Measuring Students’ Chemistry Literacy Ability of Acid and Base Concepts

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Abstract. The goal of this study was to investigate Students' levels of chemistry literacy ability on acid and base concepts. A quantitative descriptive method was used for this study. The subject of this study consisted of 251 second-year high school students in Yogyakarta. The data were collected by a test to measure chemistry contexts, chemistry knowledge, and chemistry competency aspects, and a questionnaire to measure attitude aspect that was developed in previous study. The students’ level of chemistry literacy for the aspects were in moderate level. Therefore, some sub aspects had a low and very low category, it might be caused by the lack of teachers’ ability to applied learning strategy for developing students’ chemistry literacy ability.

Keyword: Students; Chemistry literacy; Acid; Base concepts.

1. Introduction
The rapid development of science and technology has an impact on the goals of science education which are more focused on improving students' scientific literacy and chemistry literacy ability’s [1, 2]. The OECD (Organization for Economic Co-operation and Development) is one of the organizations that agrees that scientific literacy and chemistry literacy must be applied as goals in science education in the concept or application [3]. Meanwhile in Indonesia, literacy has also been implemented in the 2013 curriculum, where the learning refers more to contextual inquiry and problem solving activities. But in fact, the implementation of the 2013 curriculum is not as expected because teachers have difficulties in carrying out contextual learning. In addition, teachers do not understand the objectives of the 2013 curriculum and are less able to carry out the applicable, interesting, and creative learning process [4, 5]. It was proven by the low test results held by PISA and TIMSS which show that Indonesia is still in low category [6, 7].

The concept of acids and bases is one of the chemistry’s applications are found in everyday life. But from some study results revealed that students still have difficulties in understanding this concept and applying knowledge in the everyday life [8, 9]. Even so, some of the results of the study only reveal the difficulties that occur in understanding the concept of acids and bases, but do not explain the ability of their chemistry literacy in the concept of acids and bases [10, 11].

The studies to specifically measure students’ chemistry literacy is still rarely founded. So, there’s no results that state the portrait or description of students’ chemistry literacy ability’s. In fact, the results of the measurement of the students’ chemistry literacy are needed to found. The result could be useful for teacher's reflection to evaluate their learning process and strategy accordingly. Study to measure students’ ability in chemistry literacy has been carried out [12], but measured chemistry literacy is still carried out in general. Therefore, this study aims to measure students’ chemistry literacy ability on the concept of acids and bases.
The rest of this paper is organized as follow: Section 2 presents literature review on chemistry literacy. Section 3 describes the proposed research method. Section 4 presents the obtained results and following by discussion. Finally Section 5 concludes this work.

2. Related Works
This section presents literature review on chemistry literacy.

2.1. Measurement
A measurement is a result, usually expressed in numbers that could be obtain by measuring something. In other words, measurement is a set of experimental operations whose purpose is to determine the size of a physical measure, or to measure it, in terms of numbers and units [13-15]. Errors in the measurement results must be as small as possible. This relates to the reliability of the measuring instrument used. A good and reliable measuring instrument gives constant results when used repeatedly, provided that the measured ability does not change [16]. So in making a measurement must minimize the level of error as small as possible so that the measurements made can provide good results.

2.2. Chemistry Literacy
PISA develops assessments that can portrait students' scientific literacy [3]. The questions used relate to the context of everyday life, including science and technology, then also create a learning environment that makes students able to make decisions. In this process, students are able to identify scientific issues, understand the underlying science, and use facts or theories competently. Aspects of scientific literacy according to the 2015 PISA framework [17] are described in Table 1 as follows:

| Scientific Literacy   | Explanation                                                                                                                                 |
|-----------------------|---------------------------------------------------------------------------------------------------------------------------------------------|
| Contexts              | Personal, local/national and global issues, both current and historical, which demand some understanding of science and technology              |
| Knowledge             | An understanding of the major facts, concepts and explanatory theories that form the basis of scientific knowledge. Such knowledge includes knowledge of both the natural world and technological artefacts (content knowledge), knowledge of how such ideas are produced (procedural knowledge), and an understanding of the underlying rationale for these procedures and the justification for their use (epistemic knowledge). |
| Competencies          | The ability to explain phenomena scientifically, evaluate and design scientific enquiry, and interpret data and evidence scientifically.           |
| Attitudes             | A set of attitudes towards science indicated by an interest in science and technology, valuing scientific approaches to enquiry where appropriate, and a perception and awareness of environmental issues. |

Students' abilities and attitudes affect their abilities. Attitudes are important in scientific literacy, because students' responses to science issues show their interest in the issue, how they support the scientific approach, and their sense of responsibility for the situation. In addition, PISA also said that science issues can be used as learning material and curriculum to support scientific literacy in learning [3]. Associated with chemistry literacy, the assessment of chemistry literacy is done by looking at the ability of students to use and understand the information provided in chemistry problems to compare that information with daily life. This ability is to understand the information provided, the capacity to choose the information needed from writing, the capacity to process the information, and the capacity to assess whether the information they receive is true or not. In addition, the ability to express opinions by involving pros and cons in arguing is also the ability in chemistry literacy. Based on the
description, if students can use the information provided and provide valid arguments based on the pros and cons, the students have a high level of chemistry literacy [18].

