The Effectiveness of Guided Inquiry-based Learning Material on Students’ Science Literacy Skills

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Abstract. The purpose of this research is to describe the effectiveness of guided inquiry-based learning material to improve students’ science literacy skills on solubility and solubility product concepts. This study used Research and Development (R&D) design and was implemented to the 11th graders of Muhammadiyah 4 Senior High School Surabaya in 2016/2017 academic year with one group pre-test and post-test design. The data collection techniques used were validation, observation, test, and questionnaire. The results of this research showed that the students’ science literacy skills are different after implementation of guided inquiry-based learning material. The guided inquiry-based learning material is effective to improve students’ science literacy skills on solubility and solubility product concepts by getting N-gain score with medium and high category. This improvement caused by the developed learning material such as lesson plan, student worksheet, and science literacy skill tests were categorized as valid and very valid. In addition, each of the learning phases in lesson plan has been well implemented. Therefore, it can be concluded that the guided inquiry-based learning material are effective to improve students’ science literacy skills on solubility and solubility product concepts in senior high school.

1. Introduction

Science literacy skills is the ability to engage with science-related issues, scientific ideas, and the capability of becoming a reflective thinking person [1]. The PISA 2015 report reveals that a person who is literate in science must have the competence to explain phenomena, evaluate and design investigations, and interpret data and evidence scientifically. There are four aspects of science literacy skills which are interrelated each other according to PISA 2015, including context, knowledge, competence, and attitudes [1]. Science literacy skills can be trained in chemistry learning because it provides a direct learning experience to the students through the use and development of process skills and scientific attitudes to solve problems in everyday life [2]. Based on the characteristics of chemistry lesson, the suitable method used to develop students’ thinking ability and improve students’ science literacy skills is guided inquiry learning model. Guided inquiry learning is a scientific process of active exploration that uses critical, logical, and creative thinking skills to answer questions by teacher guidance [3].

Various results of researches showed that the implementation of guided inquiry model which integrated with guided inquiry-based learning material in chemistry lesson is effective and efficient to get learning outcomes with the best quality. Activity and student achievement on solubility and solubility product can be increased if the applied guided inquiry model is equipped with student worksheet [4]. Generally, the students are better to learn through the use of guided inquiry-based
learning with laboratory experimental method. Through the guided inquiry learning, significant improvements occur in all aspects of students’ attitudes and academic achievements. In addition, there was a significant decrease on students’ anxiety in chemical laboratories [5]. In inquiry-based laboratory activities, the students have fewer misconceptions and understand concepts much more meaningfully. The average score of students’ performance were also increasing significantly. The students believed that chemical knowledge helps to interpret the phenomenon in everyday life and has an important role in modern life [6]. In addition, implementation of science literacy skills based on inquiry learning in laboratory activities can improve the science literacy skills of high school students in terms of content, context, process and attitudes aspects. Therefore, it can be concluded that guided inquiry learning model can make students more confident and make the learning process more meaningful [7].

The average score of students’ conceptual understanding using guided inquiry model is greater than traditional teaching. The guided inquiry learning model is effective to build conceptual relationships and rectifying misconceptions [8]. The students’ achievement increases at nominal, functional, and conceptual levels of chemical literacy through the inquiry learning. The highest increase is achieved by conceptual aspect of chemical literacy, that is understanding the relationship between concepts and main ideas [9]. However, the researches did not discuss about learning material which compatible with guided inquiry learning to improve students’ science literacy skills and learning outcomes of science literacy on the content, context, processes and attitudes aspects are not discussed in detail. In addition, the science literacy skills on attitude aspect are not discussed and only focus on cognitive aspect. Therefore, this research would develop guided inquiry-based learning material and implemented it in order to improve students’ science literacy skills in terms of context, competence, attitude, and knowledge aspects on solubility and solubility product ($K_{sp}$) concepts.

The results of preliminary study done to the 11th graders of Muhammadiyah 4 Senior High School Surabaya showed that students still lacked of science literacy skills. Based on test of science literacy skills in context, competence and knowledge aspects, the students have not been able to answer the problem well and correctly. There was 92% of the students who could not propose an exact problem formulation in accordance with phenomenon, 84% of the students who could not formulate hypothesis, and 92% of students who could not determine the variables correctly. A lot of students could not answer the questions based on observation table correctly and determine conclusions appropriately. It is because the learning methods used by the teacher during this time always use lecturing method or conventional learning model. It can be seen from the result of student questionnaire that 80% of them agree with the statement above.

Based on questionnaire and interview with chemistry teacher showed that learning material (worksheet) contained questions without experimental activities. A lot of students thought that the summary of the material in the worksheet is not interesting and the language is difficult to understand. The worksheet is not made by the teacher but from the publisher, so it is general and not in accordance with characteristics of students in that school. Based on the description above, the researcher develops a chemistry learning material that are able to fulfill the criteria of validity, practicality, and effectiveness. Generally, the purpose of this research is to describe the effectiveness of guided inquiry-based learning material to improve students’ science literacy skills on solubility and solubility product ($K_{sp}$) concepts.

