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Differentiated Learning: Analysis of Students' Chemical Literacy on Chemical Bonding Material through Culturally Responsive Teaching Approach Integrated with Ethnochemistry

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Abstract: This study aims to obtain information and analyze the chemical literacy profile of class X students of one of public high school in Surakarta on chemical bonding material after carrying out differentiation learning with Culturally Responsive Teaching integrated with ethnochemistry. This research used descriptive qualitative approach with post-test only design. The research was conducted on 36 students of class X at one of public high school in Surakarta during 2 meetings. The results of the study showed that the literacy level of students after learning was carried out there were 25% of students classified as high, 56% classified as medium, and 19% classified as low. Based on the results of the analysis on each indicator of chemical literacy, students showed very good levels on all indicators, namely content, context, high-level learning skills, and affective. Therefore, the level of chemical literacy of students is classified as good after learning is differentiated with Culturally Responsive Teaching integrated with ethnochemistry because learning becomes contextual, meaningful, and in accordance with student learning readiness.

Keywords: Chemical bonding; Chemical literacy; Culturally responsive teaching; Differentiated learning; Ethnochemistry

Introduction

In response to changing times, the Indonesian government has undergone a series of curriculum changes since 2020, transitioning from an emergency curriculum designed as a simplification of the 2013 curriculum to what was initially called the prototype curriculum, now referred to as the Merdeka curriculum. The Merdeka curriculum emphasizes essential material, providing ample time for in-depth learning of fundamental competencies, with a particular focus on literacy (Kemendikbudristek, 2022). One essential aspect of literacy is scientific literacy. According to OECD (2023), in the PISA 2022 results for the science category, Indonesia ranks 71 out of 81 countries with a score of 383 where the results are below the average PISA score, which is 485. Before that, in the PISA 2018 results, the science literacy scores of Indonesian students also were still below the average PISA scores. These results indicate room for improvement and are a significant concern in the context of implementing the Merdeka curriculum (Kemendikbudristek, 2022).

Chemistry, as a branch of science, plays a vital role in contributing to general scientific literacy and chemical literacy (Shwartz et al., 2006a). Chemical literacy encompasses an individual's understanding of properties of matter, chemical reactions, chemical laws and theories, and general chemical applications in everyday life (Barnea et al., 2010). Further elaborate on chemical literacy, Shwartz et al. (2006b) defined

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chemical literacy as consisting of 4 domains, namely scientific and chemical content knowledge, chemistry in context, higher-order thinking skills, and affective aspects. Similarly to scientific literacy in science education, chemical literacy is the primary goal in chemistry education. It aims to equip students with the ability to apply scientific knowledge, solve problems, present findings based on evidence, and evaluate the impact of human activities on the natural world (Cigdemoglu & Geban, 2015).

One of the key topics in chemistry for high school students is chemical bonding. The scope of chemical bonding material covered in high school includes discussions of ionic bonding, polar and nonpolar covalent bonding, and metallic bonding, all of which involve various chemical concepts related to molecules, atoms, protons, neutrons, electrons, cations, anions, and the interactions between like and opposite charges (Tsaparlis et al., 2018). Chemical bonding is critical for understanding chemistry but often considered abstract and complex by curriculum designers, teachers, and students (Rahayu & Fitriza, 2021). Students cannot see in real terms about atoms, the structure of atoms, and how they bond so many students have difficulty in understanding the concept of chemical bonding (Rahim et al., 2016). This difficulty hinders students' understanding which can later affect students' chemical literacy. One of the factors that cause students difficulty studying chemistry is teaching in high schools primarily that focuses on the macroscopic and symbolic levels, with minimal attention to the submicroscopic level, leading to students memorizing without a deep understanding of how the concepts work (Fahmina et al., 2019). Therefore, research on chemical literacy on chemical bonding material as part of the basic concepts of chemistry needs to be carried out.

This research implemented differentiated learning and Culturally Responsive Teaching (CRT) integrated with ethnochemistry. Merdeka curriculum strongly advocates the use of differentiated learning strategies, which cater to diverse learning needs by optimizing students' potential development to achieve their learning goals (Basra, 2022). Another opinion states that differentiated learning is a series of rational decisions (common sense) made by teachers that adjust to student needs (Faiz et al., 2022). Differentiated learning encompasses three primary strategies: content differentiation, process differentiation, and product differentiation (Tomlinson, 2001). Differentiated learning can improve the chemistry learning outcomes of the second grade high school science students with an average student completeness of 50% in the pre-cycle (Sari & Anggraini, 2022).

