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Has The Teacher Taught Chemical Literacy? A Phenomenological Qualitative Research

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Abstract. *Chemical literacy consists of understanding chemical properties, theory, chemistry, and the nature of chemical phenomena. Proficiency in chemical literacy is fundamental in obtaining basic chemistry concepts, such as chemical interactions at the microscopic, macroscopic, symbolic, and process levels, and understanding and describing phenomena scientifically. Chemical literacy is critical in the learning process at school; therefore, teaching and learning should focus on chemical literacy. This study aims to determine whether teachers have taught chemical literacy in schools. This research is phenomenological qualitative research. Data collection techniques through natural conditions, primary data sources, in-depth interviews, documentation, and participatory observation techniques. The study participants were 24 chemistry teachers: eight on Papua Island representing eastern Indonesia, eight on Sulawesi Island representing central Indonesia, and eight on Java representing western Indonesia. Data were analyzed using the Bogdan and Biklen model. The results showed that the Teacher had yet to teach chemical literacy, although, in the learning process, several principles of chemical literacy had been implemented.*

Keywords: *Bogdan and Biklen model, chemical literacy, phenomenological qualitative.*

INTRODUCTION

Technological advances that are happening so fast are now influencing human life. Technology also has the most fundamental role in chemistry, for example, in observing the shape of molecules, compounds, and images of chemical structures. In education, students are expected to master chemical material in chemical interactions at the microscopic, macroscopic, symbolic, and process levels and understand and describe phenomena scientifically. *Chemistry* is the knowledge that can make students aware of events in their surroundings (Höper et al., 2022). Students expect many problems in learning chemistry to solve problems themselves with the knowledge they have gained in the learning process. To solve problems in chemistry, students must have a strong foundation in introducing the basics of chemistry. Kanapathy et al. (2021) stated that chemistry in teaching should consider the main challenges in actual science practice, application in technology, and social attitudes toward environmental issues related to resources for students to understand a topic. Through chemical literacy, students need to use themselves to solve everyday problems. Student literacy plays a role in determining whether a problem will be answered (Hadi et al., 2018). With the curriculum, the teaching and learning process can be integrated with literacy to know about the context of literacy, and students are accustomed to problem-solving (Retnawati & Wulandari, 2019).

One part of scientific literacy is chemical literacy. According to UNESCO, literacy is a concept that has several meanings and purposes, among others: "With literacy being able to identify something, understand it, interpret it in a particular form, make something similar even though it is not precisely the same, communicate well and calculate in a certain way. Literacy is a continuous learning cycle to obtain optimal learning objectives, explore student potential and develop broader knowledge (Ndukwe & Daniel, 2020). Because of the importance of literacy, literacy intervention is needed (Quick, 2019). Program for International Student Assessment (PISA) defines *literacy science* as scientific knowledge used as a basis for asking, answering, making decisions, and drawing conclusions about a scientific process (Rahmayani et al., 2019).

The definition of literacy is always related to (a) natural knowledge, norms, and scientific methods; (b) introduction to scientific theories, concepts, and principles; (c) introduction of processes and benefits of science and technology for society; (d) understanding of reading, writing, and understanding systematic scientific knowledge; and (e) application of knowledge, skills and scientific reasoning in life (Kahn & Kellner, 2023; Valladares, 2021; Whitehead, 2019). In principle, although there are various definitions of scientific literacy, there are at least three general terms that are agreed upon, namely: (1) understanding the ideas and concepts of science, (2) understanding how to acquire knowledge and the process of inquiry, (3) understanding the influence of science and technology scientific activities on life (Kelp et al., 2023; Klemenčič et al., 2023; Norambuena-Meléndez et al., 2023).

According to He et al. (2021) and Cigdemoglu & Geban (2015), the notion of chemical literacy can be seen from the teacher's four main dimensions of literacy. First, the dimensions of chemistry content knowledge state that *chemical literacy* is defined as understanding general ideas. Second, chemistry in its teaching must be by the context. The third dimension is the learning skills dimension, which states that people with chemical literacy can ask the right things, have connections, and have a massive curiosity about chemistry. Finally, the fourth dimension of attitude states that the affective aspect has a role in increasing or decreasing the development of chemistry. Meanwhile, according to Thummathong and Thathong (2016), chemical literacy refers more to a person's ability to understand chemistry and how to use their chemical understanding of the necessities of life.

Various levels of chemical literacy can be seen from various definitions of existing chemical literacy. Gilbert (2005) divides chemical literacy into three levels: level 1: chemically literate as generally functioning in society. A person who has attained Level 1 will be able to use a restricted set of ideas derived from chemistry, e.g., as a consumer or as a socially active citizen; Level 2: chemically literate as being competent with the ideas of chemistry. A person who has attained Level 2 will be able to draw on a restricted body of knowledge of chemical ideas in order to be able to communicate successfully with others about chemical problems that are set within a restricted range of contexts, activities, or problems; Level 3: chemically literate as being learnéd. A person who has attained Level 3 will have acquired substantial chemical knowledge without a specific reason and can use it in many contexts.

