The Analysis of High School Students’ Science Literacy Based on Nature of Science Literacy Test (NOSLiT)

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Abstract. Nature of Science Literacy Test (NOSLiT) is an instrument to measure students’ understanding on scientific facts so they fulfilled the success of science literacy in high school students. The purpose of this research was to find out students’ science literacy based on NOSLiT instruments. The method used for this research is descriptive qualitative and descriptive quantitative. This research samples were 29 students of 10st grade drawn from one public school in Karanganyar Regency, Central Java, Indonesia. The result showed that majority of the students have reached the science literacy while few of them have not fulfilled the requirements yet. Students have fulfilled frameworks such as science nomenclature, experimental ability and basic observation, scientific postulate, and rules of scientific evidence in such a large number. While frameworks such as scientific disposition and major misconception about science were still in small number. Science literacy values familiarity as well. Students taken as samples for this research were not really familiar with the type of questions asked during the science literacy test. Thus, their result was still below the average students in United States. The average of science literacy for student in X Science 4 with NOSLiT instrument is 57.14%.

1. Introduction
The vast development of knowledge and technology is a sign of civilization in globalization era. Citizens are urged to have basic skills to survive in society. As a competitive generation, there is a need of knowledge and technology, especially science literacy [1]. Based on the facts above, it is compulsory for each individual to possess science literacy which includes knowledge on science, science processing skill, and scientific actions. It is important to develop science literacy since individual with such skill is able to take advantage on science, identify questions, and draw conclusions based on evidence as well as understand that every decision is related with natural evolution through human activities [2].

Study on science literacy keeps on going and developing. This is due to the need to deliver a clear understanding on science literacy for everyone. Science literacy is a multidimensional skill which includes knowledge (vocabulary, fact, and concept), processing skill (skilled and intellectual), disposition (behavior & attitude), well connection between science-technology-people nearby, and students’ possession on science history and fact [3]. Science literacy is the skill that students need in order to identify problems and explain the scientific facts based on the conclusion to take a decision related to natural phenomenon and the impacts in human activities [4]. A journal entitled The Meaning of Science states that science literacy is an honour to knowledge by developing some learning components from people’s own self to contribute to social affairs [5]. Based on several statements from the expert, it can be concluded that science literacy is a multidimensional skill that must be
possessed by students to identify problems related to natural phenomenon and its impacts toward human’s daily activities so they can contribute to society.

It had been science’ main objective to enhance students’ science literacy for more than 10 years. There are various definitions of science literacy that it is quite difficult to decide which aspects have to be determined. One of the most important subject in science literacy is the understanding about Nature of Science (NOS). NOS is refers to values and assumptions about scientific knowledge and its development [6]. The NOS sees science as the development of knowledge. It plays a prominent part in enhancing students’ science in literacy so they can understand functionally about scientific facts [7]. Understanding NOS means that people play an important role in developing science literacy [5]. Research from [8] discusses that Nature of Science (NOS) in education helps enhancing science literacy.

There is a study conducted by research institute called PISA (Programme for International Student Assessment), but it is only for students age 10 to 15 years old. It is for students in elementary and junior high school level [9]. PISA measures how far students at 15 year old are ready to face challenge in the future and evaluates their ability to mirror the knowledge and experience in real life situation [10]. Several researches are also conducted regarding to scientific facts for teachers and college students from science major. [11] states that most researches are focused on elementary of middle school teacher. Research on college students through observation on their perspective while learning biological evolution have been conducted by [12]. Similar research was conducted by [6] about the influence of History of Science towards 166 bachelor and master students and also 15 pre-job secondary science teachers.

This research assumes that there is a need to do the same to different range of age group or high school students in this case, by using Nature Of Science Literacy Test (NOSLiT) instruments. NOSLiT can be used to measure high school students’ understanding of scientific facts to finally achieve science literacy [3]. NOSLiT can also be used to identify students’ weakness in understanding subjects, fixing their learning process, and determining whether a program is effective or not. This research is conducted in order to give the information about high school students’ level on science literacy as well as suggestions to enhance the result.

2. Methods

The research was conducted in 10th grade of one public school in Karanganyar Regency, Central Java, Indonesia. The subject for this research are students from Class X of science program. There are 29 samples from Class of Science X. They are selected through random sampling.

The method for this research was using test consists of 35 science literacy questions which is composed using NOSLiT instruments developed by [13]. NOSLiT is a valid instrument with high reliability, and an ideal level of difficulty [3]. Correct answer is worth 1 and wrong answer is worth 0. It applies to all question from number 1 to 35. The result from analyzing science literacy is presented by counting the number of students with correct answer and divides them into total students then times 100 percent.

Data was analyzed using descriptive qualitative and descriptive quantitative method. Descriptive qualitative and descriptive quantitative method were selected to identify the pattern of data which answers the question about who, what, where, when, how far, and focused on relevant aspect of a phenomenon. Descriptive qualitative and descriptive quantitative method were also used to identify and illustrate the trend and variation of population, create new measurement from key phenomenon, or even describe the research sample to identify causal effect [14]. This research started from collecting data process, processing data, data description, and discussing the result with relevant theory as a measurement to interpret it.