2. Method
The research subjects of the implementation of guided inquiry-based learning material on solubility and solubility product concepts are 20 students who are 11th graders of Muhammadiyah 4 Senior High School Surabaya in 2016/2017 academic year. The development of learning material uses Research and Development (R&D) design [10]. The developed learning material in this research consists of lesson plan, student worksheet, and science literacy skills tests. The stages in research and development method include preliminary study, model development, and testing [10]. However, this research is limited to the stage of model development. The learning material that is implemented in this research have passed the validity test stage with valid and very valid category.
This research was conducted in 5 weeks starting from April to May 2017 by employing a pre-experimental research, that is one group pre-test and post-test design [11]. Experimental design was used to investigate the effectiveness of guided inquiry-based learning material. The data to seek for the effectiveness was obtained through students’ science literacy skills test scores in terms of context, competence, and knowledge aspects (assessment sheet 1) and attitude aspects (assessment sheet 2). Then, the data that were obtained was analyzed descriptively. The scores of students’ science literacy skills are categorized based on the following criteria: very less, less, enough, good, and very good [12][13]. The differences in students’ science literacy skills scores before and after the treatment were analyzed using N-gain. The N-gain calculation data were then converted using the criteria that presented in Table 1.

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\text{Normalized gain (g)} = \frac{\text{Post - test score} - \text{Pre - test score}}{\text{Maximum score} - \text{Pre - test score}}
\]

Table 1. Criteria N-gain score was adopted from reference [14]

| Score N-gain | Criteria |
|--------------|----------|
| 0.7 < N-gain | High     |
| 0.3 ≤ N-gain ≤ 0.7 | Medium |
| N-gain < 0.3 | Low      |

3. Results and Discussion

3.1. Scores of students’ science literacy skills in terms of context, competence, and knowledge aspects

Students’ science literacy skills were measured using a test instrument consisting of 20 multiple-choice questions and 5 essay questions (assessment sheet 1). Table 2 shows the scores of students’ science literacy skills and the increase of N-gain score.

Table 2. Results of N-gain analysis of students’ science literacy skills in context, competence, and knowledge aspects

| Student | Pre-test |   | Post-test |   | N-gain | Category |
|---------|----------|---|-----------|---|--------|----------|
|         | Score    | Category | Score    | Category |         |
| A       | 34       | Less     | 95       | Very good | 0.92    | High     |
| B       | 39       |Less      | 70       | Good     | 0.51    | Medium   |
| C       | 30       |Less      | 75       | Good     | 0.64    | Medium   |
| D       | 47       |Enough    | 82       | Very good| 0.66    | Medium   |
| E       | 33       |Less      | 71       | Good     | 0.57    | Medium   |
| F       | 34       | Less     | 73       | Good     | 0.59    | Medium   |
| G       | 31       | Less     | 87       | Very good| 0.81    | High     |
| H       | 37       | Less     | 93       | Very good| 0.89    | High     |
| I       | 35       | Less     | 70       | Good     | 0.54    | Medium   |
| J       | 38       | Less     | 72       | Good     | 0.55    | Medium   |
| K       | 32       | Less     | 82       | Very good| 0.74    | High     |
| L       | 30       | Less     | 70       | Good     | 0.57    | Medium   |
| M       | 35       | Less     | 72       | Good     | 0.57    | Medium   |
| N       | 29       | Less     | 65       | Good     | 0.51    | Medium   |
| O       | 31       | Less     | 72       | Good     | 0.59    | Medium   |
| P       | 28       | Less     | 76       | Good     | 0.67    | Medium   |
| Q       | 28       | Less     | 70       | Good     | 0.58    | Medium   |
| R       | 36       | Less     | 82       | Very good| 0.72    | High     |
| S       | 41       | Enough   | 87       | Very good| 0.78    | High     |
| T       | 35       | Less     | 90       | Very good| 0.85    | High     |

Data in Table 2 showed that students’ science literacy skills scores of context, competence, and knowledge aspects at pre-test ranged from 28 to 47, in which 18 students got scores with less category
and 2 students got scores with enough category. After implementing guided inquiry learning using learning material that was developed and conducted post-test, the students’ science literacy skills scores ranged from 65 to 95, in which 12 students got scores with good category and 8 students got scores with very good category. The students’ science literacy skills are significantly increasing which is stated by N-gain score. There are 7 students (35%) got N-gain score in high category, and 13 students (65%) got N-gain score in medium category. The high increase in N-gain score showed that implementation of developed learning material through guided inquiry learning can improve students’ science literacy skills. The increase of N-gain score occurs because the teacher who has been performing all phases of guided inquiry learning implemented in well to excellent category. In addition, the learning steps in the lesson plan were developed in accordance with the syntax of inquiry learning model which includes six phases focusing on the activities, explaining inquiry process, presenting inquiry problem, formulating hypotheses, collecting data, formulating conclusion, and reflecting problems and developing thinking process [15].

