Analysis of UoS contextual chemical literacy ability of chemistry pre-service teacher on reaction rate topic

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Abstract. The chemical literacy ability is an essential ability that should be possessed by a pre-service teacher. This research aims to acknowledge the achievement of knowledge, context, competence, and attitude. This research was descriptive-qualitative research whose population consisted of the students of chemistry education. The subjects were 25 students who took a general chemistry class. The techniques of data collection were the interview and questionnaire. The research instrument was the assessment instrument based on chemical literacy and UoS. Based on the research conducted, it was known that the chemical literacy ability of pre-service teachers on the reaction rate topic, the aspect of knowledge found was 71.87%, the aspect of context was 70.25%, the aspect of competence was 73.67%, and the aspect of attitude was 71.53%. The results showed that chemistry pre-service teachers' chemical literacy ability on the reaction rate was medium, with 71.83%.

1. Introduction
The 21st century is marked by an increasingly fast and complex world development. Various changes occur in the field of knowledge, technology, and information worldwide, and these changes are intended to improve the quality of modern social life. One that is being intensively carried out in the education field is to develop 21st-century life skills, the ability of scientific literacy for students [1]. This condition results from the rapid development of science and technology that requires the pre-service teacher to adapt and must be balanced with understanding in interacting with the development of science and technology. Responding to the development of science and technology in developed countries led to an effort for universities so that each pre-service teacher has the ability in scientific literacy. The importance of scientific literacy for pre-service teachers is that it can engage students in understanding the environment, health, economy, and many other problems faced by modern society [2].

The research results conducted by PISA (Program for International Student Assessment), organized by the OECD (Organization for Economic Cooperation and Development) the ability of scientific literacy in Indonesia is still low from year to year. The latest PISA results in 2018, the ranking of Indonesian students' scientific literacy decrease, which ranked 70 out of 78 countries. Indonesia achieved an average score of 396, far below the OECD average score of 489 [3]. The data shows that most students in Indonesia have not been able to apply scientific knowledge to complicated life situations with high cognitive levels, but only can use scientific knowledge to life situations with low
cognitive levels. This low literacy ability should be improved by improving the literacy abilities of the pre-service teacher.

Science literacy is inseparable from science education. The interconnection of the two becomes a holistic part of realizing a more meaningful science learning. In science learning, lecturers must recognize that there is literacy meaning through the scientific process. Likewise, in chemistry learning, lecturers are expected to help the pre-service teacher practice their scientific literacy through chemistry learning [4]. Thus students will be expected to have chemical literacy and become resilient communities in facing the challenges of the 21st century and realize more meaningful science learning.

Chemical literacy is part of scientific literacy [5]. According to PISA, science literacy is the ability to connect issues related to science and scientific ideas, as a citizen who is reflective [3]. Chemical literacy refers to a person’s ability to understand and apply chemical knowledge in daily life to understand three main aspects, knowledge, awareness, and the application. Chemical literacy consists of six components: knowledge and understanding of chemical content; knowledge and experience of the relationship between chemistry, technology, and society; application of analytical thinking; application of reason; moral awareness and sense of responsibility; and attitudes towards chemistry [6].

Chemical literacy is an understanding of the nature of matter, chemical reactions, chemical laws and theories, and the application of chemistry in daily life. People who have chemical literacy must understand the basic concepts of science and chemistry [7]. The importance of chemical literacy is related to how students can appreciate nature with the science and technology they have mastered [8]. Sri Rahayu stated that chemical literacy comes from scientific literacy and can be defined from two main theoretical frameworks: PISA and the description from Shwartz, which is built from the agreement between scientists, educators, and chemistry teacher [9]. According to PISA, Chemical literacy is divided into four interrelated aspects: content, context, competence, and attitude of science [3]. The description was shown in Table 1.

Table 1. The aspect of Chemical Literacy

| Aspect     | Description                                                                                                                                 |
|------------|--------------------------------------------------------------------------------------------------------------------------------------------|
| Knowledge  | Understanding the central facts, concepts, and explanatory theories that build the foundation of scientific knowledge. Knowledge in the form of knowledge about the universe and technological artifacts (content knowledge), knowledge of how ideas are generated (procedural knowledge), and an understanding of the rationale underlying the procedure and justification for its use (epistemic knowledge) |
| Context    | The scientific literacy aspect is an understanding of the situation that has to do with the role or application of science in daily life, which is used to apply processes and knowledge of science concepts. |
| Competency | The ability to explain phenomena scientifically, evaluate and design scientific inquiry                                                                 |
| Attitude   | Attitude is an interest in science and technology, assessing a scientific approach to an appropriate inquiry, and perceptions and awareness of environmental issues. |

Chemistry learning in Islam's view is to study chemistry as a unit that is sourced from God through the Al-Qur'an and hadith [10]. The reality is that most chemistry learning is only on the aspects of humanity's benefit, but there is no meaning to planting monotheism. It makes students view religion and chemistry as two different entities and do not greet each other [11]. Turgut revealed that faith and chemistry's dichotomy resulted in the separation of religious sciences from real life. In contrast, chemistry developed without a touch of religious ethics and spirituality to lose meaning [12]. Zain et al. also stated the dichotomy impact is the absence of the contribution of chemistry learning to the
formulation of a positive attitude in recognizing and glorifying the creator as the source of all knowledge [13].