3. Results and Discussion
NOSLiT was developed by [15] and divided into 6 frameworks on its instruments which include science nomenclature, experimental ability and basic observation, rules of scientific evidence, scientific postulate, scientific disposition, and major misconception about science. Students with science literacy will at least get half of the total questions or 17.50 of 35.0 total point [3]. NOSLiT instrument is in English since it is developed by Carl J. Wenning specifically to measure high school students' science literacy in United States.

The first step for this research is translating NOSLiT from English to Indonesian and validating the result to linguists. The trial for the guidelines was conducted by science literacy framework developed by [13].

Based on the science literacy test with NOSLiT on 10th grade of one public school in Karanganyar, Central Java, the data is presented in Table 1. Table 1 showed that the highest score is 23, the lowest at 16, and the average at 20 of all 35 questions tested for Class X of Science 4. Data from Table 1 showed there are 25 students with higher score than 17.50 and 4 students with lower score than 17.50 of all 29 students. The result shows that 86.20% of the students in that class have already possessed science literacy. Meanwhile, 13.80% of the students have not possessed science literacy. Research by [12] shows that students in chemistry class gets average score of 24.4 from total 35 (68.6%) while being tested with NOSLiT instrument. It shows that student literacy in science is better than Wenning's research with average score of 20.8 from total 35 (59.6%).

Table 1. The Result for NOSLiT Test

| Skor of NOSLiT test | Amount of Student |
|---------------------|------------------|
| 16                  | 1 student        |
| 17                  | 3 students       |
| 18                  | 1 student        |
| 19                  | 2 students       |
| 20                  | 6 students       |
| 21                  | 5 students       |
| 22                  | 9 students       |
| 23                  | 2 students       |

The average score for science literacy for students in Class X of Science 4 according to NOSLiT instruments is at 57.14%. Meanwhile, the average score for the same subject using Wenning's NOSLiT in United States is at 59.60%. It shows that Wenning's result is higher than the one from the researcher. NOSLiT for high school students and normal standard group must have an average score at 50% [3]. There are several factors that differentiate the result from Wenning's and researcher's.

The first factor is the quality of education where NOSLiT was developed at the first time. United States as a first world country has a better quality than Indonesia. Based on PISA 2015, United States has science literacy score at 493 compared to 403 in Indonesia [4]. The second factor is they type of questions using NOSLiT instrument is not familiar for students. It needs a high level of skill to answer those since most of the mare presented in NOSLiT as dominant analysis. Students are still not familiar to solve problem with high level of thinking. It is stated in [16] that there are still three indicators to why high level thinking skill can still lead to low score even though teachers have implemented active learning model.

Figure 1 showed that the highest result for students in third framework (rules of scientific evidence) is at 56.65%. Most students can answer correctly the questions on phenomenon in this third indicator or framework. This is because such phenomenon is close to students' daily life or in line with their logic or way of thinking.

Figure 1 below shows the percentage of each science literacy indicators achieved in NOSLiT framework:
Figure 1. The Precentage of Each Science Literacy

Notes:
Framework 1: Science nomenclature
Framework 2: Experimental ability and basic observation
Framework 3: Rules of scientific evidences
Framework 4: Scientific Postulate
Framework 5: Scientific disposition
Framework 6: Major misconception about science

Figure 2. NOSLiT Instruments and Student Responses that Measure The Framework of Rules of Scientific Evidence.

Figure 2 shows the questions about procedure in a trial, started with observation and conducting the next trial by reporting the evidence. It is common for science students as seen in their daily practice class. Option a is the correct answer because they have to be honest in reporting their trial as a practician. PISA has three dimensions to decide the science with one of them being scientific situation. It involves everyday situation instead of science practice in classroom or laboratories. Students should have the capacity to use scientific knowledge to identify questions and draw a conclusion based on the facts in understanding about nature as well as its changing due to human activity [5]. Students’ involvement in scientific issues related to everyday life train their science literacy [17].

Scientific postulate is the framework with second highest score at 48.28%. This is a point of view in science which expands from long time ago up until now. It is a foundation on how scientists study, discuss, and conduct a scientific research. The test shows that there are several students who have not understood the eight aspects of scientific postulate from NOSLiT instruments. Those eight aspects of postulate are as follows: a) all universal scientific laws, b) time and place consistency, c) there are no effects without natural causes, d) explanation without test is not acceptable in science, e) science does not acknowledge repetitive observation, f) scientific knowledge lasts long but tentative, g) science has no absolute certainty, h) science is not a personal matter related to its own problem [15].
Statement number 18 in Figure 3 discusses about the consistency of a conclusion from the perspective of time. Option a is the most correct answer because conclusion changes when a more accurate evidence is found. Consistency in nature as seen from time and space shows the natural process that explains things from the past, present, and future. The postulate of knowledge is assumptions above operating science. They function as a fundamental science and thinking to the limit that decides whether something is accepted under scientific proof or not [15].

