Journal of Physics: Conference Series

PAPER • **OPEN ACCESS**

Students' chemical literacy level: A case on electrochemistry topic

To cite this article: A Wiyarsi *et al* 2020 *J. Phys.: Conf. Ser.* **1440** 012019

View the article online for updates and enhancements.

IOP ebooks™

Bringing you innovative digital publishing with leading voices to create your essential collection of books in STEM research.

Start exploring the collection - download the first chapter of every title for free.

This content was downloaded from IP address 125.163.158.232 on 06/02/2020 at 19:27

Students' chemical literacy level: A case on electrochemistry topic

A Wiyarsi[1], A K Prodjosantoso[1] and A R E Nugraheni[1]

[1]Chemistry Education, Universitas Negeri Yogyakarta, Sleman, Indonesia

Corresponding author: antuni_w@uny.ac.id

Abstract. The study purpose to analysis the students' chemical literacy level of electrochemistry topic. Descriptive study with a quantitive approach was done. There were 148 twelfth-grade students as samples that came from two senior high schools in Yogyakarta, Indonesia. The Electrochemistry Chemical Literacy Test (ECLT) was used to gain the data. The ECLT had fifteenth open-ended questions that covers four concepts, i.e. redox reaction, voltaic cell, electrolysis, and corrosion. To ensure the content validity of ECLT, a group of experts have looked at and give some suggestions. The students' responses toward ECLT was examined quantitatively and categorized into five levels: illiterate, nominal, conceptual, functional, and multidimensional ones. The results shown that the mostly students achieved at nominal and conceptual level, also illiterate in almost similar percentages. The lowest achievements were for functional and multidimensional level. In the view of concepts, corrosion gained best result, meanwhile electrolysis have lowest result. These suggest that the chemistry teachers should facilitate an appropriate and conducive learning environment for students' learning. It is useful for enhancing the chemical literacy level, especially by conduct context-based chemistry learning.

Keywords: *chemical literacy, electrochemistry, level*

1. Introduction

The complex and rapidly changing world requires some Basic understanding regarding chemistry [1] since this can be used to support scientific literacy, which is widely perceived to be the main goal of science education. Chemistry as one of the branches of applied science is also have purposes to gain a high level of students' chemical literacy. Chemical literacy means that students are expected to understand the framework and the use of their chemistry knowledge to solve the daily life issues [2]. The significance of chemistry as a subject in the context of securing sustainable education grows by developing students' competences that create chemical literacy [3].

Chemical literacy covers four aspects, i.e chemical content knowledge, chemical in context, higher order learning skills, and affective [2]. The chemical content knowledge describes how a chemically literate student should understand the (a) general chemical ideas, such as scientific investigations, generalize findings, and use knowledge to explain a phenomenon; and (b) key ideas or the characteristics of chemistry, including how the students can explain the macroscopic level of chemistry. The chemical in context matchs the contextual domains by PISA and it explains about the real-life situation involving chemistry and technology so that students should be able to use chemistry knowledge for clarifying everyday phenomena, explaining daily-life chemistry, make effective decisions, and engaging in social arguments regarding chemistry-related issues. The students' higher order learning skills involve

Content from this work may be used under the terms of the Creative Commons Attribution 3.0 licence. Any further distribution of this work must maintain attribution to the author(s) and the title of the work, journal citation and DOI.
Published under licence by IOP Publishing Ltd

decision making and reasoning abilities. The affective aspects describe the students' interest in learning chemistry. Students show a response toward scientific issues reflecting their interest these issues, promoting to the scientific approach, and having a sense of the responsibility toward the situation.

According to Witte and Beers [4] to assess the students' chemical literacy needs the ability of students in using and dealing with written information on a chemical problem and analyzes their chemical knowledge and skills in order to solve daily-life problem. The students could understand the information and choose the information needed from the text so that they have skills in using and dealing with given information and argumentation that means they have high chemical literacy levels. Most students feel that chemistry lesson is not important for later life, unless they end up working in a profession related to chemistry field. Teaching strategies, media and sources that are suitable could support students' chemical literacy.