Chemical literacy is very important for the progress of students' knowledge development. Chemical literacy has many components, such as learning the names of chemical elements, symbols in chemistry, equalizing reactions, classification of chemical compounds, classification of chemical elements (metals and non-metals), naming rules, and various other components. These components can be divided into four main bases: the microscopic, macroscopic, symbolic, and process. According to Ad'hiya & Laksono (2018), chemical literacy leads to understanding concepts and the relationship between concepts and aspects of life to understand, analyze, and solve chemical problems.

This research primarily aims to determine whether the teacher teaches chemical literacy. Learning findings in chemical literacy can be observed in four domains of chemical literacy: knowledge, context, higher-order learning skills, and emotional aspects. Based on knowledge, chemistry aims to understand and explain life in terms of the chemical structure and processes of living systems, macroscopic and microscopic explanations, the study of reaction processes, and energy changes during reactions. This context means recognizing the importance of chemical knowledge in explaining everyday phenomena and understanding the relationship between chemical innovations and sociological processes. At a high level, learning skills means asking questions, seeking information, relating it, and analyzing the strengths and weaknesses of a chemical. Finally, it means having a broad, impartial, and realistic view of chemistry and its application based on affective aspects.

Today, students have low chemical literacy, which impacts their learning outcomes (Prasemmi et al., 2021). Students cannot acquire chemical literacy just like that; they must be familiarized with and taught it in the learning process. Improving student literacy needs to involve the teacher, who is expected to teach it to students.

METHOD

This research uses a qualitative research approach with a type of phenomenology. In qualitative research, researchers try to study natural settings and understand or interpret the meaning people give to everyday language experiences (Hennink et al., 2020). This study employed a phenomenological approach to explore teachers' experiences concerning chemistry literacy. In phenomenology, this research requires descriptive meaning and questions. Questions can be expressed broadly without specific references to existing literature or question typologies (Creswell & Creswell, 2017). Judging from its purpose, this research is a descriptive-exploratory study because it aims to describe and discover the use of literacy in learning chemistry in schools.

Participants

This study involved 24 chemistry teachers from various regions: eight teachers from Papua and Maluku, representing the Eastern Indonesia region; eight teachers from Sulawesi and Kalimantan, representing the Central Indonesia region; and eight teachers from Java and Sumatra, representing the Western Indonesia region. This sampling strategy was chosen to ensure a variety of perspectives and experiences related to teaching chemical literacy in various contexts. It aimed to ensure a representative sample of teachers from various regions with various experiences, challenges, and perspectives on teaching chemical literacy. The research respondents are shown in Table 1, and the distribution map of respondents by region is shown in Figure 1.

Table 1. Research Respondents

School Name	A representative	Teacher's Initials
SMAN A	Eastern Indonesia	TNE 1
SMAN B	Eastern Indonesia	TNE 2
SMAN C	Eastern Indonesia	TNE 3
SMAN D	Eastern Indonesia	TNE 4
SMAN E	Eastern Indonesia	TNE 5
SMAN F	Eastern Indonesia	TNE 6
SMAN G	Eastern Indonesia	TNE 7
SMAN H	Eastern Indonesia	TNE 8
SMAN I	The middle part of Indonesia	TNM 9
SMAN J	The middle part of Indonesia	TNM 10
SMAN K	The middle part of Indonesia	TNM 11
SMAN L	The middle part of Indonesia	TNM 12
SMAN M	The middle part of Indonesia	TNM 13
SMAN N	The middle part of Indonesia	TNM 14
SMAN O	The middle part of Indonesia	TNM 15
SMAN P	The middle part of Indonesia	TNM 16
SMAN Q	Western Indonesia	TNW 17
SMAN R	Western Indonesia	TNW 18
SMAN S	Western Indonesia	TNW 19
SMAN T	Western Indonesia	TNW 20
SMAN U	Western Indonesia	TNW 21
SMAN V	Western Indonesia	TNW 22
SMAN W	Western Indonesia	TNW 23
SMAN X	Western Indonesia	TNW 24

