Improving students' NOS understanding through explicit-reflective learning with socio-scientific issues context

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Abstract. As part of the scientific literacy component, the nature of science (NOS) contributes to the process of forming students with scientific literacy. This study aims to develop students' NOS understanding through explicit-reflective learning with socio-scientific issues (SSI) context. The quasi-experimental research method with the non-equivalent pretest-posttest control-group design was used in this study. A total of 45 students in seventh grade from a private junior high school in Prabumulih participated in this study and were grouped into 24 students in experimental class and 21 students in comparison class. Essay questions are used as the instruments in pre- and post-learning to measure students' understanding five aspects of NOS, which are subjective, tentative, empirical, observation, and social and cultural. The results show that the percentage of students in the experimental class who display an increase in NOS understanding is greater than the students in the comparison class. This study shows that explicit-reflective learning with the SSI context could be used to develop students' understanding of NOS.

1. Introduction

Helping students in achieving scientific literacy is the focus of science education nowadays [1,2,3]. Science literacy refers to the conceptual understanding of ideas in science (such as, cause and effect, balance, structure and function, cycles, and scale) that is beyond understanding scientific content [1]. Scientific literacy offers students the opportunity to choose, organize, and utilize scientific knowledge in everyday life [4].

Based on educational curriculum documents in Indonesia, students are targeted to have scientific knowledge in factual, conceptual, procedural, and metacognitive scopes and be able to apply this knowledge in the context of everyday life [5]. Indonesia has emphasized through its education curriculum document that science education is directed towards forming students who have scientific literacy. This is a major step for science education in Indonesia to support and follow the goals of science education nowadays.

Unfortunately, the achievement of Indonesian students in scientific literacy has not been satisfactory. The students' performance for the scientific literacy section of Program in International Science Assessment (PISA) shows that the score is below the average among the participant countries [6,7]. The low achievement is believed a result of inadequate student understanding of the nature of science (NOS). Students who possess the scientific literacy character has a direct connection to the NOS component [8]. NOS refers to the epistemology of science that aims to develop scientific knowledge [1].
NOS can be taught through explicit-reflective learning [9] by connecting the aspects of NOS to the science content in the curriculum or by teaching them separately. Explicit-reflective learning will be better by bringing up the context of controversial social problems as it provides a "natural" context to describe aspects of NOS, allow for the use of real data and interpretations, and allow discussion of social influences on scientific progress [10].

Socio-scientific issues (SSI) are controversial social problems related to science [11] in the conceptual, procedural aspects, or between science and technology [12] that have direct connections to real-life [2]. The current life situation opens our eyes that the existence of SSI is in our surroundings. Teachers can take this opportunity and implement it in learning processes to help students consider and apply basic concepts of science content and the aspects of NOS deeply when solving science problems that have social concern through local contexts that can be easily accessed [13].

The previous study about students' NOS understanding through explicit-reflective learning with SSI context presents that students showed improvements in NOS understanding [14,15,16]. The improvement is to the point of the informed view (i.e. proper understanding of NOS with relevant examples). Meanwhile, this kind of study in Indonesia is still limited. Based on the explanation, this study will explore students' understanding of NOS through explicit-reflective learning with the SSI context. The purpose of this study is to develop students' NOS understanding through explicit-reflective learning with SSI context followed by the research question "How is the improvement of students' NOS understanding through explicit-reflective learning with SSI context?"

2. Methods
The quasi-experimental with a non-equivalent pretest-posttest control-group design [17] have been applied to this study. The study involved 45 seventh-graders from a private junior high school in Prabumulih, South Sumatera Province. The students then were divided into an experimental group that consists of 24 students and 21 students in the comparison group. Due to the COVID-19 pandemic, this study was conducted by utilizing online media i.e. Google classroom as the virtual classroom for forum discussion and carrying out pre-test and post-test.

At the beginning of the study, all students responded to the pre-test. Then, different treatments were given to each class for two weeks. The students in the experimental class received explicit-reflective learning with the SSI context and the students in the comparison group experienced explicit-reflective learning with the context in scientific content. The topic discussed in both classes is a chapter in science subjects which is the interaction of living creatures with the environment. At the end of the study, a post-test was administered to all students.

Students' NOS understanding was assessed using the written test in the form of essay questions. The questions were created based on the SSI passage that is adapted with the NOS aspects assessment. The intended aspects are subjective, tentative, empirical, observation, and social and cultural. The pre-test and post-test instruments had been judged and validated by experts and had held a prior study in a school. Data obtained from the pre-test and post-test results are used to categorize students' NOS understanding into naïve, intermediary, and informed views [3]. Student views are categorized as naïve views if the views expressed are not appropriate because they are inconsistent with the contemporary views of NOS. If the views expressed by students are fragmented (on one side they present a naïve view and on another side, they give an informed view) then it is categorized as intermediary views. An informed view shows that it corresponds to the contemporary views of NOS approved by science philosophers, scientists, and science educators.

3. Result and Discussion
A total of 24 and 21 students as experimental and comparison groups respectively are participated in this study. But, explicit-reflective learning with the SSI context had been carried out for the experimental class. Students from both classes worked on pre-test and post-test which aims to assess their NOS understanding of five aspects, namely subjective, tentative, empirical, observation, and social and cultural. Data obtained from the tests were processed and categorized according to the type
of view of NOS understanding, i.e. naïve, intermediary, and informed view. The percentage of view of NOS from the results of both tests is shown in Table 1 below.

