The Profile of Students’ Scientific Inquiry Literacy Based on Scientific Inquiry Literacy Test (ScInqLiT)

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Abstract. This study aimed to describe the profile of scientific inquiry literacy. This study used a descriptive method with engaging 205 students from three junior high schools in Kediri Regency. The sample selection used a purposive sampling technique. The used scientific inquiry literacy instrument referred to ScInqLiT (Scientific Inquiry Literacy Test) by Wenning [12]. The results showed that students’ achievements of scientific inquiry literacy were indicated in the indicators such as identifying and controlling variable (38,05%) with low category; recognizing and analyzing alternative explanations and models (42,93%) with enough category; drawing appropriate conclusions from evidence (60,98%) with enough category; understanding and analyzing data (48,62%) with enough category; constructing and interpreting graphs (38,70%) with low category; constructing hypotheses (39,15%) with low category; designing experimental procedures (61,63%) with high category; and identifying problems to be investigated (51,95%) with enough category. Thus, it can be concluded that students’ scientific inquiry literacy in Kediri was relatively low. Accordingly, for the further studies, they are recommended to enhance some indicators of students’ scientific inquiry literacy with applying appropriate learning methods and teaching materials.

1. Introduction
The policy for curriculum and competencies to face the challenge of 4.0 Industrial Revolution continues to be pursued. Nasir as the Minister of Research, Technology and Higher Education states that education must be included in the development of Science and Technology [1]. Education must be based on the development of scientific advances, technological innovations, and the era of 4.0 industrial revolution. According to Auon, new literacies that make competitive individuals extend to data literacy, technology literacy, and humanist literacy [2]. Data literacy is the ability to read, analyze, and use information [2]. Data literacy can be improved by learning science using information and scientific issues in everyday life, which is so-called scientific literacy [3]. Science literacy is a part of foundational literacy [4]. Scientific literacy is highly needed by students to face the global world and bring them to be competitive individuals.

21st century competencies are contained in several frameworks that have been integrated in the curriculum of many countries. China through Core Competencies for Student Development depicts that one of the things which must be possessed by students is scientific literacy [5]. Some also state that scientific literacy is the main goal of science education including science education in England [6], Australia [7], and China [5]. The policy of science education on the basis of scientific literacy is as a transferable outcome [8]. Leading students to become "literate" generations of science is the main goal of science education [9].
The National Science Education Standard states that a person is called "literate in science" if he/she has an understanding of 6 major scientific literacy components including: (1) science as inquiry, (2) science content, (3) science and technology, (4) science in personal and social view, (5) history and the nature of science, and (6) the combination of concepts and processes [10]. Science literacy and scientific inquiry are the parts of science education [11]. Wenning [12] also states that scientific inquiry is one component of scientific literacy. Gormally states that there are two indicators of scientific literacy including: 1) understanding of scientific inquiry methods to determine scientific knowledge, and 2) organizing, analyzing, and interpreting qualitative data as well as scientific information [13]. The Next Generation Science Standards (NGSS) adds that to understand the concept of science fundamentally, scientific inquiry can be applied as a component of scientific literacy [14]. Therefore, it can be concluded that scientific inquiry is a form of scientific literacy.

Scientific inquiry consists of process skills and scientific understanding [11]. Process skills include the design of investigations, data collection, and data analysis. In addition, scientific understanding deals with the philosophy and sociology of science aspects, such as tentative scientific theories or the role of creativity in experiments. Both process skills and scientific understanding are intended to provide an authentic description of how scientists involve their experiments in science learning [15]. Scientific inquiry includes the process of traditional science, but it still refers to the process of gaining scientific knowledge, scientific reasoning, and critical thinking to build scientific knowledge [6].

Scientific inquiry based on Wenning [12] is a learning that tends to involve identifying problems to be investigated, using an introduction to formulate hypotheses, using deductions to make predictions, designing experimental procedures, conducting scientific experiments, collecting meaningful data, organizing and analyzing data accurately, and explaining any unexpected research results. Wenning uses the inquiry stage as a framework to develop a scientific inquiry literacy assessment so-called ScInqLiT (Scientific Inquiry Literacy Test) [12]. ScInqLiT developed by Wenning can be used to identify weaknesses in students' understanding, improve teaching skills, and determine a range of effective programs for teaching scientific literacy [12]. ScInqLiT is a paper-based test whereby students can design experiments and draw conclusions based on the experiments. In addition, students can be provided with numeric data so that they can interpret the data and conclude the experiments.