The context of chemistry toward daily life situations provide the students' probability to show their literacy skills. Gilbert [1] proposed that a context should be designed in various way to engage all students, and the collection of such contexts should be in various ways could make chemistry more relevant to the daily life situation. The context-based learning approach leads students towards making links between the real-life situation and chemistry [5] The context in chemistry regarding these forms can be an environmental issue, an everyday life problem, and an industrial process. The used of a context-based approach proposes to improve students' chemical literacy. The work results of Cigdemoglu and Geban [6] revealed that the used of the context-based approach is better to increase students' chemical literacy level. Some of phemonena in daily life become familiar not only in chemistry and related discipline in formal education, but also the social media, such as newspaper, TV programs, internet, and so on in the informal education [7]. This phenomena such as environmental issues that cover greenhouse effect, ozone depletion, and acid rain. These learning sources leads the students becomes a more informed citizen as part of chemical literacy ability since these issues concern any chemistry concepts and other science concept well.

Electrochemistry, including its comprised concepts, is a complex subject that has considerable importance in many applications [8]. There are some application of electrochemistry concepts in the daily life such as battery and electroplating. Students with good chemical literacy will be able to connect their knowledge in problem-solving of the automotive field by thinking critically, rationally and responsibly. Nevertheless, it was reported that high school students had learning difficulties and misconceptions about galvanic, electrolytic, and concentration cells [8-12]. This learning difficulty can be an obstacle in the achievement of students' chemical literacy. Electrochemistry is applied in several numbers of things in our daily life. However, how is the chemical literacy in this subjects? This research purpose to analysis the level of students' chemical literacy on the electrochemistry topic.

2. Research method

This research applied descriptive study with quantitive approach. This method was chosen because this research aims to know and describe the extent of students' chemical literacy level by emphasizing quantitative data. Researchers did not give any treatment to the samples.

2.1. The Sample of Research

There were 148 twelth-grade students (45 males and 143 females) taken as the samples of the research. The age ranges from 17-18 years old. They had the same economic and social background. They were come from two senior high schools in Yogyakarta, Indonesia. Convenience sampling technique was used to select a sample of 148 students. This sampling technique was chosen because the two schools already had collaboration with the university where the researcher taught so that it facilitated the data collection process. The selected students are all 12th grade students in both schools who take the science program.

2.2. Data Collection Tools
Electrochemistry Chemical Literacy Test (ECLT) was used to collect the data. The development of the instrument was focused on the context, content and HOLS aspect proposed by Shwartz [2].

The aspect of contexts consist of: Photosynthesis (How the plants make food), Alkaline battery (How the electricity comes up), Electro refining: (the process of getting pure copper), and dangerous corrosion under the sea (environmental awareness). The concepts consist of Redox reaction, voltaic cell, electrolysis and corrosion. Each of ECLT item as an open-ended question was used to explore different level of chemical literacy i.e. nominal, functional, conceptual, and multidimensional level, also illiterate [2, 13-14]. Table 1 showed the ECLT items distribution. A group of experts have looked at the ECLT to ensure the content validation. Experts' suggestion was used to revise some of items.

Table 1. The ECLT items distribution

Context	Concept/Content	Number of item to measure chemical literacy level			Number of items
		Nominal, Functional	Functional, Conceptual	Conceptual, Multidimensional	
Environmental (Photosynthesis)	Redox reaction	2	-	1	3
Energy (Battery)	Voltaic cell	3	1	1	5
Industry (Electro refining)	Electrolysis	3	-	1	4
Environmental (Corrosion in the sea)	Corrosion	1	1	1	3
				Total	15

