development scientific literacy through NOS within inquiry approach

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The Development of Scientific Literacy through Nature of Science (NoS) within Inquiry Based Learning Approach

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Abstract. Understanding of science instructional leading to the formation of students scientific literacy, seems not yet fully understood well by science teachers. This certainly needs to be reformed because scientific literacy is a major goal in science education for science education reform. Efforts of development scientific literacy can be done by help students develop an information conception of the Nature of Science (NoS) and apply inquiry approach. By combining both, it is expected that students' scientific literacy can develop more optimal.The purpose of this research is to produce scientific literacy development model of NoS within inquiry-based learning. The preparation of learning tools will be done through Research and Development (R & D) following the 4-D model (Define, Design, Develop, and Disseminate) and Borg & Gall. This study is a follow-up of preliminary research results about the inquiry profile of junior high school students indicating that most categories are quite good. Design of the model NoS within inquiry approach for developing scientific literacy is using MER Model in development educational reconstruction.

1. Introduction

The implementation of free economic system at the ASEAN level or known as the ASEAN Economic Community (MEA) has been begun in December of 2015. Thus, the people of Indonesia must prepare as well as possible so as to compete in the MEA system. In terms of anticipating the implementation of the MEA, education is an important element that should be given top priority. Education is expected to contribute in formation of the whole person for including soul, body, intelligence, sensitivity, aesthetics, responsibility, and spiritual values. Through education, everyone should be empowered to think independently and critically. In a world that is constantly changing and colored by social and economic innovation, education appears to be one of the driving forces to improve the quality of imagination and creativity as an expression of human freedom and the standardization of individual behavior. Opportunities need to be given to the younger generation to experiment and discover something new.

However, the results of the study indicate that almost half of Indonesian senior high school students (41%) have only limited knowledge in science. It is further revealed that no student can consistently identify, explain, and apply the concept of science to a more complex life situation. In addition, there are also Indonesian students (6.9%) who do not have scientific literacy (Anna Permanasari, 2011: U19-U20). In fact, the era of the MEA demands the preparation of Indonesian human resources quality superior. The great challenge faced by Indonesia is how to strive for productive age human resources, reaching its peak in 2020 to 2035 as much as 70% of the

total population of Indonesia can be transformed into human resources that have the competence and skills through education in order not to become a burden.

Therefore, students should be equipped with the ability to care and respond to the challenges and problems that develop in society, critical thinking, creative, problem solving and have a deep understanding to apply the concept of science in problem solving. This can be achieved if students have scientific literacy. Scientific literacy is very important to solve various problems due to rapid changes in the field of science and technology, both related to ethics, morals and global issues. Literacy assessment is not solely on the measurement of the level of understanding of science knowledge, but also the understanding of various of scientific processes and the ability to apply knowledge and the process of science in real situations. Especially at this time the nation of Indonesia is facing the MEA era is full of competition in various fields and demanding qualified human resources in order not to lose compete.

Some countries, including Indonesia, have incorporated implicit scientific literacy in the curriculum. Unfortunately, not all teachers understand how to teach scientific literacy. It also has an impact on the low quality of science learning outcomes which still indicates that science learning process in Indonesian schools still ignores the acquisition of scientific literacy students. In the 2012 Program for International Student Achievement (PISA) survey, out of a total of 65 countries from the surveyed countries, Indonesia was ranked 64th .Indonesia ranked 62 out of the 70 countries that PISA tested in 2015 . In addition, there is a lack of availability of teaching materials containing Nature of Science (NoS) explicitly as research conducted by Maharani Savitri and Anita Marina Maryati (2005: 406).

Because of the importance of scientific literacy as the main goal of science education and as an effort to realize the quality of human resources of Indonesia is superior then the role of education, including science education. In this case, it is important to be held science lesson that is able to develop student scientific literacy. One of them is the implementation of the Nature of Science (NoS) inquiry approach. It is as Anna Permanasari (2011: U17) states that learning that can build scientific literacy is a lesson that focuses on student active learning, based on scientific inquiry, and constructivism.