Concurrently, Culturally Responsive Teaching (CRT) was implemented. CRT is a learning approach emphasizing equal rights for every student to receive instruction without discrimination based on their cultural backgrounds (Rahmawati et al., 2017). CRT principles include content integration, facilitating knowledge construction, prejudice reduction, social justice, and academic development (Hernandez et al., 2013). The abstract nature of chemistry can be made more accessible through a CRT approach tailored to the students' culture. In this research, CRT approach integrated with ethnochemistry, which explores chemistry from a cultural perspective. Ethnochemistry in this study is integrated with the CRT approach because the use of ethnochemistry on the principle of content integration in CRT aims to involve students with their indigenous knowledge (Rahmawati & Ridwan, 2017). Ethnochemistry can be seamlessly integrated with chemical bonding material, making abstract concepts relatable, such as connecting the *srah-srahan manten* procession at Javanese weddings to the stability of electrons and their role in the formation of ionic bonding (Wahyudiati, 2022). This culturally-based approach is a key component in creating meaningful learning experiences (Aikenhead, 2000). This is in line with Wiradharma et al. (2021) that showed 81% of students reached good level of chemical literacy after culture-based learning.

The application of differentiated learning, CRT approach, and ethnochemistry simultaneously in this study is based on Vygotsky's social constructivism learning theory which prioritizes the construction of knowledge and cognitive development of students in socio-cultural contexts so that students achieve independence. In this study, researchers used differentiated learning and CRT integrated with ethnochemistry to trigger students’ chemical literacy.

The subjects of this research are the first grade students in a public high school in Surakarta. This particular school was selected due to its extensive experience in implementing the Merdeka curriculum and its reference status for the Merdeka curriculum in Central Java Province (Fitriani, 2022). Given the significant differences in educational approaches, there is a need to assess students' chemical literacy in the context of the Merdeka curriculum chemistry learning process in the first grade at this school. This evaluation will provide valuable insights for teachers and policymakers.

Based on the problem description above, this research aims to analyze the students chemical literacy profile on chemical bonding material through differentiated learning and CRT approach integrated with ethnochemistry, especially in the context of the Merdeka curriculum.

Method

This study used a descriptive qualitative approach with a post-test-only design. We chose this approach to provide a detailed description and analysis of students' chemical literacy in the context of the chemical bonding material. Our research participants consisted of the first grade students from a public high school in Surakarta during the 2022/2023 academic year. We used purposive sampling techniques to select a sample of 36 students from class X-E2.

In terms of data collection, we utilized various instruments. Firstly, an initial assessment was conducted before the study began to categorize students based on content and process differentiation. The assessments aimed to differentiate students' readiness for learning. Additionally, chemical literacy tests, reflective journals, and interview sheets were used. These assessments took place during the learning process, allowing us to capture students' evolving comprehension and insights. The chemical literacy test consists 13 two-tier multiple choice questions which were evaluated for content validity and reliability using SPSS. The test declared valid by two chemistry education lecturers and realiable to use. Data analysis in this research is based on the Miles and Huberman model which consists of data reduction, data display, and conclusions drawing or verification.

The CRT approach principles, including content integration, facilitating knowledge construction, prejudice reduction, social justice, and academic development (Hernandez et al., 2013), were integrated into our teaching methodology. We assessed chemical literacy using indicators based on (Shwartz et al., 2006b) framework (Table 1), including scientific and chemical content knowledge, chemistry in context, high-level thinking skills, and affective aspects. To implement our chosen teaching approach, Problem-Based Learning model and differentiated learning incorporating CRT integrated with ethno-chemistry was provided over two sessions, with each session spanning two teaching hours (2 x 45 minutes). Through this comprehensive approach to data collection and analysis, we aimed to gain an in-depth understanding of students' chemical literacy within the context of the chemical bonding material.

Table 1. Chemical Literacy Indicators (Shwartz et al., 2006b)

Chemical literacy indicators	Chemical literacy sub indicator
Scientific and chemical content knowledge (content)	a. Conduct scientific investigations, generalize discoveries, and propose theories to explain natural phenomena.
	b. Knowing that chemistry can explain phenomena in other fields.
	c. Explains the macroscopic level through the molecular structure of matter.
	d. Investigating the dynamics of reaction processes.
	e. Investigate energy changes in chemical reactions.
	f. Understand and explain life through chemical processes and structures in living systems.
	g. Appreciate the contribution of scientific language to the discipline of chemistry.
Chemistry in context (context)	a. Recognize the importance of chemical knowledge in explaining everyday phenomena.
	b. Using an understanding of chemistry in solving problems in everyday life.
	c. Understand the relationship between chemical innovation and social and cultural processes.
High order learning skills (hols)	a. Ask questions and look for needed information.
	b. Analyze the pros and cons of a phenomenon.
Affective aspect (affective)	a. Demonstrates interest in chemistry issues.

