DESIGNING OF LEARNING ACTIVITY FOR EXPLICATING NATURE OF SCIENCE

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Abstract
This study was aimed at clarifying the learning activities for explicit Nature of Science (NOS) which provide through context based STS (Science, Technology, Society) learning approach. The study followed the 4-D procedure but in this article only was presented up to the third step. These steps included define, design, and develop. The data were gathered through expert judgment by chemistry educator for product revision. The views of the chemistry teacher were explored through a closed-questionnaire that was analyzed by percentage. One of learning activity plan have arranged. The learning activity with context based STS approach consists of 5 stages including identification of social issues/history, identification of potential solution, need for knowledge, decision-making, and socialization and completion decision stage. Chemistry teachers’ view toward the feasibility of learning activity plan was good. The learning activity was developed with topic a history of the Father of Modern Chemistry for grade 10th. The findings show that his learning activity is able to help teacher for teaching NOS in classroom and foster students’ NOS through a historical story.

Keywords: basic law of chemistry, nature of science, learning activity

INTRODUCTION
One of the 21st skills demand is to have scientific literacy. The scientific literacy is commonly defined as the ability to critically analyze and evaluate the information of the scientific ideas and concepts required for personal decision-making in the daily life situations (Jarman & McClune, 2007; OECD, 2015; Shwartz, Ben-Zvi, & Hofstein, 2006; Cigdemoglu, Arslan, & Cam, 2017). However, the study conducted by the Programme for International Students Assessment (PISA) shows that Indonesian students’ scientific literacy is very low compared to other countries. In 2012, Indonesian Students Scientific Literacy was in the 64th rank out of the 65 countries listed. In 2015, Indonesian Students Scientific Literacy was in the 62nd rank out of the 70 countries listed. In 2018, Indonesian Students Scientific Literacy was in the 70th rank out of the 78 countries listed.

One of the prominent aspects of scientific literacy is Nature of Science (NOS). Numerous studies revealed that a proper understanding of the NOS is essential for scientific literacy and that NOS can be learned best by the explicit approach (Abd-El-Khalick & Lederman, 2000a; Donovan-White, 2006; Khishfe & Abd-El-Khalick, 2002; Lederman 2007; McComas, 2000). Allchin (2004) stated that “basic scientific concepts provide a framework. But one must also know about science—how research is pursued, how conclusions are justified, even how scientists may sometimes error be shaped by cultural biases.” Many science education documents such as the American Association for the Advancement of Science and the National Research Council emphasize an important role in
improving students’ understanding of NOS. NOS is important because it is needed to make, manage and process scientific and technological objects, inform decision making on socioscientific issues, respect the value of science as a culture of the present, NOS develop an understanding of the norms of the scientific community to realize a moral commitment that is of general value to the community and facilitating the subject matter of science learning (Hardianty, 2015).

In fact, for many science teachers, fruitful educating of NOS is demanding. Also for chemistry teacher since they should introduce NOS for grade X students while teaching nature of chemistry and scientific method as. That is the first matter for chemistry learning in senior high school. However, science teachers frequently do not really have adequate comprehension of NOS, and in any event, having such a comprehension does not ensure students’ learning of NOS (Lederman, 2007). Notwithstanding an adequate comprehension of NOS, teachers additionally need to have reasonable instructive aptitudes and substance information to train NOS and they have to appreciate NOS as a learning objective (Lederman, 1999). Teacher also need to make a reasonable plan to be success in teaching NOS. Regarding to that issue, learning activity that can help teacher for teaching NOS in classroom and could foster students’ NOS is needed to develop.

The phrase “nature of science” commonly alludes to the epistemology of science, science as a method of knowing, or the values/qualities and convictions inborn to the development of scientific knowledge (Lederman, 1992, 2007). Beyond these general portrayals, no agreement directly exists among scholars of science, antiquarians of science, researchers, and science teachers on a particular definition for NOS. This absence of agreement, in any case, should not be perplexing nor astonishing given the multifaceted nature and unpredictability of the logical attempt. Conceptions of NOS have changed all through the improvement of science and orderly contemplating science and are reflected in the manners the logical and science instruction networks have characterized the expression “nature of science” during the previous 100 years (e.g., AAAS, 1990, 1993; California Department of Education, 1990; Center of Unified Science Education at Ohio State University, 1974; Central Association for Science and Mathematics Teachers, 1907; Klopfer & Watson, 1957; NSTA, 1982).