2.3. Data analysis
The students' responses toward Electrochemistry Chemical Literacy Test (ECLT) were assessed quantitively. The data were then categorized into five levels: illiterate, nominal, conceptual, functional, and multidimensional levels. The following is the description of the five literacy levels according to [2, 13-14 *Illiterate* means that student cannot relate to, or respond to a reasonable question about science, do not have the vocabulary, concepts, contexts, or cognitive capacity to identify the question as scientific thinking. *Nominal* level means that students recognize a concept related to science, but the level of understanding clearly indicates misconceptions. *Conceptual* level means that students develop some understanding of the major conceptual schemes of a discipline and relate those schemes to their general understanding of science. *Functional* level means that students can describe a concept correctly, but have a limited understanding. The last, *multidimensional* means that students incorporate an understanding of chemistry that extend beyond the concepts of scientific disciplines and procedures of scientific investigation. Students develop some understanding and appreciation of science and technology regarding its relationship to their daily lives. Students begin to make connections within scientific disciplines, and between science, technology, and the larger issues challenging society. Then, we calculated the percentages both for total and each content to display the distribution of students' chemical literacy level.

3. Results and Discussion
The first finding was the percentage of students' chemical literacy of electrochemistry concept for each level. As seen from Figure 1, the mostly students achieved at nominal (23.5%) and conceptual level (22.1%). There were amount 15.7% students that illiterate.

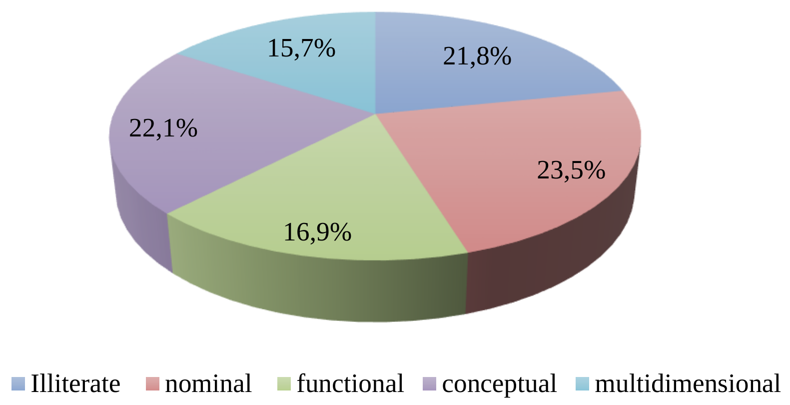


Figure1. The percentage of categorie' students chemical level of electrochemistry topic

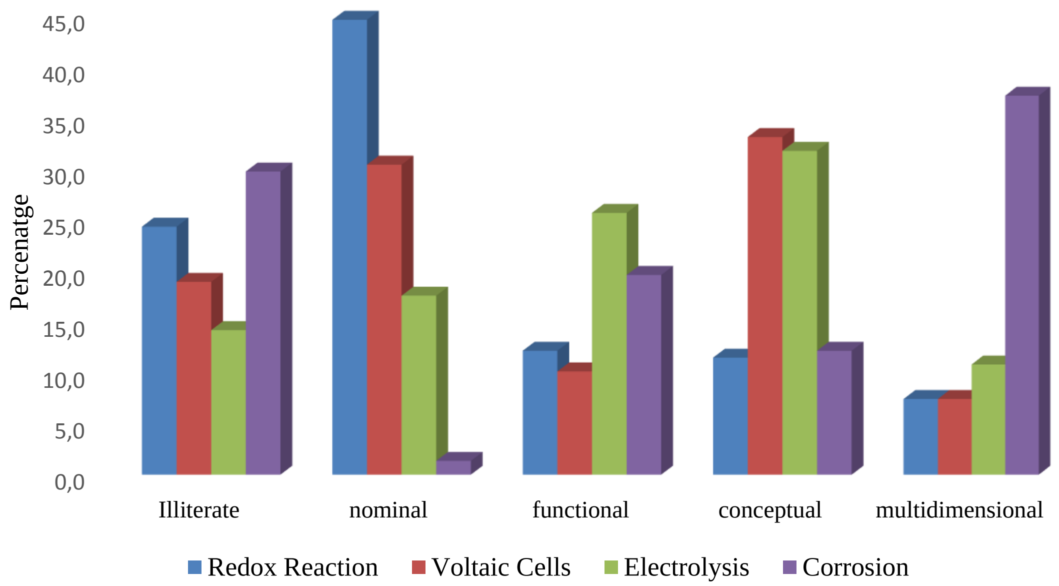
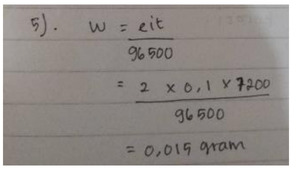