Table 2. Example Questions of Chemical Literacy Test

Chemical literacy indicator & sub indicator	Question	Answer key and reason
Theme: fireproof brick		
Pizza is one of the typical italian foods that has been known throughout the world. This food is made by grilling on a fire stove. The pizza kiln is composed of bricks that have the peculiarity of being resistant to high temperatures. The refractory brick is composed of chemical components, such as Mgo and Al2O3. Both compounds have strong chemical bonds so that the boiling point is high enough as a pizza kiln material.		

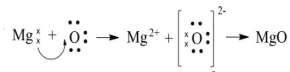
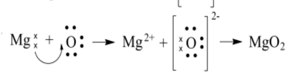
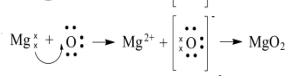
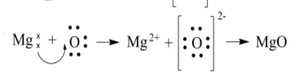
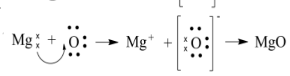
Chemical literacy indicator & sub indicator	Question	Answer key and reason
Context: recognize the importance of chemical knowledge in explaining everyday phenomena.	The chemical bonds contained in the components of making pizza burning bricks are... a. Metal bonding b. Nonmetal bonding c. Ionic bonding d. Covalent bonding e. Mixed bonding The correct reason for the answer to the above question is... a. MgO and Al_2O_3 are composed of bonds between metals and metals, respectively. b. MgO and Al_2O_3 are composed of bonds between metals and nonmetals, respectively. c. MgO and Al_2O_3 are composed of bonds between nonmetals and nonmetals, respectively. d. MgO and Al_2O_3 are each composed of bonds between positively charged ions. e. MgO and Al_2O_3 are each composed of bonds between negatively charged ions.	Answer c Reason b
Content: explains the macroscopic level through the molecular structure of matter.	Known electron configuration of one of the components of making pizza burning bricks as follows: a. $_{12}Mg = 1s^2\ 2s^2\ 2p^6\ 3s^2$ b. $_{8}O = 1s^2\ 2s^2\ 2p^4$ The ionic bonds formed from these two elements in the lewis structure is... a.  b.  c.  d.  e.  The wrong reason for the answer to the above question is... a. The Mg element gives up 2 electrons and the O element accepts 2 electrons to achieve stability. b. The valence electrons of the elements Mg and O are 2 and 8 respectively. c. The elements Mg and O bond ions to form MgO compounds. d. After achieving stability, element Mg becomes Mg^{2+} and element o becomes O^{2-}. e. Element O accepts 2 electrons from element Mg to achieve stability.	Answer a Reason b

Table 3. Two-Tier Multiple Choice Scoring Criteria (Yamtinah et al., 2016)

Criteria	Score
Not choosing the answer and the reason or the answer from both is wrong	0
Wrong answer – right reason	1
True answer – wrong reason	2
Correct answer and reason	3

Result and Discussion

Results

Differentiated learning containing ethnochemical integrated CRT begins by giving students an initial assessment to group students into 3 categories, namely students who need guidance, students who are quite advanced, and students who are very advanced. From each category, 2 groups were formed so that from 36 students there were 6 differentiated learning groups.

Differentiated learning applied process differentiation and content differentiation. Grouping students into 3 categories is the application of process differentiation during learning. Students are grouped according to their readiness to learn (readiness) so that students can follow chemical bond learning according to their respective abilities. Then, the content differentiation in this study lies in the difference in the content of student worksheet containing ethnochemical integrated CRT. This group activity is important becase students can develop scientific skills and knowledge abilities, attitudes, and values through discussion and presentation activities on student worksheets (Al Fasya et al., 2022). In student worksheet, students are given ethnochemical articles on the process of *srah-srahan manten* in Javanese traditional marriages which are associated with the process of ion formation according to Wahyudiati (2022). Starting from the chemistry article, the student group needs guidance guided by the teacher in order to achieve learning objectives, while the student group is quite proficient and very proficient in getting more portion of practice questions about ion bonding in order to achieve learning goals tailored to their abilities.