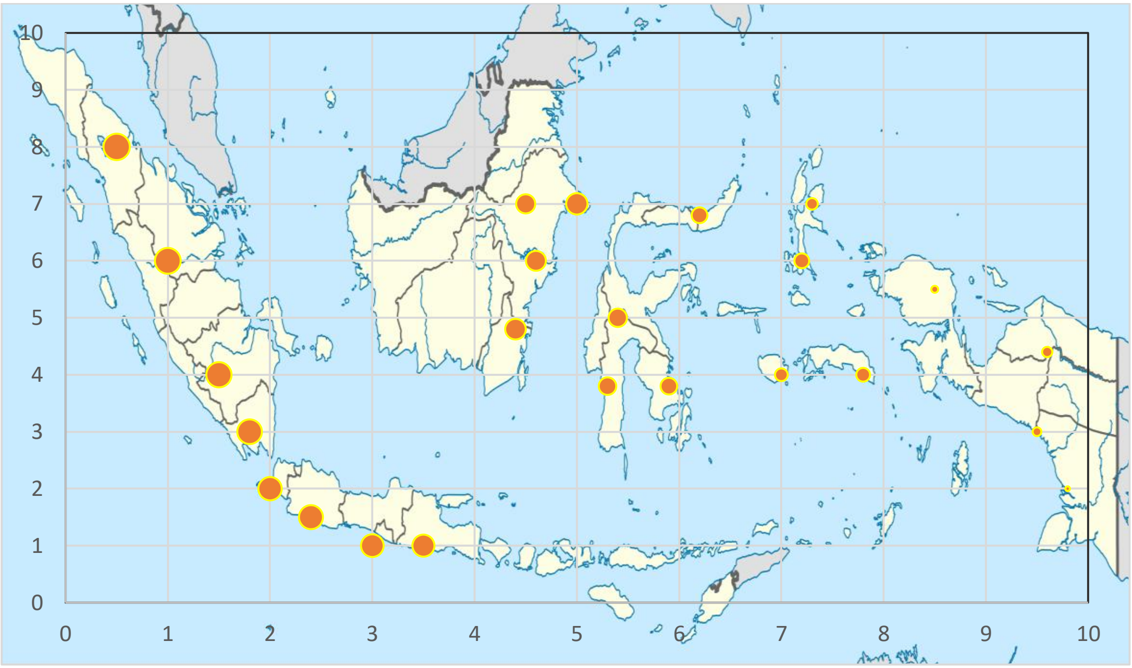

Figure 1. Distribution Map of Respondents by Region

Procedures

This study employed a phenomenological approach to explore teachers' lived experiences in teaching chemistry literacy. Phenomenology aims to understand individuals' subjective meanings and interpretations within specific contexts. To achieve this, data were collected through in-depth semi-structured interviews. Data using primary sources was obtained through structured interview techniques. There are five steps in collecting qualitative data in this study, which is by (Creswell & Creswell, 2017), among others:

Participant Selection.
Purposive sampling was employed to select 24 teachers from three regions in Indonesia: western, central, and eastern. Participants were chosen based on their years of experience, teaching level, and willingness to participate to ensure diverse perspectives and experiences.

Ethical Considerations and Permissions.
Informed consent was obtained from all participants before the interviews, ensuring they understood the research objectives, their rights, and the voluntary nature of their participation.

Data Collection.
Semi-structured interviews were conducted face-to-face to allow for deeper exploration of teachers' lived experiences and to establish rapport. The interview guide was developed based on phenomenological principles, focusing on open-ended questions.

Designing question instruments.
This study compiles ten core questions that must be present in the interview, adopted from Coppi et al. (2023), Hairida et al. (2023), and Shwartz et al. (2005). These questions consist of knowledge, context, competency, and attitudes.

5. Data Analysis.
Data analysis followed a thematic analysis approach guided by phenomenological principles. This involved: (a) Familiarization: Thoroughly read and re-read the transcripts.(b) Identifying initial codes: Identifying and labeling key concepts and themes within the data. (c) Searching for themes: Grouping and organizing codes into broader themes. (d) Reviewing themes: Refining and refining

themes based on the data. (e) Defining and naming themes: Giving clear and concise names to the identified themes. (f) Writing a narrative: Developing a rich and insightful narrative that captures the essence of the teachers' lived experiences.

Data Analysis

After data collection, analysis, and interpretation procedures were performed using the Bogdan and Biklen model. Bogdan & Biklen's model includes three essentials: developing Coding Categories, Predefined Coding Systems, and Effects on Coding and Analysis (Cohen et al., 2018). The data obtained from the results of structured interviews are presented in tabular form.

FINDINGS

The main objective of this research is to determine whether the teacher has understood chemical literacy. Chemical literacy is part of scientific literacy. In the Indonesian curriculum, literacy is a part that must be strengthened. This study used 24 chemistry teachers as the primary respondents to extract chemical literacy information. The 24 chemistry teachers came from various regions in Indonesia, consisting of eight chemistry teachers in eastern Indonesia, eight chemistry teachers who taught in central Indonesia, and eight chemistry teachers in western Indonesia.

In this study, chemical literacy learning has several themes. The themes in this study result from an in-depth exploration process of students' experiences in chemical literacy learning. They are also based on a literature review, which shows that these themes often appear in chemical literacy research. Some of the themes in this study include knowledge of chemical literacy, understanding chemical literacy, forms of chemical literacy in learning, interactions in implementing chemical literacy, student involvement in the learning process, findings of types of knowledge in education, student mentoring can be developed, providing examples of problems that arise in affective students and reasons for not studying chemical literacy. The explanation of this sub-theme is described as follows.

Knowledge of the Term Chemical Literacy

Table 2 presents the results of interviews with chemistry teachers regarding their understanding of the term chemical literacy.

Table 2. The teacher hears the term chemical literacy

Hear the term "chemical literacy"	Verification results
I have, but more often, hear scientific literacy Yes, always together with the mention of scientific literacy Yes, I have heard Once part of scientific literacy Yes, but only occasionally Once, literacy was compulsory in the current curriculum, but rarely about chemical literacy Yes, in reading, there is usually scientific literacy	All teachers have heard the term chemical literacy, but more often hear the term scientific literacy than chemical literacy.

