Identify students’ scientific literacy through tests on kinetics of chemistry concept

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Abstract. The purpose of this study was to determine students' scientific literacy through test on the kinetics of chemistry concept. Scientific literacy is one of the abilities students must have to know how much they can implement their knowledge to be applied in life. This test was established randomly selecting 65 students as participant of eleventh grade from senior high school in Sukoharjo. Twenty five number of questions tested is multiple choice. In each item of the questions contain aspects in the dimensions of scientific literacy including dimensions of content, context, and competence. The questions tested were divided into 5 low difficulty questions, 12 moderate difficulty questions and 8 high difficulty questions. The results of this study, 59.07% participant can answer low questions, 42.3% medium questions, and 57.5% high level of difficult questions. Furthermore, students’ scientific literacy of 67.69% are low with 7.69% get good point. This shows that many students don’t understand yet how to use and apply of science in life.

1. Introduction

Science is the key to modern knowledge so prioritizing the development of knowledge to be applied to society. This is because science plays an important role both now and in the future related to their daily lives and work [1]. Science education is oriented to produce someone who is productive, creative, innovative, and effective. It can be achieved by students through strengthening attitudes (know why), skills (know how), and knowledge (know what) are integrated [2]. Science education has a useful role in knowledge in life. For a better understanding of the importance of science, it is necessary to be familiar with the scientific environment through systematic knowledge. One of the most important goals of Science Education is the development of scientific literacy [3]. The importance of the scientific literacy is revealed in school curriculums standards in many countries (include Indonesia) and in international studies PISA (Program for International Student Assessment) [4].

The success of students in understanding a learning concept can be seen from their ability to implement the knowledge they get. Scientific literacy is defined here as knowing basic facts and concepts about science and having an understanding of how science works [5]. [6] Lawless etc. did a research the level of scientific literacy ability that is implemented in social study classrooms. Which is measured is in the consumption, evaluation and communication of science information in daily life.
Science literacy is scientific knowledge and use of knowledge to identify questions, acquire knowledge, explain scientific phenomena, and draw facts-based conclusions about science-based issues [9]. The dimensions measured to determine scientific literacy skills include competency, content, context and attitude. [10] They describes the dimensions and aspects measured in scientific literacy:
1. Competence: the ability to demonstrate scientific competence to obtain information that can be reviewed and tested for its truth
2. Content: the ability to understand nature based on scientific knowledge
3. Context: the ability to recognize life situations that involve science and technology
4. Attitude: ability to show interest in science, support science research, and motivation to act and be responsible.

Reflective instruction in the nature of science that shows literacy activities in scientific investigations can provide learning for the development of scientific literacy [8, 9]. The importance of scientific literacy skills for each person makes the researcher interested in identifying high school students. Chemistry lesson is science education that is studied in high school. Kinetics of chemistry is the one of topic on eleventh grade can be applied to diagnose student’s scientific literacy.

2. Methods
The aim of this identification test is to find out the extent to which students succeed in the learning process and find out the uses or implementation of the chemistry they get through scientific literacy tests. The test questions were tested on 25 multiple choice that refer to the kinetics of chemistry concept. A sample of 65 students was taken randomly from the eleventh class of high school in Sukoharjo. The measured dimensions of scientific literacy consist of dimensions of competence, content, and context where each question contains each indicator of them.

| Table 1. Distribution of question number on kinetics of chemistry concept |
|---------------------------------------------------------------|
| **Concept of kinetics**                                  | **Number of Questions** |
| factors that influence the kinetics                        | 1-7, 9, 14, 15, 22, 23 |
| reaction order and law of the kinetics                    | 8, 10-13, 16-18, 20, 21, 24, 25 |
| how to store and use chemicals                            | 19 |

Indicators the dimensions of scientific literacy contained in the test questions are shown in table 2.

| Table 2. Aspects in the dimensions of scientific literacy and question numbers |
|---------------------------------------------------------------|
| **No.** | **Indicators scientific literacy** | **Number of Items** |
|-----------------|--------------------------------------|------------------|
| 1.              | Competencies: explaining scientific phenomena | 1                |
|                 | Content: epistemic                   |                  |
|                 | Context: local                       |                  |
| 2.              | Competencies: identifying scientific phenomena | 2, 15            |
|                 | Content: epistemic                   |                  |
|                 | Context: global                      |                  |
| 3.              | Competencies: using scientific evidence | 5-8, 10-13, 16-18, 21-25 |
|                 | Content: procedural                   |                  |
|                 | Context: personal                     |                  |
| 4.              | Competencies: using scientific evidence | 3, 9, 14         |
|                 | Content: procedural                   |                  |
|                 | Context: global                       |                  |
| 5.              | Competencies: explaining scientific phenomena | 4               |
|                 | Content: knowledge                    |                  |
|                 | Context: personal                     |                  |
6. Competencies: explaining scientific phenomena 20
Content: knowledge
Context: global