Table 4. Core Learning Activities

PBL model syntax	Core activities of differentiated learning	CRT approach principles
Meeting 1		
Students orientation on problem	a. Teacher gives an introduction to the basic concepts of atomic stability and ionic bonding.	Content integration
	b. Teacher shows a video of the *srah-srahan manten* procession and its image in a traditional javanese wedding.	Facilitating knowledge construction
	c. Teacher provides opportunities to learners to determine problems related to ionic bonding in everyday life.	
Organizing students to learn	Teachers form students in 6 groups based on the results of initial assessments on learning readiness. Students in groups are asked to solve problems with the help of questions in student worksheet about atomic stability and the formation of ionic bonding. (content differentiation)	Prejudice reduction Social justice Academic development
Guiding individual or group inquiry	a. Students in groups with teacher guidance discuss problem solving in accordance with student worksheet. b. Students collect information to learn ionic bonding based on experimental results through literacy activities by finding and reading various references from various sources and exchanging information with their groups. (process differentiation)	Prejudice reduction Social justice Academic development
Meeting 2		
Developing and presenting result	a. Students discuss the results of the ion bond experiment to solve problems which are assisted through the process of answering questions in student worksheet in groups. b. Teacher monitors and guides students in the discussion before the students are ready to present the results of the discussion. c. Students present the results of discussions with their groups. The results of the discussion can be in the form of power point slides, videos, songs, mini dramas, or other student interests according to group agreement. (process differentiation)	Prejudice reduction Social justice Academic development
Analyzing and evaluating problem solving process	a. Teacher gives appreciation and encourages students to give appreciation also to the group that has presented the results of the discussion. b. Teacher evaluates the results of each group's discussion in solving problems. Students evaluate the results of their group discussions. c. Students analyze the results of problem solving from the presentation of the results of each group's discussion. d. Teacher and students equate perceptions to answer problems in the orientation section.	Prejudice reduction Social justice Academic development

After the lesson, students take a chemical literacy test. Figure 1 shows the highest percentage of chemical literacy test results where students are in the medium category (56%), followed by students in the low category (25%), and the lowest percentage are students in the high chemical literacy category (19%). This percentage was then analyzed according to chemical literacy Shwartz et al. (2006) on content, context, high-level learning skills, and affective indicators.

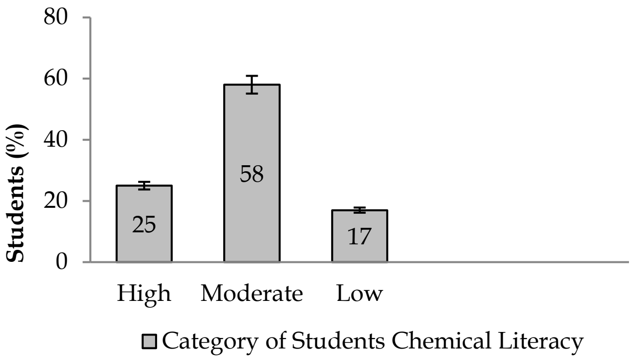


Figure 1. General description of students' chemical literacy abilities

Content Indicator of Chemical Literacy

The content chemistry literacy test in this study assesses students' ability to explain how an element achieves stability through the process of scientific investigation, generalizing discoveries, and explaining natural phenomena, as well as explaining phenomena in other fields. Furthermore, the ability of student content in explaining the occurrence of ionic bonding is seen from the process of explaining the macroscopic level, investigating the dynamics of reaction processes, investigating energy changes in chemical reactions, understanding and explaining life through chemical processes and structures, and appreciating the contribution of scientific language to the discipline of chemistry (Shwartz et al., 2006). Figure 2 shows students' chemical literacy abilities on content indicators. The highest percentage was 25% in the very good and good categories with a total of 18 students. Then, in the poor and very poor categories, it was 22% each with a total of 16 students. Meanwhile, in the sufficient category, it was 6% with 2 students. In general, there are many students having high content abilities in chemical bonding learning, but the number of students with low content ability is not much different and should also be considered.

Atoms achieve stability by releasing or accepting electrons to form ions. Metal atoms lose electrons to form positive ions (cations) when they react with nonmetals and nonmetal atoms form negative ions (anions) by accepting electrons from that metal. Thus, metal and nonmetal atoms react chemically to form ionic bonding by electron handover (Keenan et al., 1986). Metals tend to react with nonmetals to form ionic bonding. Each ion formed in the reaction has the same electron configuration as the noble gases to achieve stability. Describing the stability of electrons in ionic bonding can use Lewis structures and chemical reactions.

Students have been able to conduct scientific investigations, generalizing discoveries, and explaining natural phenomena, as well as explaining phenomena in other fields, but there are some misconceptions. This is proved by students who are able to explain the concept of elemental stability and determine the pairs of elements that can form ionic compounds.

"*Atom F has atomic number 9, ma'am, to be stable, it must accept 1 more electron. There Na atomic number 11 must mean removing one electron to be stable, ma'am. So, Na can give 1 electron to F and F can give 1 electron from Na to form a compound pair of NaF ion, ma'am.*" *(Interview of Student in the Medium Chemical Literacy)*

However, there are also students who are still unable to distinguish whether an element tends to give off or accept electrons.

"*To be stable, the cation releases electrons and the anion accepts electrons. This is fluorine, there are 9 atomic numbers. But here I'm confused if fluorine ions need to give up or accept electrons.*" *(Interview of Student in Low Chemical Literacy)*

Students have been able to explain the macroscopic level, investigate the dynamics of reaction processes, investigate energy changes in chemical reactions, understand and explain life through chemical processes and structures, and appreciate the contribution of scientific language to the discipline of chemistry, but there are also some misconceptions. This is proved by students being able to explain the process of forming ionic bonding from ionic compounds in everyday life.