The results of the data analysis in Table 2 show that all chemistry teachers have heard of chemical literacy, but chemical literacy still sounds new. More teachers have listened to the term science literacy than chemical literacy. This shows that although teachers are familiar with the concept of literacy, their understanding of chemical literacy still needs to be improved. This finding indicates that literacy is generally understood without any specification in a particular field of science, especially in chemistry.

Understanding of Chemical Literacy

Teachers conveyed various opinions about understanding chemical literacy. Although chemical literacy is still relatively new, an understanding of it already exists. Table 3 presents our analysis of how teachers conceptualize chemical literacy.

Table 3. An Understanding of Chemical Literacy

Understanding of chemical literacy	Initial Verification	Verification Results
1. Chemical literacy is a source of learning chemistry that can be in text, video, or images. 2. Someone can understand the knowledge that can be in reading, writing, counting, and others. 3. Chemical literacy is an activity in the learning process that aims to foster student interest in reading. 4. Ability to understand a reading related to chemistry	Ability to understand chemistry through reading, writing, calculating, drawing, or video activities in the learning process	Chemical literacy is the ability to understand chemical concepts through reading, writing, calculating, drawing, or video activities whose applications are related to the environment and everyday life.
1. Understand chemical reactions, chemical laws, chemical theory, chemical properties, and the benefits of chemistry in life 2. Students' understanding of chemistry related to the surrounding environment 3. Chemical literacy is a skill in applying chemistry in everyday life. 4. Chemical literacy, education related to chemistry in life 5. The ability of students to understand natural phenomena related to chemistry	Understanding and applying chemical concepts related to the environment and everyday life	

Table 3 reveals two distinct outlines that teachers used to describe chemical literacy. The first outline emphasizes the cognitive aspects of literacy, focusing on the ability to acquire and process information through various activities. The second outline highlights the practical application of chemical knowledge in real-world situations, demonstrating a more contextualized understanding of chemical literacy.

These findings suggest that while some teachers understand chemical literacy as a set of skills and knowledge, others perceive it as a broader concept encompassing the application of chemistry in daily life. This diversity in understanding may have implications for how teachers approach the teaching and assessment of chemical literacy in the classroom.

Forms of Chemical Literacy in Learning

Table 4 presents various teacher activities related to literacy in the chemistry learning process. In this section, teachers were asked to explain the activities they carry out in the learning process that they consider to be forms of chemical literacy.

Table 4. Forms of Chemical Literacy in Learning

Forms of chemical literacy in learning	Verification Results
1. Before starting learning, literacy is used by books or media that are related to students. 2. Writing (books, web) or videos/pictures of natural phenomena related to the surrounding environment 3. I was reading textbooks, browsing the internet, calculating chemical problems, and others. 4. Performing narratives related to chemical problems in daily life 5. In apperception activities, providing stimulus and gathering information by providing opportunities for students to read readings and view videos related to the subject matter and the surrounding environment. 6. Beginning of learning (apperception) 7. Chemical literacy at the opening and core steps in the learning process	Chemical literacy activities that start at the beginning and core of learning can include writing, reading material, narration, video, internet media, and practicum related to the environment and everyday life.

8.	Explanation of the material or example given is taken from the surrounding environment.
9.	Practicum uses surrounding materials.
10.	One of them is in practicum activities, such as making hand sanitizer/disinfectant to prevent the spread of Coronavirus, which is happening right now because it is related to the surrounding environment.
11.	Analysis of the latest phenomena through internet media and natural phenomena in daily life around through activities in the laboratory

Table 4 reveals that teachers integrate various literacy activities into their chemistry teaching. These activities span the entire learning process, from the initial stages of apperception to practical applications. Key findings include:

1. Emphasis on diverse literacy forms: Teachers utilize various literacy forms, including reading, writing, visual media (videos, images), and internet resources.
2. Integration of real-world contexts: Many activities connect chemical concepts to real-world phenomena and everyday life, such as using hand sanitizer or analyzing environmental issues.
3. Early emphasis on literacy: Teachers recognize the importance of literacy from the very beginning of the learning process, integrating it into introductory activities and apperception.

These findings suggest that teachers are increasingly aware of the importance of literacy in chemistry education. However, the diversity of approaches and the lack of explicit policies supporting chemical literacy implementation may indicate a need for further professional development and resources to ensure consistent and effective integration of literacy across all chemistry classrooms.

Constraints In the Implementation of Chemical Literacy

Table 5 presents the teachers' perspectives on the obstacles encountered in implementing chemical literacy in their classrooms. Four primary constraints emerged: infrastructure, student factors, teacher factors, and community perception.