Figure2. The percentage of categories of students' chemical literacy for each concept/content

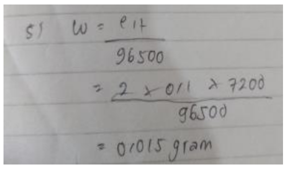
Figure 2 showed that the highest percentage of nominal level was achieved for Redox reaction concept (44.6%), and functional level was gained for Electrolysis concept (25.7%). Furthermore, for conceptual level, the highest percentage (33.1%) was taken from Voltaic cells concept. The last, Corrosion had highest percentage for multidimensional and illiterate level were 37.2% and 29.7% respectively.

The result state that the four concept have variation of students' chemical literacy level. The best achievement of students' chemical literacy level is for corrosion concept. It has high students with multidimensional level. It means that students can extend and apply their concepts and integrate with technology to solve the daily life problems. In this case, students able to explain the dangerous of corrosion in the sea that affect the ship safety. Then, students can incorporate the technology into their idea to solve and prevent the corrosion problem. Corrosion context may more familiar in daily life for students rather than other context so students can understand and handle the problem better. Interestingly, that this concept also gained the highest percentage for students' that illiterate.

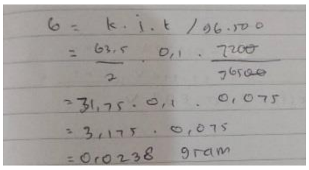
Based on this finding, electrolysis is in the lowest level of the students' chemical literacy, i.e illteracy.. It means that the students do not have capacity about vocabulary, concepts, contexts, or cognitive to recognize the question as scientific thinking [2]. Actually, the students can answer some questions, However, they do not mention the keyword, for instance, for the question 6. Almost of students answered that "metal have bad impact for human", Even though, they did not mention which metal. Some of them just mention that "metal have bad impact for human life without explanation". In other case, the students literally could not answer the question. For example, in the question number 5, almost of students give a false answer. They could not calculate correctly the mass of copper in cathode. Some of the false answers are shown in Figure 3.



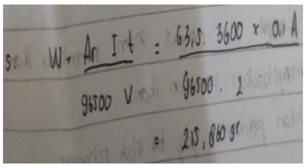
(a)



(b)



(c)



(d)

Figure 3. The Examples of Students' False Answers

Figure 3a. shows that the student did not involve mass of molecules to calculate the equivalent mass. Figure 3b. indicates that the student is not aware how much the times needed to electrolysis process. Furthermore, Figure 3c shows that the student did not calculate exactly. Lastly, figure 4d indicates like figure 3a. The students did not involve mass molecule to calculate the "e" value. Based on the samples, both of figure 3a and 3d indicate that the students did not have true concept to calculate the metal mass. Meanwhile, figure 3b and 3c indicate that the students did not have cognitive capacity to identify the question.

Furthermore, Voltaic cell is in the highest students'chemical literacy on conceptual level. It means that some understanding and main conceptual schemes of discipline and relation them to their general science understanding cannot be extended by students [4,14]. Students can use voltaic cell concept to explain the work of alkaline battery. Unfortunately, not more students achieved the multidimensional level. It means students have less ability in making generalizations and providing knowledge used to explain the effect of battery waste disposal on environmental damage.