Celik [1] conducted a study to determine the level of chemistry literacy of prospective science teacher students in Turkey. The measured chemistry literacy is divided into four parts, which are nominal literacy, functional literacy, conceptual literacy, and multidimensional literacy. Data collection instruments in the form of questionnaires developed by Schwartz [3]. The questionnaire used is divided into three different formats. The first questionnaire is in the form of a Likert scale (1-3) which aims to measure nominal and functional literacy. In this questionnaire there are also open-closed questions that ask students to explain some chemistry concepts. The second questionnaire aims to measure the conceptual literacy of students. This questionnaire contains questions that are accompanied by descriptions of various phenomena about chemistry, students are expected to explain and relate the phenomenon to chemistry concepts. The last instrument is used to measure the level of multidimensional literacy of students. This questionnaire aims to determine the ability of students in reading and retrieving information related to chemistry contained in the article.

From the several studies that have been carried out, some have developed test instruments to measure scientific literacy. While several other studies have developed test instruments to measure chemistry literacy, the study subjects are college students. Therefore, this study intends to be more specific in measuring the chemistry literacy of students in high school. Aspects to be measured based on aspects of chemistry literacy are in accordance with the 2015 PISA framework [17] which are, the context of chemistry, chemistry content, chemistry competence and affective. If in previous study, the measured chemistry literacy was still in general scope, then this study focused more on chemistry literacy on the concept of acid-base only.

Various forms of tests to measure scientific literacy and chemistry literacy have been developed, such as multiple choice, open-ended questions, and questionnaires. However, this study is intended to measure the ability of chemistry literacy students in more complex, where the advantages can measure the ability of chemistry literacy of students who are more complex. In addition, students can more freely organize answers with their own opinions.

3. Material and Methodology

This section presents data used and the proposed method.

3.1. Method

This study is a quantitative descriptive study that aims to measure students' chemistry literacy ability on the concepts of acids and bases. The subjects of this study were 251 second-year high school students in Yogyakarta, Indonesia. The instrument used in this study is divided into two, which are the test instrument and questionnaire. The test instrument aims to measure chemistry literacy ability’s in chemistry contexts, chemistry content and chemistry competencies. This instrument formed by 24 items of essay which contain questions about the concepts of acids and bases in daily life. The instrument is also equipped with scoring guidelines to make it easier to give a score on the test results.

While the affective questionnaire aims to measure students' attitudes toward the concepts of acids and bases. On this questionnaire sheet, students are asked to give their responses to interests, interests in chemistry issues around acid-base, and how they behave and apply their knowledge of the concepts of acid and bases in everyday life. The questionnaire sheet has 14 statement items which bring up the theme of soil acidity, heartburn, bee stings, industrial waste, acid rain, and hair pH.

3.2. Data

3.2.1 Technique of Data Collection

The technique of data collection uses test instruments and questionnaires that have been developed in previous studies. The instrument has been valid and has a reliability of 0.78 and 0.80. Both instruments are given separately to students with 100 minutes of finishing times.
3.2.2 Data Analysis
Data in this study were analysed descriptively. To show the level of literacy ability of students, the data were analysed quantitatively. For the results of the test instrument, the score range given is 0-3 based on the scoring guidelines. While the questionnaire instrument uses a Likert scale with a score range of 1-4. After obtaining each score, the criteria for students’ chemistry literacy abilities are then determined.

4. Results and Discussion
The results of the measurement of students’ chemistry literacy abilities are explained based on four aspects, which are: chemistry context, chemistry knowledge, chemistry competencies, and attitude aspects. The following are the measurement results for each aspect:

4.1. Chemistry Context
This stage describes the results of the measurement of students’ chemistry literacy ability’s in the aspect of the chemistry context. This aspect consists of three scopes, which are: personal, national, and global. Measurement results can be seen in Table 2.

| Chemistry Context | Score | Category |
|-------------------|-------|----------|
| Personal          | 58.86 | Moderate |
| Local             | 34.26 | Very Low |
| Global            | 55.96 | Low      |

Measurements in the scope of the personal context include about stomach ulcers, bee stings and hair pH that are consist in health area, while in the environmental area bring out the theme about pH of the soil. From the measurement results, the ability of students is in moderate category with a score of 58.86. Whereas in the context of national scope, the score was found 34.26 which is in the very low category. In this scope, the item being tested is an environmental problem such as industrial waste. Low scores indicate that students have not fully understood the concept of acids and bases in the industrial field. The scope of the global context has a result of 55.96 which is in the low category. The global context raises the issue of acid rain. These results also show that students have not been able to link the concepts of acid and base to a broader context. Of these three spheres, the achievement of personal context is in the highest scope compared to the other contexts. This shows that students are more familiar in linking the concepts of acid and base to everyday life which are very simple, but have a low understanding on broader and larger issues.