Table 5. Constraints in the Implementation of Chemical Literacy

Obstacles encountered	Constraint factor	Verification results
1. Supporting tools from schools are limited (in focus), and the number of books is insufficient for the number of students. 2. In applications for students often constrained in finding teaching material that is internet access at school 3. Limited media availability constraints	Infrastructure	Constraints in the implementation of chemical literacy in learning include limited media and chemical literacy materials, lack of student interest in reading, which makes it difficult to process information that has an impact on student behavior; teachers find it challenging to make literacy-based questions because they have not received training and are demanding to determine proper material explanation so that all students can understand the material being taught as well as the public's perception that chemistry is identical with laboratories and hazardous chemicals.
4. Lack of student interest in reading textbooks 5. Many students still have difficulty processing the intent of a given phenomenon. His critical thinking skills are still below average. Interest in reading students is also still lacking. 6. Sometimes, some students can express their opinions, but others choose to be silent. 7. Student intake is relatively low so not all students can achieve the expected competencies.	Students	
8. Not all children have the same environment, so they must look for explanatory material that all children can understand. 9. The mindset of teachers who still use the old patterns in teaching means that in the learning process, students are still not trained on literacy-based questions. even this is also because the teacher has not been provided with (given training), so the teacher himself is still having difficulty / does not yet have the skills to make questions based on literacy.	Teacher	
10. People generally assume that chemistry exists only in the laboratory, even though it is found everywhere. Naturally, chemicals are always identified as hazardous substances. Chemistry is widely used in human life.	Community perception	

Table 5 highlights several key constraints to implementing chemical literacy in the classroom.

1. Infrastructure limitations: Insufficient resources such as books, media, and internet access pose a significant barrier.
2. Student factors: Lack of interest in reading, difficulty processing information, and limited critical thinking skills hinder students' engagement with chemical literacy.
3. Teacher factors: Limited training in developing and implementing literacy-based activities and a lack of familiarity with diverse teaching approaches also pose challenges.
4. Community perception: The prevailing perception of chemistry as solely laboratory-based and associated with hazardous substances limits its integration into real-world contexts.

These findings underscore the need for multifaceted interventions to address the constraints in implementing chemical literacy. This may include:

1. Improving school infrastructure: Providing adequate resources such as libraries, internet access, and multimedia equipment.
2. Promoting reading and critical thinking skills: Implementing strategies to enhance students' reading comprehension, critical thinking, and information processing abilities.
3. Providing professional development for teachers: Offering workshops and training programs on integrating literacy into chemistry teaching, developing literacy-based activities, and utilizing diverse teaching approaches.
4. Raising community awareness: Conducting public awareness campaigns to dispel misconceptions about chemistry and highlight its relevance in everyday life.

Despite the obstacles encountered in implementing chemical literacy, Table 6 demonstrates that students are actively engaged in learning. The table presents the teachers' responses regarding student activity levels and the learning strategies most frequently employed during chemistry lessons.

Table 6. Learning Strategies and Student Activity

	Learning strategies and student activity	Verification results
1.	Students are active because they often use inquiry and cooperation.	Students are actively involved in the learning process using various learning strategies depending on the material. The most widely used strategy is inquiry learning.
2.	Students are most active when using inquiry, although sometimes using other methods.	
3.	Students must be active because they use the correct method or model, usually using inquiry according to the 2013 curriculum.	
4.	Some are active, and some are not, depending on the strategy used. So now, the recommendation is to use inquiry more.	
5.	Active when material about practicum. The most frequent inquiry and Problem-Based Learning	
6.	Depending on the chemical material, it will be active if it relates to practice, but it is not easy to be active if it relates to reading material only. So, most often, use STAD and inquiry.	
7.	Be active with the inquiry strategy so that the inquiry is more frequent than occasionally using other methods.	
8.	In addition to difficult practicums, active practicum sessions are active in class. The strategies vary, often using Problem-Based Learning and inquiry.	
9.	Some are active, and some are passive. As per the curriculum directions, use the inquiry more often.	
10.	Active at the beginning of learning. More frequent inquiry and discussion	
11.	Most are active in learning. Practice, discussion, LSQ, inquiry. Almost comparable all	

Table 6 reveals that students are generally active in the chemistry learning process. Key findings include:

1. Inquiry as the preferred strategy: Inquiry-based learning is consistently highlighted as the most frequently used and effective strategy in fostering student engagement.

2. Context-dependent activity: The nature of the learning materials influences student activity levels. Practical activities and hands-on experiments tend to elicit higher levels of student engagement than solely relying on reading material.
3. Variation in learning strategies: Teachers utilize various techniques, including problem-based learning, cooperative learning, and discussion, depending on the specific learning objectives and content.

These findings support the importance of inquiry-based learning in promoting student engagement and active learning in chemistry classrooms. However, the variability in student activity levels across different learning strategies and materials suggests that a diverse range of teaching approaches is necessary to cater to students' diverse learning needs and preferences.

Differences in Declarative Knowledge, Procedures, and Epistemic

Three domains are recognized in teaching and learning: cognitive (knowledge), psychomotor (skills), and affective (attitudes) (Hoque, 2016)Three types of knowledge within the cognitive domain are relevant to chemistry literacy: declarative, procedural, and epistemic. Table 7 presents the teachers' definitions of these three types of knowledge.

Table 7. Teachers' Definitions of Declarative, Procedural, and Epistemic Knowledge

	The definition of declarative knowledge, procedure, and epistemic	Verification results
1.	Declarative about chemical concepts, procedures about processes, epistemic about the nature of science	Declarative knowledge is related to concepts or chemicals, knowledge of related procedures, steps, actions, and stages, while epistemic knowledge is related to his philosophy of the nature of science.
2.	Declarative about chemical theory, procedure about action, epistemic about science	
3.	Declarative chemicals, process procedures	
4.	Declarative is the science of chemical theory; the procedure is the stage; epistemic is knowledge of science in general.	
5.	Declarative chemical material, steps procedures, epistemic nature of knowledge.	
6.	Declarative chemicals, step procedures, epistemic philosophy	
7.	Declarative all materials about chemistry, procedures about practicum, epistemic from epistemology	
8.	The declarative chemistry, the procedure stages, epistemic including words that I just heard	

Table 7 reveals that while all teachers demonstrate some understanding of declarative, procedural, and epistemic knowledge, their definitions vary in specificity and accuracy.