Bagheri et al. suggested that to dispel the dichotomy view of religion with chemistry, efforts needed to involve aqli and naqli in chemistry learning, namely unity of sciences [14]. Fanani explained that unity of sciences (wahdatul ulum) is a paradigm which states that basically, all knowledge is a unity that originates and empties into God through His revelations, both directly and indirectly [15]. The unity of sciences makes students view all branches of science as a holistic whole, not fragmented, and directs student understanding to the regularity of God's creation [15]. Lubis also revealed that the unity of science could contribute to educational goals and is expected to increase student chemical literacy[16].

2. Method
This research was descriptive analysis with a quantitative approach. The sampling technique used is purposive sampling, where the subjects are 25 chemistry education pre-service teachers at Walisongo State Islamic University Semarang. The Topic is the reaction rate in general chemistry class. This research aims to know students' chemical literacy ability by using chemical literacy and UoS oriented assessment instruments. The test is used in this scientific literacy research in UoS in the form of description because it has advantages in reasoning on the cognitive side, such as analyzing, synthesizing, and evaluating. The purpose of providing UoS contextual science literacy test questions is to determine the ability of students’ chemical literacy. Student answers will be analyzed according to the assessment rubrics made and then made presentations, measured by each indicator, as shown in Table 2.

Table 2. Chemical Literacy Category

| Percentage (%) | Category   |
|----------------|------------|
| 86-100         | Very High  |
| 76-85          | High       |
| 60-75          | Moderate   |
| 55-59          | Low        |
| ≤ 54           | Very Low   |

3. Result and Discussion
According to data analysis, the results showed a mean of 71.83%. It shows that the chemical literacy ability of students is a moderate level. The percentage of each aspect is studied to determine the value of each question item. Where aspects assessed are knowledge, context, competence, and attitudes.

Table 3. Percentage of Each Aspect

| No | Aspect    | Percentage (%) |
|----|-----------|----------------|
| 1  | Knowledge | 71.87          |
| 2  | Context   | 70.25          |
| 3  | Competency| 73.67          |
| 4  | Attitudes | 71.53          |
|    | Mean      | 71.83          |

3.1. Knowledge
Science knowledge refers to the fundamental concepts of science needed to understand natural phenomena and changes made to nature through human activities [17]. The criteria for selecting scientific content are relevant to real situations: essential knowledge and long-term use. There are three aspects of knowledge assessed on scientific literacy: content knowledge, procedural knowledge, and epistemic knowledge. The knowledge aspect includes personal, local, national, and global issues. It can be in the current problems or issues that already occur that require an understanding of science and technology. This study uses UoS contextual chemical literacy items on knowledge literacy aspects
with three literacy indicators: content knowledge, prosedural knowledge, and epistemic knowledge. There is an example of an instrument for UoS contextual literacy problems in the knowledge aspect with an indicator explaining content knowledge in question number 13 is shown in Figure 1. The research results on aspects of knowledge literacy with three indicators are presented in Figure 2.

3.2. Context
The context aspect of science is a dimension of scientific literacy, which is applying science in everyday life, which is used as an application of the process and understanding of science concepts. There are three indicators of context literacy aspects assessed on scientific literacy, 1) knowing the critical role of chemical knowledge to explain daily phenomena (A), 2) knowing the application of chemical concepts in everyday life (B), and 3) knowing the chemical processes in daily life (B). The research results on aspects of context literacy with three indicators are presented in Figure 3.
3.3. Competency

The aspect of competence consists of 3 parts that are: (1) explain phenomena scientifically. Educated people are expected to use standard scientific models to make simple statements to explain daily phenomena. These competencies consist of the ability to describe or interpret phenomena and predict the possibility of change. Also, it may involve recognizing or identifying descriptions, explanations, and predictions. (2) evaluate and design scientific investigations. Explain and assess scientific inquiry and propose ways to answer questions scientifically. Ability to identify questions explored in a scientific study, distinguish problems that might be carried out to investigate scientifically, and offer ways to examine specific questions scientifically. (3) interpret data and evidence scientifically. Analyze and evaluate scientific data, claims, and arguments in various representations and draw appropriate conclusions that demonstrate the ability to: change data from one model to another; analyze and interpret data and draw reasonable conclusions.