Lederman, Lederman, and Antink (2013) suggested that there are seven aspects of the NOS that are noncontroversial and accessible to K-12 students and which are also considered to be relevant to their daily lives: scientific knowledge is tentative (subject to change); empirically-based (based on and/or derived from observations of the natural world); subjective and/or theory-laden; partly the product of human inference, imagination, and creativity (involves the invention of explanation); socially and culturally embedded; the distinction between observations and inferences, and the function of, and relationships between scientific theories and laws.

METHOD

This study followed Four-D Model (Thiagarajan, Semmel, & Semmel, 1974) in designing the learning activity. There were four steps covered Define, Design, Develop, and Disseminate but this study just reported till Develop step.

Define step started by searched relevant literatures and conducted initial interview with chemistry teacher about teaching NOS in senior high school. The result showed
that teaching NOS mostly was implemented by context-based learning; inquiry; and Science, Technology, and Society (STS) approaches. Also, chemistry teachers still have not introduce about NOS explicitly during chemistry learning since many difficulties. These difficulties included ways to integrated NOS with chemistry topics/matters and used appropriate strategy.

Design step conducted by arranged of learning activity design based on result of Define step. Design included chosen learning approach for developing learning activity namely context-based (STS) that founded by Yuenyong (2006) and chemistry topic scope of eleventh grade namely Nature of Chemistry and Scientific Method (Regulation of Indonesian Ministry of Education and Culture Number 37 Year 2018).

In the Develop step, learning activity design was described in five steps regarding to the features of context-based STS. The description give guideline the activities that should conduct by students and teacher in explicating NOS. The learning activity was developed with topic a history of the Father of Modern Chemistry for grade 10th.

Data collection was carried out in two stages, namely expert judgment and questionnaire. Expert’s suggestions were related to the construct accuracy of the context-based STS, the accuracy of the concept, grammar and writing. These suggestions were used to revise the learning activities. Meanwhile, the questionnaire was used to determine the feasibility of a learning activity according to the chemistry teacher view as a potential user. The closed questionnaire consists of 10 statements which represent two aspects, namely, feasibility in terms of content and feasibility in terms of language. The questionnaire consists of three alternative choices i.e. good, moderate, and less good.

Expert suggestions data was only processed qualitatively by mapping the types of suggestions and used as a basis for improving learning activities. The questionnaire data from 10 chemistry teachers were analyzed quantitatively by percentage.

RESULT AND DISCUSSION
The lesson plan of Nature of Science NOS learning activity was developed on the concept of Context-based STS learning approach which the NOS learning activities should provide not only the ways of investigation and solving problem but also a real-world problem-solving. Besides, this learning activity was organized for explicit NOS through a historical story. Regarding Yuenyong (2006), the context-based STS learning approach consists of 5 stages included identification of social issues, identification of potential solution, need for knowledge, decision-making, and socialization and completion decision stage. The lesson plan could be provided in Table 1.

This lesson plan is designed for 10th graders who are taking up Natural Sciences Interest. Each class will be divided into some groups and each group will be tasking themselves in the solving of problems.

Stage 1. Identification of Social Issue/History. In this stage, the teacher provides a history of the Father of Modern Chemistry (see Figure 1). Furthermore, the teacher asks students to identify the history in the worksheet.

Upon identifying the history, the teacher will ask some questions. In this case, the questions are divided into three parts. That is NOS reflective questions, content questions, and social questions. NOS reflective questions aim to enhance students’ NOS. Meanwhile, content questions purpose to identify students’ conceptual understanding. Furthermore,
### Nature of Science Learning Activity Adapting the Context-based STS Learning Approach

<table>
<thead>
<tr>
<th>Step</th>
<th>Activity</th>
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<tbody>
<tr>
<td>1</td>
<td>Identification of potential issues/history of social and environmental issues. The teacher provides a history of the Father of Modern Chemistry. The teacher asks students to identify the history in the worksheet; Students discuss in group.</td>
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<td>2</td>
<td>Decisions. Each group identifies the possibility to answer the questions. Each group determines its answer; Example of students' answer:</td>
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<tr>
<td>3</td>
<td>Knowledge of potential solutions. Students work in a group to discuss the questions.</td>
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<td>4</td>
<td>Nature of Science Learning Activity. Students share their final result in social media, for example, Instagram, Facebook, etc.</td>
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<tr>
<td>5</td>
<td>Socialization. Each group presents their answer and defends it in classroom discussion; Students share their final result in social media, for example, Instagram, Facebook, etc.</td>
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society questions aim to know how students solve problems in their daily life. **Stage 2. Identification of Potential Solution.** In the second stage, the teacher facilitates the class discussion about thinking of potential solutions to answer all questions in three aspects. Each group identifies the possibility to develop their answers.  