1. Declarative Knowledge: Most teachers correctly associate declarative knowledge with chemical concepts or facts.
2. Procedural Knowledge: Teachers generally link procedural knowledge to processes, steps, or actions, although some definitions are less precise.
3. Epistemic Knowledge: Understanding of epistemic knowledge is more varied. Some teachers accurately relate it to the nature of science or philosophy, while others provide less specific or inaccurate definitions.

These findings suggest that while teachers generally understand the three types of knowledge, there may be room for improvement in their conceptualization and application in teaching practices. Providing teachers with clear and consistent definitions and engaging in professional development activities focusing on the nature of science and the different types of knowledge could enhance their understanding and ultimately improve student learning outcomes.

Determination of the Type of Knowledge in Learning

Table 8 explores how chemistry teachers determine the specific type of knowledge (declarative, procedural, and epistemic) to teach students.

Table 8. Teacher Practices in Determining the Type of Knowledge Taught

Determine the knowledge that will be taught to students	Verification results
1. No, what is essential is the topic of the material. 2. No, focus on the chemical concept. 3. It depends only on the material, but so far more on the concept. 4. I have, but sometimes it is troublesome, so I teach. 5. No, when in class, use only concepts; while in the laboratory, use procedures.	Most teachers do not specify the knowledge (declarative, procedure, and epistemic) taught to students and focus more on declarative knowledge.

Table 8 reveals that most chemistry teachers do not explicitly determine the type of knowledge (declarative, procedural, and epistemic) they aim to impart to students. Instead, their focus is primarily on the content or topic itself. This finding suggests that while teachers may be aware of different types of knowledge, they do not consistently integrate this understanding into their lesson planning. This approach could potentially lead to an overemphasis on declarative knowledge (facts and concepts) at the expense of procedural knowledge (skills and processes) and epistemic knowledge (understanding the nature of science).

Student Skills That Can Be Developed

Table 9 presents the teachers' perspectives on the student skills that can be developed in chemistry education beyond the technical skills associated with laboratory equipment.

Table 9. Student Skills That Can Be Developed

Student skills that can be developed besides laboratory skills	Verification results
1. Question and answer skills 2. Public speaking skills 3. Social skills 4. Organizational skills 5. Skills in providing solutions to a problem 6. Ability to help people around him 7. Cooperation skills with friends 8. Skills for working with others 9. Problem-solving skills	Student skills that can be developed in addition to laboratory skills include speaking skills so students can ask and answer questions, organizational skills so that students can appear in public, work together with others, be skilled in problem-solving, and provide solutions to problems, and social skills so that students can work with others and help people around them.

Table 9 reveals that teachers recognize the importance of developing a wide range of skills in their students beyond technical laboratory skills. Key findings include:

1. Emphasis on communication and interpersonal skills: Teachers emphasize the development of speaking, public speaking, and social skills, highlighting the importance of communication and collaboration in the learning process.
2. Focus on higher-order thinking skills: Problem-solving skills and the ability to solve problems are also crucial skills that should be developed in chemistry education.
3. Recognition of personal and social responsibility: Developing skills such as helping and working with others demonstrates a broader focus on student's personal and social growth.

These findings suggest that teachers understand the importance of a holistic approach to education. They recognize that chemistry education can contribute to the development of a wide range of valuable skills beyond the subject matter itself. These skills are essential for students' success not only in academic pursuits but also in their personal and professional lives.

Provoking Students' Affective Nature through Questioning

The third domain, affective, focuses on students' attitudes and emotions towards chemical problems, particularly those related to existing chemical views and realities. Table 10 presents the teachers' responses to questions that elicit effective student responses.

Table 10. Giving Examples of Questions That Provoke Students' Affective Nature

Examples of questions that attract students' affective attention	Verification results
1. I have, but not always. 2. Never but only on material Reaction rate 3. I have, but on specific material. 4. Ever, for any material related to practicum. 5. Once, get students more interested in chemistry. 6. I have, and the results are excellent 7. Never, but to make a problem requires a challenge. 8. Often, it is directly related to daily life.	The teacher once gave examples of problems that provoke students' affectivity on certain materials.

Table 10 reveals that while some teachers utilize questions designed to evoke affective responses from students, it is not a universal practice. Key findings include:

1. Variability in approach: Teachers use affective questions with varying frequency, ranging from “never” to “often."
2. Context-dependent use: Affective questions are often tied to specific topics or learning activities, such as practical work or real-world applications.
3. Recognition of challenges: Some teachers acknowledge the challenges associated with creating and implementing practical questions, particularly those that connect to real-life situations.