Inquiry-based learning is effectively guided to improve students' science literacy skills due to the students’ learning stages according to Piaget's cognitive development including the formal operational stage – a stage in which students can already think abstractly or symbolically and solve problems through doing experiment [16]. Visually, the difference between the pre-test and post-test scores of students’ science literacy skills is presented in Figure 1.

![Figure 1. Diagram of pre-test and post-test scores of students’ science literacy skills in terms of context, competence, and knowledge aspects](image)

### 3.2. Scores of students’ science literacy skills in attitude aspect

Students’ science literacy skills were measured using a questionnaire instrument consisting of 30 positive and negative statements. Those statements include 4 indicators of attitudes: students’ attitudes toward science, the importance of science in life, students’ responses to science as a career, and students’ responses to science learning in schools (assessment sheet 2). The assessment sheet 2 consists of two types of assessment: self assessment and peer assessment. The scores of students’ science literacy skills and the increase of N-gain score are presented in Table 3.

| Student | Pre-test Score | Pre-test Category | Post-test Score | Post-test Category | N-gain | Category |
|---------|----------------|------------------|-----------------|-------------------|--------|----------|
| A       | 2.29           | Enough           | 3.67            | Very good         | 0.81   | High     |
| B       | 2.05           | Enough           | 3.46            | Good              | 0.72   | High     |
| C       | 2.37           | Enough           | 3.60            | Very good         | 0.75   | High     |
| D       | 2.63           | Good             | 3.60            | Very good         | 0.71   | High     |
Data in Table 3 showed that the average score of students’ science literacy skills in all aspects of attitude at pre-test reach the range 2.03 to 2.96 with enough to good category. After the implementation of guided inquiry learning and post-test implementation, the average score of students’ attitudes reach the range 2.97 to 3.95 with good to very good category. The average score of attitude aspect is derived from self-assessment and peer-assessment because self-assessment has a weakness in terms of the validity of the answer. The existence of elements of the preferred properties and concepts that are considered good by the society cause the answer given is not necessarily in line with the facts practiced everyday [17]. These data indicated that there is an increase in the score between pre-test and post-test in every aspect of attitude. It means that guided inquiry-based learning material on solubility and solubility product (K_sp) concepts can improve the students’ science literacy skills in all aspects of attitudes.

A total of 14 students (70%) got N-gain score in high category, and 6 students (30%) got N-gain score in medium category. The high improvement in N-gain score showed that implementation of developed learning material through guided inquiry learning can improve students’ science literacy skills. The improvement of N-gain score is because teacher has been performing all phases of guided inquiry learning in well to excellent category. In addition, the improvement of the average score on all the indicators of attitude is because the students have been trained to use the scientific attitude through guided inquiry-based learning activities conducted during the three meetings, such as discussing with a group of friends in identifying and formulating problem based on the given phenomenon, preparing hypothesis, determining experimental variables, experimenting, writing experimental data, analyzing experimental results, and formulating conclusions. In guided inquiry, there is a scientific process that employs critical, logical, and creative thinking skills to answer questions posed with scientific attitudes [3].

This results are supported by Ural who states that there is a significant increase in all aspects of students’ academic attitudes and achievements through the use of guided inquiry-based laboratory experimental method. In guided inquiry, the students are more confident and the experiment becomes more meaningful [5]. It is also supported by Setowati’s research which states that activities and students’ achievement on K_sp material that include aspects of knowledge, attitude, and skills improve. The assessments of spiritual attitudes, cooperation, honestly, discipline, and responsibility increase and those assessments are classified into very good category [4].
4. Conclusion
Based on the results and discussion of this research, it can be concluded that the developed guided inquiry-based learning material is effective to be used in teaching and learning in order to improve students’ science literacy skills on solubility and solubility product (K_{sp}) concepts. This is proven by the increase of N-gain score with medium and high category both on science literacy skills in aspects of context, competence and knowledge, as well as in aspects of attitude. Thus, there is a positive effect between the development of guided inquiry-based learning material and the improvement of various aspects of science literacy skills for senior high school students. Moreover, it is suggested that further researchers can develop similar learning material for other subjects or materials to train students’ science literacy skills, experimental skills, as well as to apply chemistry concepts in everyday life. In addition, teachers should prepare various sources of literature, master learning steps, and manage the class well so that guided inquiry-based learning will be more effective in improving students’ science literacy skills.

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