This study uses the UoS context chemistry test items on aspects of competency literacy with three literacy indicators that are, explain scientific phenomena (A), evaluate and design scientific investigations (B) and interpret data and evidence scientifically (C). The following is an example of an instrument for UoS literacy problems in competency literacy indicators is shown in Figure 4. Knowing the critical role of chemical knowledge to explain daily life phenomena. The research results on competency literacy aspects with three indicators are presented in Figure 5.
3.4. Attitude

The 2019 PISA assessment evaluates students' attitudes towards science in three areas: interest in science and technology issues, environmental awareness, and assesses scientific approaches to inquiry that are considered the core of scientific literacy preparation. These three fields were chosen for measurement because of the positive attitude towards science, concern for the environment, and an environmentally sustainable way of life. Literacy indicator aspects of attitude that are, showing curiosity and great interest in issues related to science (A), showing concern for the environment and sustainable life (B), and showing attitude to take action from promoting environmentally friendly behavior (C).

The following is an example of a literacy instrument explaining the scientific phenomenon of the context of UoS on attitude literacy aspects. Demonstrating curiosity and great interest in issues relating to science are found in question number 26. The research results on aspects of attitude literacy with three indicators are presented in Figure 6.

Based on Table 3, it is known that aspects of student concept knowledge are relatively low at 71.87%. Similarly, in the aspect of competency, analyzing and evaluating data that reached 73.67%. While aspects of using knowledge or concepts, meaningfully, are included in the moderate or sufficient category, that is 70.25%. The attitude aspect is included in the medium category, which is 71.53%. This study's findings are in line with the PISA research results in 2000 and 2003, showing that the literacy of Indonesian students is only able to recall scientific knowledge based on simple facts. Many experts have indeed highlighted this condition.

According to Mujib & Suparingga said that field facts, students in Indonesia tend to be well at memorizing but are less skilled in applying their knowledge [18]. It is also because the teacher familiarizes it. The tendency use rote learning as the ability to think as a procedure to master science.
It seems that science or chemistry education in Indonesia emphasizes abstract conceptualization and less on developing an active experiment. Both should be proportionally balanced. The fact that occur recently, education is still dominated by the point of view that knowledge is a set of attributes that must be memorized. Most students only remember concepts and cannot relate what they have learned with their application to new situations. Students generally consider the subject matter, which is full of procedural and rules to be memorized to find it easier to answer the exam [19]. The psychological burden that arises from informal education is that they have to learn, which causes boring situations, precisely the opposite of what is expected with their efforts. Children are more focused on how to get good grades than mastering their knowledge.

Students’ inability to analyze a problem is a condition that Indonesian students’ thinking ability is feeble. According to Johnson, the ability to think critically is based on the thought process to analyze arguments and bring insight to each meaning of a problem [20]. Critical thinking is a systematic process that makes it possible to formulate and evaluate their own beliefs and opinions. Critical thinking is an organized process that allows students to assess the evidence, assumptions, logic, and language that underlies others’ statements. The ability to think at a high level is essential to be developed in science learning because this ability will enable a person to solve the problems encountered in his life.

Deboer defines thinking as a mental activity to help formulate or solve a problem, make a decision, or fulfill a desire to understand [21]. This opinion asserts that when someone develops a problem, solves a problem, and wants to understand something, he is thinking. Creative thinking is a mental activity used to find many possible answers to a question and generate ideas or new ideas. A person can think creatively higher if he can show many possible solutions to a problem. But all the solutions must be in accordance with the problem and right, besides that the answer must vary.

Science literacy, including chemical literacy, is essential to be taught to students to survive in the modern 21st-century society. Various efforts have been made in many countries, including Indonesia, to increase student science literacy and chemical literacy, for example, the launch of a new curriculum in 2013. As a determining point for these efforts’ success, chemistry pre-service teacher candidates need to understand well of chemical literacy, how to assess and design chemistry learning that is oriented towards increasing students’ chemical literacy. How to assess chemical literacy can use the PISA scientific literacy framework and Shwartz’s chemical literacy. Whereas chemistry learning can be designed by optimizing aspects of literacy: choosing chemistry topics that have a lot of relevance to students’ lives and consist of declarative, procedural, and epistemic knowledge; inquiry-based learning strategies; determine relevant contexts, contemporary or sociocultural issues; determine the affective values and ways of student learning that will be developed in chemistry learning-oriented, and incorporate religious values into learning to strengthen the character and faith of students.

4. Conclusion
Chemical literacy is an understanding of the nature of particle matter, chemical reactions, chemical laws and theories, and the application of chemistry in daily life. Chemistry and Islam have often considered two different things that cause the absence of the contribution of chemistry learning to the formation of a positive attitude in recognizing and glorifying the creator as the source of all knowledge. This research uses an instrument of chemical literacy problems in the context of UoS so that there is no dichotomy between chemistry and Islam. This study's results are the chemical literacy abilities of chemistry pre-service teachers on the reaction rate topic, the knowledge aspect of 71.87%, the context aspect of 70.25%, the competency aspect of 73.67%, and the attitude aspect of 71.53%. These research results indicate that the UoS contextualized chemistry pre-service teachers’ chemical literacy ability on the reaction rate topic is moderate, 71.83%.

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