These findings suggest that while there is a growing awareness of the importance of affective learning in chemistry education, further efforts are needed to encourage the consistent and effective use of practical questions in the classroom. This may involve:

1. Providing teachers with specific examples and resources: Sharing best practices and model questions that can effectively elicit affective responses from students.
2. Professional development: Offering workshops and training sessions focusing on developing and implementing effective questioning strategies.
3. Curriculum support: Integrating affective learning objectives into the curriculum and providing clear guidelines for assessing student attitudes and emotions.

Barriers to Implementing Chemical Literacy in Classrooms

Table 11 presents the reasons given by 24 chemistry teachers for not yet implementing chemical literacy in their classrooms.

Table 11. Reasons For Not Teaching Chemical Literacy

Have you ever practiced chemical literacy? Why?	Verification results
1. Never is there any official indication of chemical literacy. 2. Never was there any training on chemical literacy. 3. No, I do not understand how to teach chemical literacy. 4. No, it is too difficult to apply. 5. Never it is hard to get information about chemical literacy. 6. Not yet, because I did not know where to start	Teachers have never practiced chemical literacy because there are no instructions and training, so they do not understand how to teach chemical literacy and assume that chemical literacy is difficult to apply.

Table 11 reveals that the primary barriers to implementing chemical literacy in classrooms are a lack of knowledge, training, and support. Key findings include:

1. Lack of training and guidance: Teachers reported a lack of training and guidance on effectively implementing chemical literacy.
2. Perceived complexity: Many teachers perceive chemical literacy as a complex and challenging concept that needs to be integrated into their teaching practices.
3. Lack of clear instructions: Teachers expressed confusion about the specific expectations and guidelines for implementing chemical literacy.

These findings highlight the need for professional development programs and support systems to help teachers overcome these barriers. Effective professional development should focus on:

1. Building knowledge and understanding: Providing teachers with clear definitions and examples of chemical literacy and equipping them with the knowledge and skills to implement it effectively.
2. Developing practical skills: Offering hands-on training and mentorship opportunities to help teachers integrate chemical literacy into their lesson plans and classroom activities.
3. Addressing misconceptions: Addressing teachers' concerns and misconceptions about the complexity and challenges of implementing chemical literacy.

DISCUSSION

This study aims to determine whether teachers teach chemical literacy. Learning findings in chemical literacy can be observed in four domains of chemical literacy: knowledge, context, high-level learning skills, and emotional aspects. This study seeks to collect information about chemical literacy in several schools in Indonesia. Chemical literacy refers to a person's ability to understand and apply chemical knowledge in everyday life to understand three essential aspects of knowledge: awareness, application, and effectiveness (Thummathong & Thathong, 2018).

Literacy emphasizes four main domains: content, context, skills, and attitudes (Marín & Castañeda, 2023). In content, it means understanding that chemistry explains macroscopic phenomena in terms of the structure of microscopic matter, investigating changes in energy during chemical and chemical reactions to understand and explain life in terms of chemical structures and processes of living systems. In context, it means understanding chemistry in daily life as a consumer of new products and technology, making decisions, participating in chemistry problems, and realizing the importance of chemical knowledge in explaining everyday phenomena. In terms of skills, people who understand chemistry can ask questions, find information, relate it, and analyze the strengths and weaknesses of the things conveyed. Finally, attitude means having an honest and realistic view of chemistry and its application and being interested in chemical problems and topics, especially in a simple framework (Collini et al., 2023; den Heijer et al., 2022).

The study results found that scientific literacy is better known than chemical literacy, which is more specific to chemistry, even though chemical literacy is part of scientific literacy. The teacher must follow five principles to achieve student chemical literacy: determining the chemical knowledge, choosing inquiry learning strategies, determining the relevant context, determining student learning skills, and affective aspects(Rahayu, 2017). This result is by Yaşar (2020) research states that literacy assessment can be divided into five main parts: the purpose of the assessment, the purpose of the assessment technique, the definition of the assessment technique, the preparation of the assessment technique, and the scoring of the results of the assessment technique. Determining chemical knowledge can distinguish three types of knowledge often obtained in chemistry: declarative, procedural, and epistemic. Declarative knowledge is knowledge of chemical content; procedural knowledge is about standard procedures scientists use to obtain reliable and valid data. Epistemic knowledge is knowledge that builds and defines essential features to build knowledge processes in science and their rules in justifying the formation of knowledge (Zetterqvist & Bach, 2023)This study found that all respondents, totaling 24 chemistry teachers, could distinguish definitions from these three pieces of knowledge, but the learning process needed to apply them. The learning process does not determine the chemical knowledge to be learned; it impacts content knowledge, which is the main focus of learning. These results indicate that the first principle of learning to achieve student chemical literacy still needs to be fulfilled.