4.2. Chemistry Knowledge
Chemistry knowledge measured in this study is content knowledge, procedural knowledge, and epistemic knowledge. Measurement results in aspects of chemistry knowledge can be seen in Table 3.

| Chemistry Knowledge | Score | Category |
|---------------------|-------|----------|
| Content             | 69.20 | Moderate |
| Procedural          | 54.52 | Low      |
| Epistemic           | 48.62 | Very Low |

Based on the Table 3 above, the results obtained in the measurement of content is 69.20 which is in moderate category. These results indicate that students have sufficient understanding of general knowledge in the concepts of acids and bases such as distinguishing between strong acids, weak acids,
strong bases and weak bases, explaining the nature of acids and bases, explaining the concepts of neutralizing acids and bases, and calculating pH. While the score on procedural knowledge is 54.52 which is in low category. In this case, students still have little difficulty in applying their knowledge of the concepts of acids and bases to solve problems in everyday life. As for epistemic knowledge, a score of 48.62 is obtained with a very low category. This shows that students have not been able to evaluate or make related decisions in solving issues or problems related to acids and bases in daily life. Generally, students have understood the basic concepts in acids and bases, but still have difficulties in using their knowledge to solve problems in everyday life.

4.3. Chemistry Competency

The competencies measured in chemistry literacy in this study are: explain phenomena scientifically, design scientific inquiry, evaluate scientific inquiry, and interpret data and evidence scientifically. Measurement results in this aspect can be seen in Table 4.

| Chemistry Competency                           | Score | Category |
|------------------------------------------------|-------|----------|
| Explain phenomena scientifically               | 57.95 | Moderate |
| Evaluate scientific inquiry                    | 56.52 | Low      |
| Design scientific inquiry                      | 43.82 | Very Low |
| Interpret data and evidence scientifically     | 62.45 | Moderate |

Based on the results in Table 4, students have been able to explain the phenomena scientifically and interpret the data and facts scientifically in a moderate category, it was proven by the acquisition of scores of 57.95 and 62.45. In this case, students are capable enough in explaining some simple phenomena that occur in everyday life and interpret them scientifically using their knowledge of the concepts of acids and bases. As for the competency of evaluating and design scientific inquiry is still relatively low with a score of 56.52 and 43.82 in the category of low and very low. These results portray that students are still having difficulties in proposing the right solutions and methods in addressing issues and problems that occur in everyday life.

4.4. Attitude Aspect

Attitude aspects in this study was collected by using a questionnaire. The sub-fields under study cover 4 things, which are interest in chemistry issues, valuing scientific approaches to inquiry, environmental awareness, and health awareness. The measurement results on the attitude aspect can be seen in Table 5.

| Attitude Aspect                        | Score | Category |
|----------------------------------------|-------|----------|
| Interest in chemistry issues           | 78.43 | Moderate |
| Valuing scientific approaches to inquiry | 81.13 | Moderate |
| Environmental awareness                | 83.76 | Moderate |
| Health awareness                       | 84.06 | Moderate |

From the Table 5 above, the measurements obtained in the sub-items were interest in chemistry issues with a score of 78.43, values in chemistry with a score of 81.13, environmental awareness with a score of 83.76, and health observations with a score of 84.06. Measurements from these four parts doesn’t show a different result because all of scope have the same category which is the moderate level category. This shows the participants have an interest in chemistry issues especially, the issues that
measured in this study such as soil pH, ulcer disease, bee stings, industrial waste, acid rain, and hair pH. In addition, students also have sufficient understanding of the values contained in the concepts of acids and bases, where they understand enough of these things. Likewise concern for the environment and health is also good enough because they allow the environment to not be polluted and more aware of the health of their bodies.

Generally, students' chemistry literacy ability’s on the concepts of acids and bases are in moderate category, although in some aspects they are still relatively low. This result is slightly different from the results of measurements conducted by PISA and TIMSS where Indonesia is at the lower rank, which shows that the ability of students is very low [6, 7]. Even so, these results cannot be generalized because this study does not measure scientific literacy in general, but only measures chemistry literacy ability’s in the concepts of acids and bases only. The ability of chemistry literacy of students who are not too high can also be caused by the lack of maximum application of the 2013 curriculum and contextual learning that can improve students' chemistry literacy ability’s. This case related to other studies which reveals that teachers have difficulties in carrying out contextual learning. In addition, teachers do not understand the 2013 curriculum objectives and are less able to carry out the learning process that is applicable, interesting, and creative [4, 5].

5. Conclusion
Based on the results of the study described, it can be concluded that the students' chemistry literacy ability’s on the concepts of acids and bases are in moderate category. For some aspects having results that are classified as low and very low, this may be due to the lack of application of learning to develop students' chemistry literacy ability’s. Even so, the results of this study can be an evaluation material for teachers in developing teaching strategies in improving students' chemistry literacy ability’s. As for suggestions for further study, study can be carried out that measures chemistry literacy in other materials to find out how far the students' abilities are.

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