7. Competencies: identifying scientific phenomena 19
Content: knowledge
Context: global

The difficulty of any item is based on cognitive level in the PISA 2015 framework. Where combinations of each question are expressed in low, medium and high levels. Grouping the level of combination of questions is presented in table 3.

| Levels of Assessment | Total items |
|----------------------|-------------|
| Low                  | 5           |
| Medium               | 12          |
| High                 | 8           |

Students' scientific literacy skills are assessed from:

1. Percentage of students who answer questions correctly on low, medium, and high categories

\[ \% = \frac{\text{sum correct answers of participants}}{\text{maximum correct answers}} \times 100\%

2. The percentage of students who can answer questions is more than 60% correctly of all questions given.

3. Results and Discussion

3.1. Result

Test questions are based on data or scientific phenomena related to chemical kinetics in high school. Percentage of participants can answer questions correctly seen from the difficulty level of the questions shown in the table 4:

| Levels of Assessment | Percentage |
|----------------------|------------|
| Low                  | 59.07%     |
| Medium               | 42.3%      |
| High                 | 57.5%      |

Table 5. Percentage of questions and the number of students who can answer correctly:

| Correct answer | Participants |
|----------------|--------------|
| 15 questions (60 %) | 21 (32.3 %)  |
| 18 questions (72 %)  | 5 (7.69 %)   |

3.2. Discussion

How to find out the scientific literacy abilities of students can be measured by instruments in the form of test questions arranged in such a way as to combine various aspects of dimension skills and indicators in a learning. Concept is derived from experience or real events. Basically, all science can be developed in context to be something that can be understood and applied in life.

In this study, scientific literacy has been measured through three dimensions: (1) Dimension of competence consist of aspects of explaining scientific phenomena, identifying scientific phenomena, and using scientific evidence, (2) The content dimension consists of knowledge, procedural, and epistemic aspects. While (3) the context dimension consists of personal, local, and global aspects. Each question tested to participants is made with a combination of aspects or indicators of the three dimensions used. The
distribution of the difficulty level of the questions based on the 2015 PISA for this assessment can be determined from:

- **Low**: questions carry out a one-step procedure, for example recall of a fact, term, principle or concept or locate a single point of information from a graph or table.
  
  Example question of low:
  
  HNO₃ (nitric acid) is the process of making nitric acid with the Ostwald process carried out by burning NH₃ in the air by heating at a temperature of around 900 ° C. The metal catalyst used in this process is Platinum (Pt). A statement that is not correct based on the reaction above is ....
  
  a. The basic ingredient in making nitric acid is ammonia
  
  b. With the use of catalysts the reaction of nitric acid production can take place faster
  
  c. The reaction of making nitric acid is carried out at high temperatures
  
  d. Making nitric acid is carried out with the help of a homogeneous catalysts
  
  e. Making nitric acid is carried out with the help of heterogeneous catalysts
  
  Of all the answers, only (D) making nitric acid (liquid) is carried out with the help of a homogeneous catalysts (metal platinum) shows the incompatibility between the answer and the statement in the question.

- **Medium**: questions use and apply conceptual knowledge to describe or explain phenomena, select appropriate procedures involving two or more steps, organize / display data, interpret or use simple data sets or graphs.
  
  Example question of medium:
  
  National waste production reaches 65.8 million tons a year. Disposal of garbage by one person per day as much as 600 grams consisting of organic waste, paper, plastic, glass, and other objects that are not used. Organic waste comes from natural ingredients such as vegetables, fruit peels, or other rotten foods. Decomposition of organic waste by bacteria takes about one week. Unlike plastic waste which has been decomposed for years. Plastic waste consists of plastic bags, plastic bottles, food wrappers, pieces of pipes, etc. The accumulation of garbage requires all of us to be wiser in consuming or using objects around to reduce environmental pollution. The decomposition reaction of plastic waste by nature is ....
  
  a. Spontaneous reaction
  
  b. Fast reaction
  
  c. Slow reaction
  
  d. Accelerated reaction
  
  e. The reaction is slowed down
  
  The right answer from the above question is (c) slow reaction. In this question most students answered incorrectly. In the kinetics of chemical reaction there are 2 types of reactions, fast reactions and slow reactions. Waste decomposition occurs for many years, so the type of reaction is slow reaction.