Teachers need to comprehend comprehensively about the Nature of Science content and be able to communicate this understanding effectively to students through various strategies or learning approaches. One of the learning approaches that is based on constructivism and can provide an authentic learning experience is inquiry. The results of this study indicate that the application of inquiry on science learning has a positive effect on cognitive outcomes, process ability, and attitudes towards of science (Ergul, et al., 2011: 62). Based on this, the students inquiry profile must be known to determine which the type of inquiry approach appropriate will be implemented in the class.

Based on those reason, the problem of this research is how to produce scientific literacy development through NoS within inquiry-based science learning design? This learning design as guide for development of subject specific pedagogic for NoS within inquiry-based in science learning.

This research is very useful because it will produce the science learning model designed to develop scientific literacy, that is with NoS within inquiry approach to solve some of the root causes of low scientific literacy. First, the student's inquiry profile have not yet comprehensively describe so it is

important to study about it as a part of need assessment. It is assumed that low student's inquiry skill will make neglected and low in scientific literacy .

2. Method of Research

This research design is research and development. The development model used in this study refers to the model Four D Models and Borg and Gall. Procedure development consists of four main phases (phase define, design, develop, and disseminate) and an additional phase (preliminary testing fields, main product revision, playing field testing, and operational product revision) taken from Borg and Gall procedure. This research has been conducting in June s.d November 2017. Research's subject is the students of junior high school in Yogyakarta City.

Preliminary testing field has be done at 2013 for collecting information about student's inquiry skill profile. The sample is chosen with purposive sampling technique. The criteria of the school as sample are scientific activities have been held in its science learning. The number of the students are 211 students from three junior high school of their favorite level . The instrument in preliminary testing of research is observation sheet for observing the students activities when do the germination project.

3. Result and Discussion

3.1. Define Phase

In define phase, we must know the need assessment. Need assessment contribute to provide of knowledge on more efficient means of learning science. It is relevant to know what aspects need to be improve in learning practice and teacher development program.

The preliminary testing field has be done by using student worksheet in theme "Germination" that apply guided inquiry approach in it. In this scientific activities, student investigate relationship between water and seed germination. Student done the germination observation for several days. Amount of water was as the treatment. The observation has been done to aspects of student inquiry skill, including: make observation note, make question based on the observation result, make a scientific problem. The observation result of students inquiry profile (N=211 students) as Figure 1.

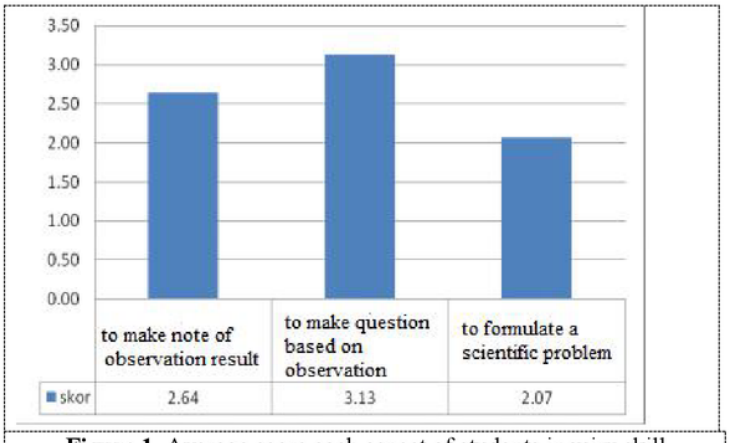

Figure 1. Average score each aspect of students inquiry skill

Figure 1 shows the highest average score of student inquiry skills reaching 3,13 on the skill of making questions based on the observation result. For the other inquiry skills that are formulate scientific problem and make note of observation result reaching enough category (less than 3). In general, the attainment of inquiry skills are still in enough good category based on Sukarni, et.al research result (2013). As for the percentage of scores on each aspect of inquiry skill aspect input as Table 1.

