the score is above 85%, it is included in the excellent category (E). If the score range is between 71%- 85%, it is included in the high category (H). If the score range is between 56%- 70%, it is included in the fair category (F), If the score range is between 41%- 55%, it is included in the fair category (L). If the score is 40% or below, then it is in the very low category (VL).

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RESULT AND DISCUSSION

The students of grade 11th in one of the senior high schools in Magelang who had been taught the chemical equilibrium were chosen as the participants of the research. At the early of the research, the researcher asked the approval from all of the teachers in the class who explained the reason for the research. The teachers also guaranteed that all of the data collected (including the identity of the students) were kept secret. Before doing the research, the researcher also asked the approval from the students and explained the purpose of the research. Based on the result, the chemical literacy in each aspect is shown in Table 2.

Table 2. The result of each aspect of chemical literacy

Number	Aspect	Percentage
1	Chemistry as Knowledge (CK)	65.55%
2	Chemistry in a Context (CC)	51.25%
3	HOLS	51.95%
4	Affective Aspect (AA)	76.50%
	Average	**61.3125%**

The average result of chemical literacy ability is 61.3125%. This result shows that the profile of chemical literacy ability in senior high school students is still in the category of fair. The score data then was analyzed using the descriptive statistics analysis technique. Based on the analysis result, it shows that the student's average ability in each aspect indicator is below.

Profile of Student's Chemical Literacy Based on Aspect of Chemistry as Knowledge

The first aspect consists of five statements matched with the indicators. The indicators used are to admit the importance of chemical knowledge in explaining a phenomenon and to determine the theory, model, and chemical concept. The result of the chemical literacy profile is shown in Figure 1 and and the descriptive statistical results are listed in Table 3.

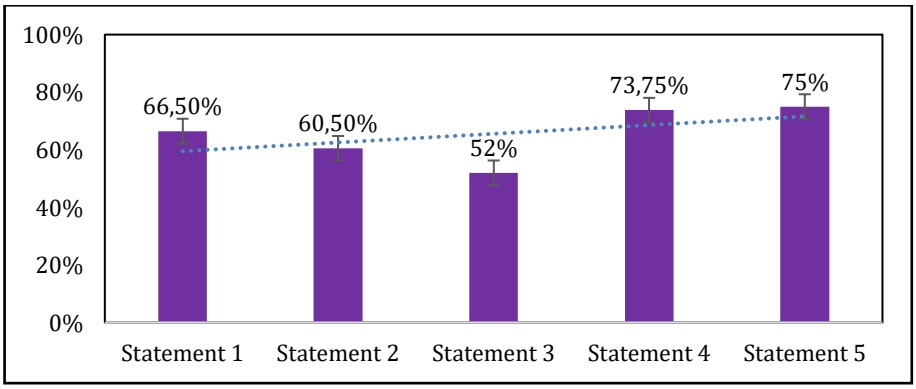

Figure 1. The Chemical Literacy Profile in Each Statement Based on CK Aspect

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Table 3. Descriptive Statistical Result for CK Aspect

Descriptive Statistical	Statement 1	Statement 2	Statement 3	Statement 4	Statement 5
Total Points	266	242	208	295	300
Standard Deviation	3.859	4.784	1.699	9.463	9.201
Percentage (%)	66.5	60.5	52	73.75	75

Based on Figure 1. 66.50% of students stated that they are interested in the phenomena related to the chemical equilibrium concept. The first statement is categorized in a fair category. However, the percentage shows that there are still a lot of students who are less interested in the phenomena related to the chemical equilibrium concept. This statement is supported by the result of statement 2. There are only 60.50% of students can understand the phenomenon related to the chemical equilibrium material. The result can be categorized in a fair category. In addition, there are only 52% of the students can explain the relation of a phenomenon with the chemical equilibrium materials. The result can be categorized in a low category and becomes the lowest percentage in the aspect of chemistry as knowledge. The good results are shown in statements 4 and 5. 73.75% of students believe that a natural phenomenon happens because of the chemical equilibrium role and 75% of students believe that the chemical equilibrium concept takes an important role in a phenomenon. Both of these statements are included in the high category. The whole result from these aspects is 65.55%. This number is categorized in a fair category. Based on the descriptive result from the students' questionnaire, there are a lot of students believe that the concept of chemical equilibrium plays an important role in a phenomenon. However, few students can integrate the chemical equilibrium concept with the phenomena; therefore the student's understanding level of the phenomenon related to the chemical equilibrium is not maximum.

Profile of Student's Chemical Literacy Based on Aspect of Chemistry in a Context

The second aspect is chemistry in a context. It consists of five statements matched with the indicators. The indicators used are the understanding of the phenomenon related to the chemical equilibrium. The result of the student's response is shown in Figure 2 and the descriptive statistical results are listed in Table 4.