"*Among Mg^{2+}, Cl^-, and K^+ ions contained in seawater, I think it is Mg^{2+} and Cl^- that can form ionic bonding, ma'am. Mg will give up two electrons, while Cl will accept one. Two Mg electrons are given to Cl so that a compound of $MgCl_2$ ion is formed.*" *(Interview of Student in Medium Chemical Literacy)*

"*The Cl atom has atomic number 17, so it becomes stable if it accepts 1 more electron and Cl is more likely to be Cl^- than Cl^+. Based on the Periodic Table, Cl has a high electron affinity so it tends to accept electrons to be stable, if it gives up electrons it is unstable.*" *(Interview of Student in High Chemical Literacy)*

However, there are students who claim it's difficult to explain how ion bonding occur in Lewis structures and still do not fully understand the previous material about the Periodic Table related to ionic bonding.

"I understand the formation of ionic bonding by chemical bonding, but I still don't understand if it is in Lewis structures. To answer this question about Lewis, I just look at the number of valence electrons. Here Cl atom has 7 valence

electrons, it means that in the Lewis structure there must be 7 dots around Cl atom." (Interview of Student in Medium Chemical Literacy)

"I forgot about ionization energy and electron affinity. I didn't make note much as well as my lack of literacy, ma'am." (Interview of Student in Low Chemical Literacy)

During learning, students experience problems that affect their chemical literacy skills, including literacy test questions that are considered difficult, teacher teaching tempo is too fast, and class hours are considered too little.

"The obstacle is difficult to understand about literacy and statements, things that can be done to ask friends who are proficient/ask teachers, do more literacy about the material." (Reflective Journal of Student in High Chemical Literacy)

"The problem is that it is difficult to understand literacy questions and statements. What I can do are asking friends who are already proficient/asking the teacher, doing more literacy about the material." (Reflective Journal of student in Medium Chemical Literacy)

"In my opinion, learning chemistry once a week in the Merdeka curriculum is not enough, because in that class the teacher teaches speed and sometimes I also don't pay attention. That's just the obstacle, ma'am, I will comprehend the material again by watching YouTube videos." (Interview of Student in Low Chemical Literacy)

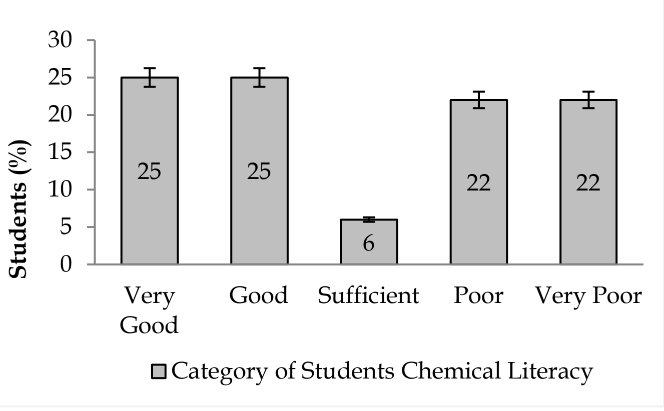


Figure 2. Students chemical literacy ability level content indicator

Context Indicator of Chemical Literacy

In the context indicator, the ability assessed is recognizing the importance of chemical knowledge in explaining everyday phenomena, using chemical understanding in solving problems in everyday life, and understanding the relationship between chemical innovation and social and cultural processes (Shwartz et al., 2006). Figure 3 shows the level of students' chemical literacy abilities in context indicators. The highest percentage was 47% in a very good category, with 17 students. Then, in the very poor category, it was 36% with 13 students. In the good and poor category, it was 6% each with a total of 4 students. Meanwhile, in the sufficient category, it was 3% with only 1 student. In general, there are more students who have high context ability in chemical bonding learning, but the difference in the number of students is not too much when compared to students with low context ability.

Students have been able to use chemical understanding in solving problems in everyday life. This is proved by students being able to explain the ions that cause hard water problems.

"The hard water contains the Mg element and in the ionic form it is Mg^{2+} because it releases 2 electrons so that it becomes 10 electrons. Then, there is also Ca^{2+} because Ca releases 2 electrons to 18 electrons. So both of them are stable." (Interview of Student in Low Chemical Literacy)

Students have been able to recognize the importance of chemical knowledge in explaining everyday phenomena and understand the relationship between chemical innovation and social and cultural processes, but there are still some misconceptions. This is proved by students being able to explain the formation of ionic bonding that exist in everyday phenomena.