**Stage 3. Need for Knowledge.** In the third stage, the teacher facilitates students to gather any information from various learning resources related to the law of mass conservation. Students can collect information from books, journals, or other articles on the internet. Besides, students need to conduct a small experiment for answering the content’s question. Furthermore, students need to conduct a small project to solve the problem in society.
Stage 4. Decision-making. In the fourth stage, each group decides its answers. After that, they present their answers and defense it in the classroom. The example of students’ answers is provide below.

NOS’s reflective questions answer.
First, No, it cannot. A scientist has to have evidence to declare a law/theory because scientific knowledge demands evidence. Second, Yes, it can. Science is dynamic. It can be changed if there is more acceptable knowledge due to the tentativeness of scientific knowledge. Third, No, it cannot. The invention of Lavoisier is the law. It cannot be categorized as a theory. Law and theory are a different kind of knowledge. Law is a statement/description of an observed phenomenon without explaining what is the cause of the phenomenon. Meanwhile, the theory explains that phenomenon. Fourth, I agree with the statement. Each scientist has a scientific method because there is no universal scientific method. Fifth, Observation is a prominent activity in science. Observations are descriptive statements about natural phenomena that are “directly” accessible to the senses and about which several observers can reach consensus with relative cases (Lederman, et al., 2013). Sixth, The inference is another prominent activity in science. Inferences go beyond the senses (Lederman, et al., 2013). Seventh, I agree with that statement because chemistry is not only about the macroscopic level, but also the microscopic level. Hence, imagination is needed in science, especially chemistry.

Content’s questions answer. Based on the result of the experiment, the mass of wood in the closed container glass before and after the reaction is the same. It is appropriate with the Law of Mass Conservation.

Society’s questions answer. Plastic waste, especially PP or PE can make to be an alternative fuel with a simple instrument. The number of plastic the same as the number of alternative fuels. For instance, if we have 10-kilogram plastic waste, we will have 6 Liter diesel fuel; 2,5 Liter gasoline; 1,5 Liter kerosene. It means “The mass of the substance before the reaction, the same as the mass of the substance after the reaction”. The result is appropriate with the Law of Mass Conservation. Furthermore, the process of the change from plastic waste to some alternative fuels also can relate to the Law of Energy.

Stage 5. Socialization and Completion Decision Stage. In the last stage, students have to present the result of their discussion in the classroom. Furthermore, students also have to share the result in social media, for instance, Instagram, Facebook, youtube, etc.

This learning activity could assist the teacher in teaching NOS in the classroom and could improve students’ NOS through a historical story. Students who utilize the two NOS historical short stories had a significantly better understanding of the NOS concepts, compared to the students in the control group (Smith, 2010). The study of William and Rudge (2019) also revealed that the introduction of historical stories of science helped students achieved a better understanding of the role of imagination and creativity in science.

Quantitatively, for the aspect of language feasibility, all teachers (100%) stated that the product had a good criteria. Meanwhile, for the aspect of content feasibility, 9 teachers (90%) said it was good and 1 teacher said it was in moderate criteria. Some suggestions given by the teacher for improving the learning activity plan were providing the related links (e.g. video or the other resources), so students can study by themselves, providing the instruction of experiment to drive students, pushing
students to conduct the other experiments to prove the content, and providing the video for apperception.

Teacher recommendations are considered to improve the learning activity plan before it is implemented in class. With the activity of adding videos, especially contextual ones, it will attract students’ interest as well as curiosity. On the other hand, the selection of animation-based videos makes it possible to expand students’ knowledge of how scientists think. This is important as the cultivation of NOS values which are beneficial for the development of students’ thinking patterns and mental learning. Moreover, hand on activity through real experiments in the laboratory will further strengthen students’ scientific understanding and skills. A good support in introducing NOS to students.

CONCLUSION
This paper shared the ideas of developing NOS learning activities regarding Yuenyong (2006) context-based STS learning approach. The 5 stages of Yuenyong (2006) context-based STS teaching approach could guide ideas of developing learning activities from history to enhance students’ NOS. This learning activity will allow students to understand NOS. Furthermore, students will have the opportunity to solve a problem in society. Since this lesson plan has not been implemented yet in a school setting, for future work it could be implemented. Hence, the effect of the implementation of this NOS learning activity can be measured empirically.

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