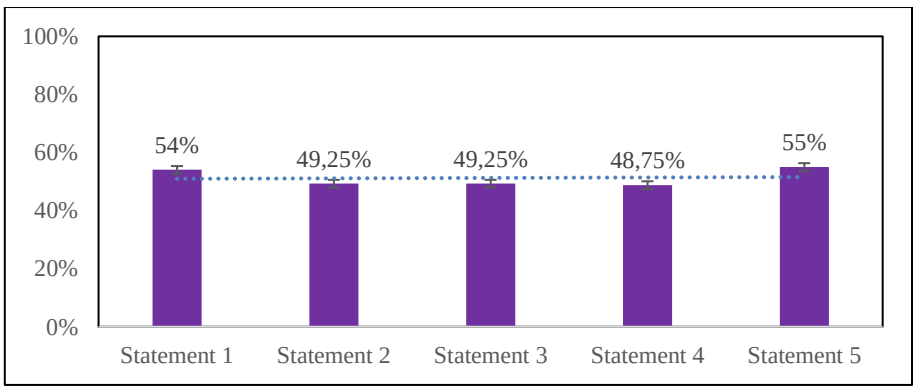

Figure 2. The Chemical Literacy Profile in Each Statement Based on the CC Aspect

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Table 4. Descriptive Statistical Result for CK Aspect

Descriptive Statistical	Statement 1	Statement 2	Statement 3	Statement 4	Statement 5
Total Points	216	197	197	195	220
Standard Deviation	0.00	1.699	2.867	0.816	4.027
Percentage (%)	54	49.25	49.25	48.75	55

From Figure 2. 54% of students stated that they can determine the type of chemical equilibrium in the phenomenon of coral reef formation. This percentage is categorized in a low category. The result is supported by the result of statement number 2. There are only 49.25% of students who can determine the equation of the reaction in the phenomenon of coral formation coral reefs. The next result is there are only 49.25% of students can determine the direction of chemical equilibrium shift if one of the concentrations from the reactant or product in the coral reefs phenomenon decreases. In addition, there are only 48.75% of students can define the direction of chemical equilibrium shift if one of the concentrations from the reactant or product in the coral reefs phenomenon increases. Last result shows, there are only 55% of the students can understand the application of the chemical equilibrium concept in the phenomenon coral reefs phenomenon. All of the results in the chemistry as a context aspect are in a low category. The entire result for those aspects is 51.25%, categorized as a low category. It was the lowest result in the research. The low level of understanding chemistry in a context causes by the perception of learning chemistry as only a memorizing learning. It makes the students cannot integrate the chemical context in the school with the daily phenomenon.

Profile of Student's Chemical Literacy based on Aspect of HOLS

The indicator of this aspect is integrating chemical concepts with everyday phenomena to stimulate students' higher-level thinking. In this aspect, the students are expected to have a high logical ability. The result of students' responses is explained in Figure 3 and the descriptive statistical results are listed in Table 5.

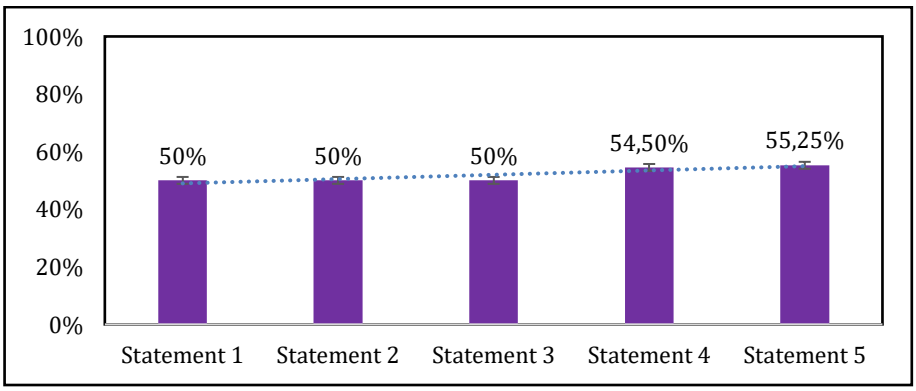

Figure 3. The Chemical Literacy Profile to the Statement Based on HOLS Aspect

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Table 4. Descriptive Statistical Result for HOLS Aspect

Descriptive Statistical	Statement 1	Statement 2	Statement 3	Statement 4	Statement 5
Total Points	200	200	200	218	221
Standard Deviation	2.059	0.471	3.681	2.055	1.699
Percentage (%)	50	50	50	54.5	55.25

Based on the Figure 3. It stated that 50% of the students always use the chemistry knowledge related to the chemical equilibrium materials to solve problems, reconstruct the process of coral reef formation based on the theory of chemical equilibrium which had been taught before, and predict the direction of chemical equilibrium shift if in the compound concentrations both reactant and product. The better percentage appears in statement 4, 54.50% of students can integrate the understanding of shifting equilibrium concept affects the amount of the coral reefs, and 55.25% of the students then can integrate the understanding of chemical equilibrium materials with the process of coral reef formation are related one another. All of the statements in the HOLS aspect are categorized as a low category except for statement 5 which is included in the fair category. The entire result from this percentage is 51.95% which is in a low category. Those results, shows that few students have high logical thinking. This is because the learning activity taught in the school is not using the HOLS for the students. Profile of Student's Chemical Literacy based on Aspect of Affective Aspect

The indicator in this aspect is to support the real action as a form of concern for a phenomenon. There are five statements developed from the indicators. The students' responses are explained in the Figure 4 and the descriptive statistical results are listed in Table 6.