"The pizza kiln that contains MgO and Al_2O_3 I thought it has a mixed bond, ma'am, because I haven't really memorized whether it's a bond between metal and nonmetal." (Interview of Student in Low Chemical Literacy)

"Yes, NaCl in seawater can be polluted due to microplastic compounds. If it's in plastic, it's rich in toxic compounds, right ma'am, but if it's in the sea, it can be polluted so that the salt in the sea is not too polluted by plastic. So it can reduce plastic pollution." (Interview of Student in Medium Chemical Literacy)

"In srah-srahan manten, the male side is likened to a cation while the female is an anion. Surrender itself is likened to an electron. So when the male gives a gift (seserahan) to the female, the cation will have positive ions while the anion has negative ions. This illustration really helped me to remember the formation of ionic bonding." (Reflective Journal of Student in Medium Chemical Literacy)

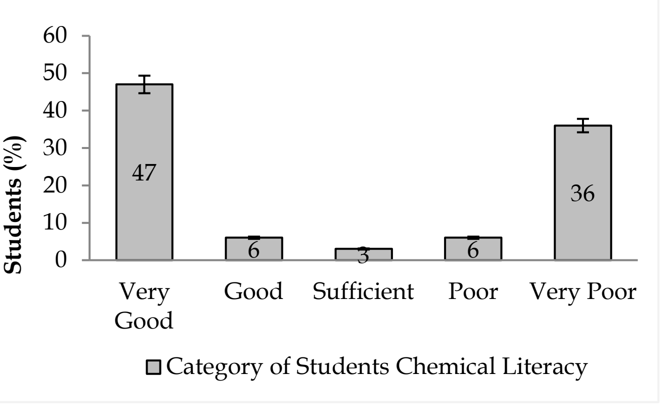


Figure 3. Students chemical literacy ability level context indicator

High Order Learning Skills (HOLS) Indicator of Chemical Literacy

In this indicator, the ability assessed is the ability to ask questions and search for the information needed, and analyze the pros and cons of a phenomenon (Shwartz et al., 2006). Based on Figure 4, students' high-level learning skills occupy the most 47% in the very good category with a total of 17 students. Then, followed by the sufficient category, there are 25% of students with a total of 9 students, the very poor category is 19% with a total of 7 students, and the good category is only 6% of students with a total of 2 students. There are no students who occupy the poor category on this indicator. The number of students with low high-level learning ability is much less than students with high high-level learning ability, indicating that most of students already have good chemical literacy skills on this indicator. This is proven by some students in class asked, *"Why should an element follow the rules of stability of noble gases?"* and during interview, students expressed their opinion about demineral and mineral water controversy.

"*In my opinion, although demineral water is useful for cleaning inorganic minerals in the body, consumption of demineral water alone is still difficult to meet the body's electrolyte needs, ma'am. I saw and searched on the internet that the ion content in mineral water is beneficial for the body to maintain pH balance, reduce dehydration, can be a regulator of pH balance. So it is wrong if mineral water is considered not beneficial than demineral water.*" *(Interview of Students in High Chemical Literacy)*

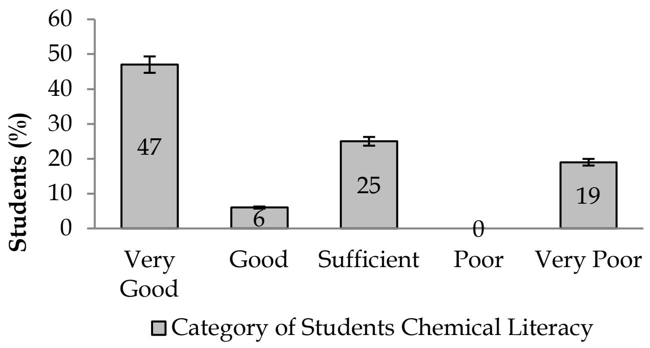


Figure 4. Students chemical literacy ability level high-level learning skills indicator

In the reflective journal, students found it helpful with group activities because students felt they have a compact group member. This indicated that implementation of differentiated learning based on students' readiness gave positive impact.

"*Group activities can help learning, because my group is compact.*" *(Reflective Journal of Student in the Medium Chemical Literacy)*

"*Group activities are very helpful in understanding the learning process, but it is also necessary to provide material individually or without groups so that students can better understand the material.*" *(Reflective Journal of Student in the Medium Chemical Literacy)*

However, students also expressed their views on problems they experienced during learning, such as class hours that were considered too little.