Additionally, the functional and multidimensioanl level are not very high compared to other level. Celik [14] declared that the inadequate levels of functional and multidimensional chemical literacy due to the delayed application of the chemistry school curriculum. Other studies have indicated that the teacher lack of preparation to teach [15, 16]. Using real-life experiences as a discussion platform in context-based learning has a significant role in increasing students' chemical literacy levels in abstract and difficult concepts [6].

4. Conclusion

Regarding this finding, it is sugessted for chemistry teachers to be able to provide an appropriate and conducive learning environment during the teaching and learning process. The use of context-based learning is recommended to enhance students' chemical literacy and other students' transferable skills. In addition, teacher can apply multiple representation approach to enhance students' critical thinking [23] as one of ability that is needed to gain the high chemical literacy level.This will support the effort to increase the chemistry learning quality in Indonesia.

References

[1] Gilbert J 2007 *International Journal of Science Education* **28** 957-76 http://doi.org/10.1080/09500690600702470
[2] Jarman R and McClune M 2007 *Developing Scientific Literacy: Using News Media in The Classroom* (New York: The McGraw-Hill Companies)
[3] OECD 2015 *Scientific Literacy: A Framework for PISA 2015* (Paris:OECD)
[4] Shwartz Y, Ben-Zvi R and Hofstein A 2006 *Chemistry Education Research and Practice* **7** 203-25 http://doi.org/10.1039/B6RP90011A
[5] Cigdemoglu C and Arslan H 2017 *Chemistry Education Research and Practice* **18** 288-303, http://dx.doi.org//10.1039/c6rp00167j
[6] Mozeika D and Bilbokaite R 2010 *The International Journal of Educational Researchers* **3** 1-16
[7] Miller G (2018) *Addressing Students' Difficulties and Misconceptions about Electrochemistry* Retrieved from http://apcentral.collegeboard.com/
[8] Garnett P J and Treagust D F 1992 *J. Res. Sci. Teach*. **29** 1079–99
[9] Niaz M 2002 *Int. J. Sci. Educ*. **24** 425–39
[10] Niaz and Chaco´n E 2003 *J. Sci. Educ. Technol,* **12** 129–34
[11] Acar B and Tarhan L 2007 *Int. J. Sci. Math. Educ.* **5** 349–73
[12] Osman K and Tien T L. 2014 *Int. J. Sci. Math. Educ.* **12** 395–421
[13] DeBoer G B 2002 *Journal of Research in Science Teaching* **37** 582-601 http://dx.doi.org/10.1002/1098-2736
[14] Bybee R, McCrae B and Laurie R 2009 *Journal of Research in Science Teaching* **6** 865-83, http://dx.doi.org/10.1002/tea.20333
[15] Witte D and Beers K 2003 *Chemical Education International* **4** 1-15 http://old2015.iupac.org/publications/cei/vol4/0401x0an3.pdf
[16] Ültay N and Çalık M 2012 *Journal of Science Education and Technology* **21** 686-701 http://dx.doi.org/10.1007/s10956-011-9357-5
[17] Cigdemoglu C and Geban O 2015 *Chemistry Education Research and Practice* **16** 302-17, http://dx.doi.org/10.1039/c5rp00007f
[18] Show-Yu L 2009 *Chemical Education Journal* **13** 1-6
[19] R Bybee 1997 *Achieving Scientific Literacy* (Heineman: Portsmouth)
[20] Celik S 2014 *Australian Journal of Teacher Education* **3** 1-15
[21] Kurt S and Yildirim N 2010 *On Dokuz Mayiz Universitesi Egitim Fakultesi Dergisi* 91-104
[22] Yasar M D and Sozbilir M 2012 *The Journal of Academic Social Science Studies* **5** 789-807
[23] Wiyarsi A, Sutrisno H and Rohaeti 2018 *Proc. Int. Conf. RIEMS (Yogyakarta)* vol 1097 (Bistol: IOP Publishing) p 1 https://doi.org/10.1088/1742-6596/1097/1/012054.