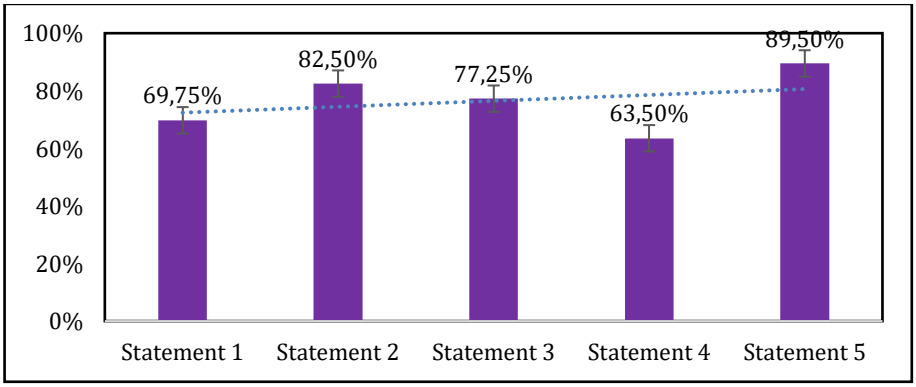

Figure 4. The Chemical Literacy Profile in Each Statement of AA Aspect

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Table 4. Descriptive Statistical Result for HOLS Aspect

Descriptive Statistical	Statement 1	Statement 2	Statement 3	Statement 4	Statement 5
Total Points	279	330	309	254	358
Standard Deviation	3.741	5.715	2.944	1.247	3.299
Percentage (%)	69.75	82.5	77.25	63.5	89.5

From Figure 4. 69.75% of students like to read and learn about the efforts to maintain the sustainability of coral reefs. 82.50% of students criticize all actions that can destroy the sustainability of coral reefs.77.25% of students will participate in social activity to maintain the sustainability of coral reefs if they are invited. 63.50% of students have ideas and alternative ways to maintain the sustainability of coral reefs while 89.50% of students believe that the sustainability of coral reefs will bring positive impacts to its area in many fields. The result of the entire percentage is 76.50% and it is categorized in the good category. The affective aspect gets the highest percentage compared with the other aspects and this is the only aspect categorized as a high category. The result indicates that students care about the preservation of coral reefs. However, this caring attitude has not been fully supported by the student's willingness to search and read the information about efforts to protect coral reefs, so only a few students have alternative ideas of how to maintain coral reefs . In addition, the geographic location of the place where the research took place is in Magelang which is so far from the marine and even more, it makes the students uninterested to search and read the information on how to maintain the coral reef.

If all aspects are reviewed, the percentage of students' chemical literacy profile in chemical equilibrium materials is 61.3125%. This result shows that the student's profile is fair. These results show the same categories in previous studies (Syamsidar et al., 2024; Prastiwi et al., 2017; Pratama & Rohaeti, 2023). This indicates that students are not quite familiar with learning activities that use scientific steps and are not yet able to fully understand chemical materials. It means that the student's learning activities still force them, students, to understand the materials without relating or applying them in their daily phenomenon (Rahmawati, et al., 2024).

Therefore, to achieve chemical literacy ability, the students need learning activities that start with observing or connecting the materials with their daily phenomena. Through those activities, the students are stimulated to build their knowledge and relate phenomena with their materials in the school. The learning activities should make the students practice their science skills so that they will be familiar with doing something related to science such as: explaining a phenomenon scientifically, using chemical understanding in solving problems, and analyzing the benefit of the application of chemistry. At the end of the lesson, the students need to do the evaluation test which orientation is increasing chemical literacy abilities. In chemical equilibrium materials, lots of topics may relate and apply to daily problems, and it can be a consideration for making questions in the test. For instance, the formation of coral reefs. That topic can be an interesting discourse for the students. The development of the questions or test should consider the scientific questions based on the Program for International Students Assessment (PISA) conducted by OECD. The test is expected to make the science literacy of students in Indonesia better so they can participate in the industrial field as well as have equal quality.

CONCLUSION

The chemical literacy profile of students in grade 11th of chemical equilibrium materials in one of the senior high schools in Magelang is categorized as a fair category with 61.3125%. The result indicates that the students are not familiar with the learning activity that uses scientific steps, they are not able to fully understand the chemical materials, and they are not able to integrate the understanding of the chemical concept with daily phenomena. Modification of learning activity is needed to increase students' chemical literacy. A further study by other researchers can take the broader research subject and use an experiment research design to identify the level of students' chemical literacy more accurately.

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