Table 1. The percentage of scores on each aspect of inquiry skill

No	Aspect of inquiry skill	Score 1		Score 2		Score 3		Score 4	
		f	%	f	%	f	%	f	%
1	Making observation note	8	3,79	67	31,8	130	61,6	6	2,84
2	Making question based on the observation result	11	5,21	46	21,8	59	27,96	95	45,02
3	Formulating a scientific problem	102	48,34	32	15,17	37	17,54	4	1,90

Note: f= frequency; skor 4=very good; 3= good; score 2=enough good; score 1=bad/not good

Table 2 shows that most of the student (more than 60%) have good skill on making observation note, even 2.84% has been very good. Similarly, for the skill to make question based on observation, most students (more than 60%) also achieved good criteria, even as much as 45.02% had been very good. However, for the ability to determine the formulation of problems that can be investigated is still apprehensive because most (48.34%) lack the ability. These results indicate that junior high school students have not been trained to do inquiry.

The low scientific literacy of Indonesian students is believed to be due to a lack of learning involving the process of science, for example in terms of formulating scientific questions, using the knowledge it possesses to explain natural phenomena, and drawing conclusions based on facts obtained through inquiry. It shows that learning with inquiry is important to do so that scientific literacy develops.

3.2. Design Phase

This research use The Model of Educational Reconstruction (MER) as mean to make a instructional design. The key concern of this model is that science subject matter issues as well as student learning needs and capabilities have to be given equal attention in efforts to improve the quality of science learning. There are three major steps that are intimately connected as in the Figure 2.

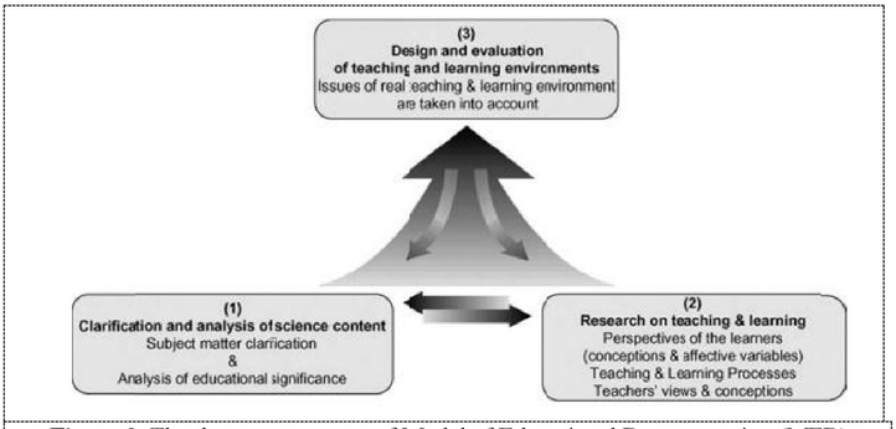

Figure 2. The three components of Model of Educational Reconstruction (MER)

1) To clarify and to analyze the science subject matter. The purpose of this component is to clarify the specific science conception and content structure from an educational point of view. Based on the curriculum of science learning in junior high school, it is still less oriented to the development of scientific literacy. Other than that, NoS is still very rarely delivered in schools. Besides because teachers do not already have an understanding of the importance of NoS and how to learn it, the teaching materials used in schools (including curriculum material 2013) have not explicitly inserted the NoS aspect. The curriculum of education in Indonesia still prioritizes aspects of the content and forgets the context and process dimensions as required by TIMSS.
2) To investigate into student and teacher perspectives regarding the chosen subject. Based on preliminary testing field show that students' inquiry skills are generally enough good. The results of the 2015 survey released today show a significant increase in educational attainment in Indonesia by 22.1 points. These results put Indonesia fourth in terms of student achievement improvement compared to previous survey results in 2012, from 72 countries that took the PISA test. Indonesia must be struggle to improve the student scientific literacy.
3) To design and to evaluate the learning environments (e.g learning materials, learning activites, learning sequences).
   It is important to make a instructional design that is oriented as effort to develop of scientific literacy through develop an information conception of the Nature of Science (NoS) and apply inquiry approach. By combining both, it is expected that students' scientific literacy can develop more optimal.

Literacy of science closely related to inquiry and NOS. As Holbrook & Rannikmae (2009: 281) point out that "an understanding of the Nature of Science (NOS) plays an important role in the development of scientific literacy". Based on this, it is important to develop a scientific literacy development model with science-based inquiry-based science design as an effort to improve the nation's competitiveness in facing the era of ASEAN Economic Community or AEC/MEA . The integration of the inquiry approach and Nature of Science is believed to further optimize the scientific literacy (Lederman, Lederman & Antink, 2013: 138).