"*In general, there are no obstacles that happen to me. However, in my opinion, the provision of material in only a few meetings makes the delivery of material not optimal.*" *(Reflective Journal of Student in the Medium Chemical Literacy)*

Affective Indicator of Chemical Literacy

In this indicator, the ability assessed is the ability to show interest in chemical issues (Shwartz et al., 2006). Figure 5 shows the level of chemical literacy on affective indicators where 89% of students with a total of 32 students are in the very good category, this result is also the highest result compared to other chemical literacy indicators. In the very poor category, there was 6% of students with a total of 2 students. Meanwhile, in the sufficient category, there was 3% of students with a total of only 1 student. There was no students who occupy the good or poor categories in this indicator. This shows that many students have a high interest in chemistry issues with different issues for each students. This is proven by the results of interview of students as follows:

"Actually, I'm quite interested in discussing chemistry, discussing elements like that. In my opinion, now it's okay if the food being sold is a little bit afraid of being contaminated with pollution or something because of chemical compounds." (Interview of Student in High Chemical Literacy)

"There is, ma'am, I'm interested, but I need friend or someone who will tell me about that. I'm interested in problems about soil pollution from fertilizer, fertilizer also contains chemical compounds." (Interview of Student in Medium Chemical Literacy)

"*I'm a little curious, ma'am, because the material is quite interesting to me, ma'am. For example, ma'am waste as far as I know. This waste contains a lot of chemicals that are dangerous to health." (Interview of Student in Low Chemical Literacy)*

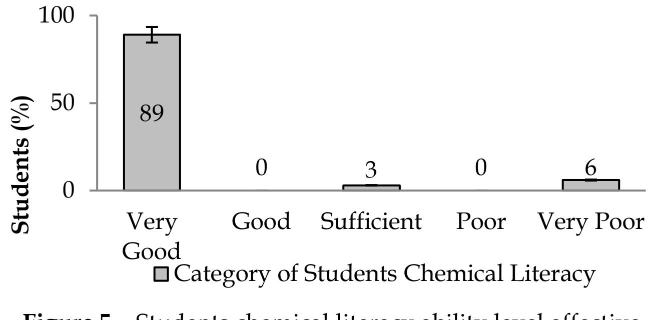


Figure 5. Students chemical literacy ability level affective indicator

Disscussions

In the content chemistry literacy indicator, students were proven to be able to explain how an element achieves stability and the formation of ionic bonding, but there were still students who experience misconceptions related to distinguish whether an element tends to give off or accept electrons and also about periodic table. This misconception is not new in learning chemical bonding because the majority of high school students experienced misconceptions in understanding chemical bonding material in the concepts of element stability, depiction of Lewis symbols and structures, ionic bonding, covalent bonding and coordination bonding (Azura & Corpiady, 2017). In addition, when students didn't fully understand terms and symbols contained in the instrument, they experienced misconceptions associated with terms contained in everyday life (Damsi & Suyanto, 2023; Kadarwati et al., 2021; Monita & Suharto, 2016). In another study, the results of science literacy tests on chemical bonding materials also showed that high school students were able to know scientific terms, but didn't have much understanding of science concept and still not able to implement the science knowledge they got to different problems (Yamtinah et al., 2019). According to the interview, misconception also happened when students have not fully understood the previous material about the periodic table related to ionic bonding. Students didn't understand the difference in ionization energy and electron affinity so students experience misconceptions in doing chemical literacy problems. This is in line with Pratiwi et al. (2023) which revealed that students' confusion in connecting one concept with another is one of the internal factors causing misconceptions in chemistry learning.

During the interview, there were students who admitted that they were not diligent in taking notes and paying attention to the teacher. This is in line with the research of Saputri et al. (2022) which revealed that students' reading ability was low because students were lazy to read and repeat the lessons that the teacher had given. This also caused the mastery of student content was not optimal. Then, in a reflective journal, there was a student who revealed that he had difficulty in understanding literacy test questions. As stated by Odja et al. (2014), students' science literacy tends to be low if students are not used to taking tests or solving problems related to science process skills. In addition, Primadianningsih et al. (2023) stated that chemical literacy must be fully implemented in learning activities, such as in textbooks that integrate chemical literacy, standardized evaluation questions, chemical literacy learning videos, and other media. Therefore, teachers should familiarize students with solving chemistry problems in various forms of problems, including literacy problems, so that students' chemical literacy skills are honed optimally.

In the context chemical literacy indicator, students were proven to be able to relate the concept of elemental stability and the formation of ionic bonding in everyday phenomena. In addition, students can also explain the formation of ionic bonding by connecting wedding Javanese tradition*s srah-srahan manten*. Students' understanding of these content indicators must be distinct from the application of the ethnochemical integrated CRT approach. Implemention of ethnochemistry learning positively impacted students' scientific literacy because learning became contextual and meaningful so that students' literacy increases (Asda et al., 2023; Wiradharma et al., 2021). Another study by Sari et al. (2023) also stated that ethnoscience learning can be integrated with differentiated learning and it can provide positive effect on students chemical literacy.