2. Methods
This study used a descriptive method to describe the initial profile of students' scientific inquiry literacy abilities. This study was conducted to the students of class VIII 2018/2019 school year from three junior high schools in Kediri regency with low, medium, and high category of school based on the average score of the National Examination of Natural Sciences (UN IPA). The total of research subjects was 205 students.

The instrument used to measure scientific literacy referred to ScInqLiT as proposed by Wenning [12]. The instrument was suitable based on the construct validator. The instrument consisted of 24 items designed in the form of multiple-choice. The instrument utilized the indicators of scientific inquiry literacy (SIL) and competency achievement indicators as stated in the 2013 curriculum according to KD 3.4 about heat and temperature material. The scores of scientific inquiry literacy were calculated by percentage technique on each indicator, and the obtained results of the percentage scores were further interpreted. The indicators of scientific inquiry literacy in this study are illustrated in Table 1.

Table 1. The Indicators of Scientific Inquiry literacy.

| The Indicators of Scientific Inquiry Literacy | Question No |
|---------------------------------------------|-------------|
| Identifying and controlling variable (1)    | 17,24       |
| Recognizing and analyzing alternative explanations and models (2) | 4,10,15,16 |
| Drawing appropriate conclusions from evidence (3) | 6,14,19     |
| Understanding and analyzing data (4)        | 2,12,21     |
| Constructing and interpreting graphs (5)    | 7,11,22     |
| Constructing hypotheses (6)                 | 5,9,18,20   |

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The Indicators of Scientific Inquiry Literacy

| Question No | Designing experimental procedures (7) | Identifying problems to be investigated (8) |
|-------------|--------------------------------------|------------------------------------------|
|             | 1, 3, 8                              | 13, 23                                    |

3. Result and Discussion

3.1. Result

3.1.1. The Achievement of Scientific Inquiry Literacy

The results of the students' scientific inquiry literacy achievement referring to ScInqLiT are shown in Table 2.

| School Category | The Indicators of Scientific Inquiry Literacy (%) |
|-----------------|--------------------------------------------------|
|                 | 1       | 2       | 3       | 4       | 5       | 6       | 7       | 8       |
| High            | 40.41   | 67.12   | 75.80   | 51.60   | 67.58   | 56.16   | 82.65   | 59.59   |
| Medium          | 37.97   | 37.03   | 62.03   | 51.48   | 27.43   | 51.90   | 76.37   | 55.06   |
| Low             | 34.91   | 18.40   | 38.99   | 40.25   | 15.72   | 18.87   | 42.77   | 12.48   |
| Average         | 38.05   | 42.93   | 60.98   | 48.62   | 38.70   | 39.15   | 61.63   | 51.95   |

Table 2 shows the achievement of indicators from high, medium and low category of schools. The highest achievement is achieved by the school with high category. The difference of achievement among the three schools is not too significant. The highest achievement indicator is designing experimental procedures (61.63%) with high category. This is reflected to the ability of students who are able to design the steps of experiment. Students have been able to design experimental procedures. It is important to know something through observation or experiment, and that way will not succeed if the observation steps are unplanned and unsystematic.

The lowest scientific inquiry literacy indicators classified as a low category are shown by indicator 1, 5 and 6. Indicator 1 refers to identifying and controlling variables (38.05%). On the questions number 17 and 24 that contain indicator 1, the students are asked to evaluate the experiment in terms of variable factors correctly. Based on interview, the students have not been able to understand the kind of variables. Indicator 5 is in accord with constructing and interpreting graphs (38.70%). The test on the basis of ScInqLiT contains reading and graphics, so that the understanding of skill is needed. On question number 7, the students who master the indicator are able to build and interpret the graph as well as able to make a graph of relationship between heat and substance change based on the data. On question number 11, the students who master the indicator can construct and interpret the graph and can determine the heat expansion coefficient based on the graph of the metal length and temperature. In the meantime, on question number 22, the students who master the indicator are able to build and interpret the graph as well as able to determine the amount of melting heat based on phase diagram. Indicator 6 is pertinent to constructing hypotheses (39.15%). The questions on number 5, 9, 18, and 20 lead students to make hypotheses based on the given fact in questions using the theories as regards heat, expansion, and heat transfer. Based on interview, students are confused about how to make a hypothesis correctly.