Table 2. Analysis for scientific activities as integrate between inquiry and NoS

NoS Aspects	Inquiry Aspects
Scientific knowledge is empirically based.	1. Observation is an important way to learn about nature as object of science. Through observation objects or phenomenon can learn to compare, contrast, and note similarities and differences. 2. Accurate observations and evidence are necessary to draw realistic and plausible conclusions. 3. The analysis of evidence and data is essential in order to make sense of the content of science.
Scientific knowledge is tentative.	1. The analysis of data from a systematic investigation may provide the student with a basis to reach a reasonable conclusion. Conclusions should not go beyond the evidence that supports them. Additional scientific research may yield new information that affects previous conclusions. 2. The scientific establishment sometimes rejects new ideas, and new discoveries or innovation often spring from unexpected findings. 3. Constant reevaluation in the light of new data is essential to keeping scientific knowledge current. In this fashion, all forms of scientific knowledge remain flexible and may be revised as new data and new methods for looking at existing data become available.
Scientific knowledge is the product of observation and inference.	1. An *inference* is a conclusion based on evidence about events that have already occurred. Accurate observation and evidence are necessary to draw realistic and plausible conclusions. 2. Communicating an observation accurately, one must provide a clear description of exactly what is observed and nothing more. Those conducting investigations need to understand the difference between *what is seen* and what inferences, conclusions, or interpretations can be drawn from the observation. 3. Scientific conclusions are based both on verifiable observations and on inferences. It is because science must empiric.
Scientific knowledge is the product of creative thinking.	1. Scientists rely on creativity and imagination during all phases of their investigations. 2. Science is a human endeavor relying on human qualities, such as reasoning, insight, skill, energy, and creativity as well as intellectual honesty, tolerance of ambiguity, skepticism, and openness mind to new ideas.
Scientific laws and theories are different kinds of scientific knowledge.	1. *Scientific laws* are generalizations of observation data that describe patterns and relationships. Laws may be changed if the new data become available. 2. *Scientific theories* are systematic sets of concepts that offer explanations for observed patterns in nature. Theories provide frameworks for relating data and guiding future research. Theories may be changed if new data become available.
Scientists use many methods to develop scientific knowledge.	1. Investigations can be classified as *observational* (descriptive) *studies* (intended to generate hypotheses), or *experimental studies* (intended to test hypotheses). 2. Experimental studies sometimes follow a sequence of steps known as the Scientific Method: stating the problem, forming a hypothesis, testing the hypothesis, recording and analyzing data, stating a conclusion. However, there is no single scientific method. Science requires different abilities and procedures depending on such factors as the field of study

	and type of investigation. 3. Different kinds of problems and questions require differing approaches and research. Scientific methodology almost always begins with a question, is based on observation and evidence, and requires logic and reasoning. Not all systematic investigations are experimental.
Scientific knowledge is subjective and culturally influenced.	1. Investigation not only involves the careful application of systematic (scientific) methodology, but also includes the review and analysis of prior research related to the topic. Numerous sources of information are available from print and electronic sources, and the researcher needs to judge the authority and credibility of the sources. 2. It is typical for scientists to disagree with one another about the interpretation of evidence or a theory being considered. This is partly a result of the unique background (social, educational, etc.) that individual scientists bring to their research. Because of this inherent subjectivity, scientific inquiry involves evaluating the results and conclusions proposed by other scientists.

To organize a Nature of Science (NoS) within inquiry approach, relevant learning tools are required. Specific learning tool or Subject Specific Pedagogic (SSP) which not only contains material content, but also invites students to inquiry and contains knowledge about science related to the nature of science (Nature of Science / NoS). The analysis for scientific activities as integrate between inquiry and NoS result as in Table 2 can be use as a guidance to make SSP NoS within inquiry approach, especially for the scientific activities as the part of learning process.

4. Conclusion

Based on the results and the above discussion, it can be concluded that: (1) In general for each aspect inquiry skill still in the category enough good. The inability of students to do inquiry is still not optimal; (2) An instructional design Nature of Science (NoS) within inquiry approach that is expected that students' scientific literacy can develop using The Model of Educational Reconstruction (MER) as mean to make a instructional design.

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