The positive impact of CRT and ethnochemistry indicates that chemistry learning using CRT integrated with ethnochemistry can be a consideration in implementing a cultural-based curriculum. There are many other studies that apply ethnoscience in chemistry learning, especially at the high school level. Research on ethnoscience in science learning in the Merdeka curriculum is more commonly carried out at the high school level because science learning has been specifically divided into biology, physics, and chemistry (Hasibuan et al., 2023). As conveyed by Dewi et al. (2019), the development of scientific literacy entails nurturing the next generation's understanding through a cultural-based curriculum, fostering contextual learning that integrates local customs into basic chemistry education, facilitating thereby deeper conceptual comprehension by bridging academic content with community ethos and daily experiences.

On the HOLS chemical literacy indicator, students were able to ask and answer questions about the concept of elemental stability and make arguments from the controversy over ion content in mineral water and demineral water. This is in accordance with learning references that train higher level learning skills, according to Hofstein (2015), including filing activities research questions, solving problems authenticity, argumentation, metacognitive skills, drawing conclusions, making comparisons, dealing with controversy, and taking a stand. The implementation of differentiated learning plays a role to trigger students' chemical literacy here. In reflective journals, students reveal that their group members are active so that it helps in understanding the learning material. This is in line with other researches where differentiated learning has proven in improving and giving good influence for students' scientific literacy in the Merdeka curriculum (Hidayah et al., 2023; Kamila et al., 2023).

The implementation of differentiated learning also has challenges related to time allocation and group division. Students revealed that once-a-week chemistry class hours were too few to understand the whole material. This can be affected by time-consuming differentiated learning activities. Limited learning time is a challenge for teachers in carrying out differentiated learning so that it requires longer learning time than other methods (Aldossari, 2018; Shareefa et al., 2019). The allocation of chemistry lesson hours can be a consideration in the implementation of further chemistry learning with the Merdeka curriculum. Then, from the results of the reflective journal, students revealed that their understanding was also influenced by active and compact group members, but it would be difficult if group members were passive and equally difficult to understand the learning material. This is natural because many students want to be in a group that has a higher academic level than them to help complete (Salleh et al., 2022). In addition, while differentiated learning showed the positive progress for students, there was still the need to pay more attention to students struggling with understanding learning materials (Masbukhin & Sausan, 2023). This is where the role of teachers in differentiated learning plays an important role in order to truly guide students who need guidance without taking their hands off other groups of students.

In the affective chemistry literacy indicator, students showed high interest in chemical issues. This shows that with differentiated learning containing CRT integrated with ethnochemistry, students' interest in chemical issues is at a good level. The implementation of the CRT approach stimulates students' self-awareness of the role of chemistry in daily life, especially in their culture which affects their cultural understanding as well (Rahmawati et al., 2017). Then, the development of ethnoscience-based learning is needed to support students' interest in science so that students have awareness to learn science and improve their learning achievement (Shidiq, 2016). Spesifically in Merdeka curriculum, Nabella et al. (2023) stated that implementation of CRT approach in chemistry learning increased students' learning interest in the high category. This showed that culture-based learning can be an alternative learning that improves students' affective chemistry literacy. Especially after the pandemic crisis, learning that can develop student content, competencies, contexts, and attitudes through culture-based learning needs to be done to produce more contextual learning (Nenohai et al., 2022).

Conclusion

According to data analysis carried out on the results of students' chemical literacy tests on chemical bonding material, students' chemical literacy skills are relatively good in learning chemistry on chemical bonding material. After a comprehensive analysis, the focus rested on students' demonstrated proficiency across various dimensions of chemical literacy indicators. This assessment delineated a significant upsurge in students' comprehension of chemical concepts and their adeptness in applying this knowledge. The evaluation uncovered a marked enhancement in students' grasp of chemical concepts, particularly in their contextual understanding. This improvement was coupled with a notable advancement in higher-order learning skills, indicating a deeper assimilation and application of theoretical knowledge. Furthermore, a highly positive response was observed in affective indicators, indicating heightened interest and engagement among students with the subject matter. Although there is unavoidable reality when teachers also face learning challenges that can lead to student misconceptions because of some factors as learning duration and student characteristics, this holistic assessment of chemical literacy indicators following differentiated learning accentuated the effectiveness of incorporating ethnochemical perspectives within the pedagogical framework. Overall, this analysis portrays a substantial progression in students' chemical literacy skills subsequent to the integration of differentiated learning intertwined with culturally responsive teaching and ethnochemistry. It signifies a promising pathway toward nurturing a more diverse and inclusive approach to chemistry education, tailored to accommodate various learning styles and cultural backgrounds and can be considered in implementation of chemistry learning in Merdeka curriculum.

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Author Contributions

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Conflicts of Interest
The authors declare no conflict of interest.

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