Experimental ability and basic observation in the third place for framework with highest score at 44.83%. The questions in this framework related to facts and connection between concepts. Empirical cycle (approach on process) such as collecting and classifying information, formulating hypotheses, creating a prediction, interpreting the result of experiment and drawing conclusion is used as teaching method in this framework. They play a part in enhancing students’ investigating and cognitive skill. Students get a chance to think analytically and try to solve problems by their own [18].
4. Representasi dari sebuah diagram yang menyatakan hubungan antara aspek fenomena dikenal sebagai . . . .
   a. model
   b. teori
   c. hipotesis
   d. parameter

Figure 5. NOSLiT Instruments And Student Answers That Measure The Framework Of Science Nomenclature

Figure 5 shows statements about a scientific term. Option a is the correct answer and 41.87% of the students can answer it correctly while 58.13% of them still has the wrong answer. [2] states that students basically understand the concept to connect science with other disciplines and are able to write scientific terms. However, they often misunderstand or fail to understand the concept. Meanwhile, students who remember the theory correctly and are able to explain the concept, they have a limited understanding and find it hard to connect the concept with their own answer. Science literacy in school level has to maintain certain level such as nominal (acknowledgement in some terms with no clear understanding about the meaning) and functional (able to use the scientific terms correctly) [5].

Major misconception about science only get the fifth place with its 39.66% score. In NOSLiT test, general misconception is made-up stories about scientific method, general hypotheses, theory from hypotheses, knowledge based on experiment, and scientific method which leads to the absolute truth [3].

33. Para ilmuwan, jika diberi cukup waktu dan sumber daya, bisa benar-benar menjawab pertanyaan apapun yang mungkin bisa ditanyakan.
   a. Benar
   b. Salah

Figure 6. NOSLiT Instruments And Student Answers That Measure The Framework Of Major Misconception About Science

Statements number 33 as seen in Figure 6 questions about a scientific method leads to an absolute truth. Most students answer it correctly but the correct answer is actually the wrong one. A scientist answer questions not based on the time given to them but the valid evidence. Several students are still unable to understand the meaning of scientific stories in NOSLiT test so they cannot decide the correct answer. Students need a strategic reading skill as it is influenced their scientific achievement. It can be concluded that students’ reading skill help them understand the scientific knowledge [20]. The improvement in reading enhance students' mathematic and science literacy [10].

Students have the lowest science literacy on scientific disposition or fifth framework with only 27.59% score. Questions for this framework related to facts and their connection to the concept. Students have an understanding in concept by scientific discourse and problems. The concept is explained by physical quality using multi representation. The more complex and the more representation understood by students enhance their understanding in scientific issues. This makes students enable to find solution in complexity. The process in finding solution is able to give students their literacy in science [17].
Figure 7 shows questions about how a scientist predicts several things that are about to happen in the future. A good scientist has to be rational and calm in predicting something that is about to happen. Option c is the correct answer even though most students pick answer d. 72.41% students are not careful in understanding the discourse in question so they fail to find solution for a rational explanation as a scientist's character as seen in the NOSLiT-based question. Research [21] shows that it is not easy to change a concept of knowledge to scientific one because students and people in general do not realize that their knowledge in concept is low.

The score on science literacy indicators on those five NOSLiT frameworks is almost equal. However, the difference between the lowest and highest score reaches to 2.46%. It has to be evaluated in teaching method as it affects the science literacy for high school students in Indonesia. Science education is meant to expand students’ literacy in science to be useful for society among them [3]. Indonesian education curriculum also stresses on the development of science literacy [19]. This will hopefully enhance students’ science literacy and equalize each indicators of it.

4. Conclusion
The result showed that majority of the students have reached the science literacy while few of them have not fulfilled the requirements yet. Based on descriptive qualitative analysis, students have fulfilled frameworks such as science nomenclature, experimental ability and basic observation, scientific postulate, and rules of scientific evidence in such a large number. While frameworks such as scientific disposition and major misconception about science were still in small number. Overall, the average student literacy from these simples were still below the result conducted by Carl Wenning in United States. Science literacy values familiarity as well. Students taken as samples for this research were not really familiar with the type of questions asked using NOSLiT. Students' involvement in scientific issues related to everyday life train their science literacy, but students are still unable to think analytically and understand the questions, students unable to remember the theory correctly and are unable to explain the concept, and students are still unable to understand the meaning of scientific stories in NOSLiT test so they cannot decide the correct answer. Thus, their result was still below the average students in United States. The average of science literacy for students in X Science 4 with NOSLiT instrument is 57.14%. The difference lay on how the teaching method in Indonesia and United States are not similar for science subject. This type of questions is not familiar for students in Indonesia either. Students’ general knowledge in science also influences the score. This research is hopefully motivated teachers, especially for high school level. Educational curriculum 2013 can hopefully enhance student’s literacy through innovative teaching method.
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5. References

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