3.1.2. The Mastery of Competency Achievement Indicator

Based on the competency achievement indicators in KD 3.4 of 2013 Curriculum, the test results are shown in Figure 1.
Analyze the concept of temperature and measurement | 35.78%  
Analyze the concept of expansion | 35.46%  
Analyze the heat concept | 44.81%  
Analyze the concept of heat transfer | 49.99%  
Analyze the effect of heat and temperature objects | 44.49%  
Investigate the effect of heat on substance change | 29.86%  
Link heat and temperature in daily life | 43.90%  
Link HT with stability mechanism of organism body | 68.90%  

**Figure 1.** Average Achievement

Figure 1 shows the average achievement of each indicator. The low category in the mastery of competency achievement indicators is shown in analyzing heat concept with 29.86%; linking heat and temperature in daily life with 35.46%; and linking heat and temperature in stability mechanism of organism body with 35.78%. The highest mastery of competency achievement indicator is shown in the indicator associated with analyzing temperature and measurement with 68.90% classified as a high category. In this study, students who are able to master this indicator can analyze the concept of temperature and analyze the work principle of the thermometer.

### 3.2. Discussion

Scientific inquiry helps students reflect on what they are doing and why experimental activities are designed in a particular way. Experimental activities can give students an opportunity to develop their knowledge. The low category mastery of scientific inquiry literacy indicates that students rarely deal with laboratory activities. The instrument in this study asks students to read short articles, graphics, and a variety of information before answering the related questions. This way needs an adequate understanding of scientific inquiry methods to determine scientific knowledge [16]. This competence is an important skill in the development of science concepts and thinking skills about science issues [15].

ScInqLiT is a scientific inquiry test that discusses the scientific process using steps based on the spectrum of the inquiry level. In addition, the locus of control at the level of inquiry will increasingly shift from teacher to students [12]. This means that the teacher’s role in this case will decrease. The low achievement of scientific inquiry literacy can indicate that the learning process is dominated by a teacher-centered stream of learning. In the deepest exploration, the emergence of a teacher-centered learning process is a consequence of exam-oriented education [17]. In addition, the characteristic of such test applied in the exam-oriented education per se is a contributing factor for the teacher to merely emphasize on assessing students' memorization abilities, which in fact can only encourage students to adopt memorization as a learning strategy. Learning in this way is merely more focused on the ability to memorize rather than the ability to use knowledge in everyday life. As a result, students may not have the ability to apply scientific knowledge to everyday situations that are important to their scientific literacy [7].

Based on Figure 1, it is shown that that there are several competency achievement indicators of mastery that are still low. The indicators such as linking heat and temperature with stability mechanism of organism body and linking heat and temperature in daily life are related to the application of science and technology in everyday life. Without the knowledge of good science, students become weak technology users because they are not able to apply all of the existing technologies [18].

ScInqLiT can be used for educational researches in improving learning outcomes and identifying students' understanding [12]. From the findings, there is some less precision of students’ understanding with respect to this study. Such condition is appertaining to some topics comprising substance change in phase diagram that makes increasing temperature, sweat evaporation as the process of releasing heat,
and the glass made of a conductor which makes the water stay warm. Understanding students' concepts about temperature and heat has been the focus of several researchers [19-21].

Bybee [22] states that the students who are more developed in terms of literacy will demonstrate the ability to make or use some conceptual models to make predictions or provide explanations in order to capably analyze scientific investigations, to link data as evidence, to evaluate alternative explanations of the same phenomenon, and to communicate the explanation correctly. Inquiry-based learning provides opportunities for students to construct their knowledge so as to encourage the emergence of various skills needed to master scientific literacy. Many studies try to enhance scientific literacy. One of them is with inquiry-based learning [15, 23, 13].

The findings from this study can be used to prepare appropriate ways to guide students in enhancing their scientific inquiry literacy through natural science learning. Various methods can be used to empower students' scientific literacy through teaching and learning activities, two of which are learning methods and teaching materials such as modules that support scientific literacy competencies [24]. Therefore, for further studies, they are highly recommended to be conducted with the foci on learning methods and teaching materials to improve several indicators of scientific inquiry literacy because scientific literacy is the starting point for students to know their readiness to face challenges in life.

4. Conclusion

Based on the results of this study and data analysis, a conclusion can be drawn whereby the results of students’ scientific inquiry literacy in terms of the assigned indicators are as follows: identifying and controlling variable (38,05%) with low category; recognizing and analyzing alternative explanations and models (42,93%) with enough category; drawing appropriate conclusions from evidence (60,98%) with enough category; understanding and analyzing data (48,62%) with enough category; constructing and interpreting graphs (38,70%) with low category; constructing hypotheses (39,15%) with low category; designing experimental procedures (61,63%) with high category; and identifying problems to be investigated (51,95%) with enough category. The ability of students’ scientific inquiry literacy is still relatively low. For future studies, learning methods and teaching materials are needed to be set as the study foci since they can contribute to improve several scientific inquiry literacy indicators. The scientific literacy is very important because the students can solve the problems oriented to environment, health, economy, and modern society depending on the development of science, technology, and 4.0 Industrial Revolution Era.

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