Inquiry Learning is one of the learning strategies suggested in the Indonesian curriculum. Scientists use a systematic inquiry approach (Kutlu Abu, 2023). Most student learning outcomes are reasonable when using inquiry-learning models, meaning that inquiry-based learning can improve student learning outcomes (Fatmawati et al., 2019). One of the principles of using chemical literacy is inquiry learning strategies. The study results found that all chemistry teachers use Inquiry Learning; this indicates that the teacher has fulfilled one of the learning principles to meet student chemistry literacy. While some progress has been made, particularly in using inquiry-based learning and integrating real-world contexts, significant challenges remain. The lack of teacher training and support and limited access to resources and materials pose a significant barrier to practical implementation. Addressing these challenges requires a multifaceted approach, including (a) Strengthening teacher education and professional development. Providing comprehensive training programs that equip teachers with the knowledge, skills, and resources to implement chemical literacy effectively. (b) Developing and disseminating high-quality instructional materials. Creating and distributing resources such as lesson plans, student activities, and assessments that support the integration of chemical literacy into the curriculum. (c) Advocate for policy changes and advocate for policy changes that prioritize developing and implementing chemical literacy in the national curriculum.

Addressing these issues can empower teachers to effectively integrate chemical literacy into their classrooms, equipping students with the knowledge and skills they need to navigate our increasingly complex and chemically driven world. During the learning process, all chemistry teachers were respondents related to activities related to the environment and everyday phenomena. Linking chemicals to the environment and everyday phenomena is part of the chemical context. This requires the teacher to fulfill the third principle in learning to meet the students' chemical literacy.

The fourth principle in learning so that students' chemical literacy is met is determining skills developed in chemistry. In chemistry, the practicum is a mandatory and inherent skill that students must possess. Also, there are a variety of other skills that can be developed in chemistry, for example, public speaking skills that can be trained through the process of discussion or questioning, questioning and answering questions, and community and organizational skills that can be trained through group learning in answering community phenomena about chemistry problems, problem-solving skills, collaborative skills and various skills that can be honed through the chemistry learning material, from the research results obtained by the fact that all teachers, in addition to developing students 'abilities in the practicum field, also develop students' skills in terms of speaking, asking, answering, socializing, organizing, and cooperating. This means the teacher has planned skills development for students from the beginning to fulfill the fourth principle in learning to meet the students' chemical literacy.

The fifth principle is the affective aspect. The affective domain involves feelings, emotions, and attitudes (Hoque, 2016). The attitude or perception of students can be known if questions are given that can provoke students to give opinions on global issues or phenomena. The study results found that all teachers have applied questions to provoke students to give opinions and find out the students' attitudes in seeing the developing global issues. These results found that the fifth principle in learning to meet students' chemical literacy was fulfilled.

From the five principles, four principles have been implemented, and one has never been implemented, so it can be said that the teacher has indirectly carried out the principle in chemical literacy. However, the teacher does not practice chemical literacy with students in the learning process. Teachers face several obstacles, so they do not teach chemical literacy to students, including teachers who have not received official instructions on chemical literacy and have never received training on chemical literacy. The teacher has not taught chemistry literacy to students. According to Retnawati and Wulandari (2019), teachers are the spearhead of literacy learning, so teacher competence in practicing student literacy in their schools must be considered. The lack of guidance and training results in the unavailability of a chemical literacy learning model, student worksheets, and an assessment sheet to measure chemical literacy. This resulted in the teacher needing to understand how to teach by involving chemical literacy, and it was not easy to get information about chemical literacy. Hence, the perception emerged that it was challenging to learn chemical literacy.

This study has some limitations. First, the sample size of 24 teachers may not represent Indonesia’s entire population of chemistry teachers. Further research with a more extensive and more diverse sample would be beneficial. Second, the study relied on self-reported data from teachers, which may be subject to bias. Future research could incorporate observations of classroom practices to gain a more objective understanding of how chemical literacy is being implemented.

Future research could also explore the following areas: (a) Effectiveness of inquiry-based learning: Conduct more in-depth studies to investigate the effectiveness of inquiry-based learning in promoting chemical literacy among students. This could involve assessing student learning outcomes, examining student attitudes and perceptions, and exploring the challenges and successes of implementing inquiry-based learning in different classroom contexts. (b) Development of instructional materials: Develop and evaluate the effectiveness of instructional materials specifically designed to support the implementation of chemical literacy in chemistry classrooms. These materials could include lesson plans, student activities, and assessment tools. (c) Professional development for teachers: Investigate the impact of professional development programs on teachers' knowledge, attitudes, and practices regarding chemical literacy. This could involve evaluating the effectiveness of different professional development models and identifying best practices for supporting teachers in implementing chemical literacy.

CONCLUSION

The teacher in chemistry learning has yet to determine the knowledge to be achieved, both in declarative, procedural, and epistemic terms. Still, the teacher has implemented an inquiry learning strategy, an appropriate strategy used in learning chemical literacy. Of all the learning processes carried out, the teacher can apply several principles of chemical literacy but does not yet understand that what is done is part of the principle of chemical literacy. In general, teachers have not yet taught students about chemical literacy because not all teachers are competent. Conduct socialization and training on chemical literacy for chemistry teachers in Indonesia so that all are competent and learning emphasizes literacy principles. Besides that, a chemical literacy learning model and an assessment sheet are needed to measure students' chemical literacy levels. This research underscores the critical importance of fostering chemical literacy in students. By understanding the current state of chemical literacy education in Indonesia, identifying key challenges, and exploring effective solutions, we can work towards creating a more scientifically literate society better equipped to address the challenges of the 21st century.

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