- **High**: questions analyze complex information or data, synthesize or evaluate evidence, justify, reason given various sources, develop a plan or sequence of steps to approach a problem.
  
  Example questions of high level:
  
  Propane (C3H8) is a gas that is used as a constituent of engine fuels, grills, and LPG (Liquified Petroleum Gas) which is widely used in homes. If propane gas reacts with oxygen it will produce carbon dioxide and water vapor. A researcher conducted an experiment on burning propane gas and obtained the following data below. The correct equation and rate reaction is ....

| No. | [C₃H₈] | [O₂] | Time (s) |
|-----|--------|------|----------|
| 1.  | 0.4    | 0.5  | 12       |
| 2.  | 0.8    | 0.3  | 5        |
| 3.  | 0.4    | 0.6  | 10       |
a. \( \text{C}_3\text{H}_8 + \text{O}_2 \rightarrow 3\text{CO}_2 + 4\text{H}_2\text{O}, \text{v} = k [\text{C}_3\text{H}_8][\text{O}_2] \)

b. \( \text{C}_3\text{H}_8 + 5\text{O}_2 \rightarrow 3\text{CO}_2 + 4\text{H}_2\text{O}, \text{v} = k [\text{C}_3\text{H}_8][\text{O}_2] \)

c. \( \text{C}_3\text{H}_8 + 4\text{O}_2 \rightarrow 3\text{CO}_2 + 2\text{H}_2\text{O}, \text{v} = k [\text{C}_3\text{H}_8][\text{O}_2] \)

d. \( \text{C}_3\text{H}_8 + 5\text{O}_2 \rightarrow 3\text{CO}_2 + 4\text{H}_2\text{O}, \text{v} = k [\text{C}_3\text{H}_8][\text{O}_2]^2 \)

e. \( \text{C}_3\text{H}_8 + \text{O}_2 \rightarrow 3\text{CO}_2 + 2\text{H}_2\text{O}, \text{v} = k [\text{C}_3\text{H}_8][\text{O}_2]^2 \)

The right answer from the question is (B). In this question, participants must understand kinetics concept. They have to know how to make equation reaction and determine the formula’s.

After calculating, 5 questions with low level can be answered by the percentage of participants who can answer correctly by 59.07%, while those who answer incorrectly are 40.03%. For 12 questions as moderate difficulty, 42.3% of participants answered the correct questions and 57.7% answered incorrectly. And for 8 high difficulty questions, 57.5% participants answered correctly and 42.5% of participants answered incorrectly. This proves that not all questions with low difficulty categories can be answered correctly, nor do all questions with a high degree of difficulty make it difficult for participants.

If we only determine how many the number of correct and wrong answer, participants who can answer questions above 60% (correct answer 15 questions and wrong answer 10 questions) in this assessment is 21 with a percentage of 32.3%. While the number of students with correct answers less than 15 questions is 44 students with a percentage of 67.69%. From the results of the assessment, which can answer correctly more than 72% (18 questions) only 5 participants with a percentage of 7.69% as good student’s scientific literacy. Students' scientific literacy skills are low due to the low student interest in reading as well and most of them study science at school without knowing its usefulness. This is in line with [8] in his research stating that students have low scientific literacy skills of students on competence and attitudes towards the dimensions of science. One factor is due to the low level of student reading.

4. Conclusion
Based on the percentage obtained from the discussion above, it can be said that students' scientific literacy skills are still low. 59.07% participant correct answer the questions with low difficulty level, 12 questions of medium difficult level can be answered by 42.3%, and 8 questions of high difficulty questions can be answered correctly by 57.5% participant. But, as a whole of questions only 32.3% participant that answered more than 60%. Then only 7.69% participant that can answered more than 72% of questions. This shows that students don’t understand yet how to use and apply their knowledge in life. This is important for teachers to teach more about the usefulness of science and knowledge than just conveying concepts to students. And one of the ways to train students' scientific literacy is to familiarize students with the exercises that are related to the application of their knowledge.

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