Table 1. Percentage of Students’ View about NOS

| Class          | NOS aspects | View of NOS | Pre- (%) | Post- (%) |
|----------------|-------------|-------------|----------|-----------|
|                | Subjective  | Informed    | 0        | 0         |
| Experimental   |             | Intermediary| 17       | 71        |
| (n = 24)       |             | Naive       | 83       | 29        |
| Tentative      | Informed    | 0           |          | 0         |
|                | Intermediary| 17          |          | 50        |
|                | Naive       | 83          |          | 50        |
| Empirical      | Informed    | 0           |          | 0         |
|                | Intermediary| 0           |          | 17        |
|                | Naive       | 100         |          | 83        |
| Observation    | Informed    | 0           |          | 0         |
|                | Intermediary| 4           |          | 17        |
|                | Naive       | 96          |          | 83        |
| Social and Cultural | Informed | 0         |          | 12        |
|                | Intermediary| 54          |          | 71        |
|                | Naive       | 46          |          | 17        |
| Comparison     | Subjective  | Informed    | 0        | 0         |
| (n = 21)       |             | Intermediary| 10       | 38        |
|                | Naive       | 90          |          | 62        |
| Tentative      | Informed    | 0           |          | 0         |
|                | Intermediary| 10          |          | 24        |
|                | Naive       | 90          |          | 76        |
| Empirical      | Informed    | 0           |          | 0         |
|                | Intermediary| 19          |          | 29        |
|                | Naive       | 81          |          | 71        |
| Observation    | Informed    | 0           |          | 0         |
|                | Intermediary| 14          |          | 29        |
|                | Naive       | 86          |          | 71        |
| Social and Cultural | Informed | 0         |          | 0         |
|                | Intermediary| 57          |          | 71        |
|                | Naive       | 43          |          | 29        |

Table 1 shows that before the learning activities, none of the students is at informed views on all aspects of NOS. Students’ understanding of NOS in all aspects for both the experimental class and the comparison class improved after the learning process. However, there is a different result of students in the experimental class where they achieve an informed view on social and cultural aspects.

The results of this study differ from the previous study [16]. Students in all groups increased in an informed view of all aspects of the NOS measured. A possible cause of these different outcomes is the duration students spend in explicit-reflective learning with the SSI context. Students in this study only received the treatment for two weeks. Meanwhile, students in the previous study spent up to eight weeks when receiving explicit-reflective learning with the SSI context. Therefore, two weeks is a short time to provide students a deep understanding of NOS.

The findings of this study are in accordance with other studies that explored students' understanding of NOS which was delivered online [18]. The findings show that online media can change students' conceptions of NOS better, which was initially naïve views. In an online discussion, students have the opportunity to reflect on the answers carefully before posting it to the forum. Besides, these opportunities facilitate students thinking skills to proceed to higher-order thinking stages.

Students from both classes in this study received explicit-reflective learning. The difference is that the students in the experimental group experienced the SSI context and the students in comparison
groups received the context in the form of the scientific content in their learning activities. The results show that understanding of NOS in all aspects of both classes is increasing. However, students in the experimental class were able to reach an informed view on social and cultural aspects even though the percentage is low. The informed view is shown through the students' answers on the post-test which provides specific examples related to social and cultural aspects.

One of the socio-scientific issues used as discourse on the instruments is about illegal fishing. Questions regarding social and cultural aspects such as the following "In your opinion, are social and cultural values in Indonesian society able to prevent or reduce damage to the constituent components of the aquatic environment? Give me your explanation!" One of the students wrote the answer during the pre-test to this question such as "No. Because the era is getting more modern". This answer is categorized as a naïve view because students do not yet understand that social and cultural values in society can influence how a person's actions deal with socio-scientific issues.

The same question is asked to students when the post-test. The results indicate changes in student responses become a more informed view. One of the students wrote the answers during the post-test such as "Yes. Because since a long time ago Indonesian society has been taught to preserve the environment such as the social and cultural values of "Panglima Laot" in Aceh which has the authority to regulate fishermen including determining the rules of fishing so as not to damage the environment". The students' answer is categorized as an informed view because students already understand that social and cultural values in society can influence how a person's actions deal with socio-scientific issues. Students also provided specific examples of social and cultural values that exist in society to support his opinion.

The findings of this study are in line with the findings of previous studies [14]. Their findings show that students who are taught explicit-reflective with the SSI context and content-based context have an increased understanding of NOS. Also, students who receive explicit-reflective learning with the SSI context can provide specific examples to support their opinions on social and cultural aspects. SSI in classroom learning has a role in showing that there is an interaction between science and society and it opens opportunities for students to think that science and society rely on each other in terms of their influence.

The results show that explicit-reflective learning with the SSI context able to promote students' NOS understanding. Explicit-reflective learning draws students' attention straight to NOS aspects through questions given by the teacher, students are allowed to discuss and review NOS aspects, and also reflect the aspects on their inquiry throughout the learning process [19]. The presence of the SSI context in explicit-reflective learning provides chances for students to observe and obtain existing data and associate it with scientific contents that are being or has been learned. This indirectly helps students in considering and applying the basic concepts of science content and aspects of NOS in solving science problems related to social life [13].

Considering the goals of science education is to form students who have scientific literacy, therefore teaching NOS should be one of the important points that science teachers need to pay attention to. NOS can be taught to students starting from lower grade levels [20]. Teaching NOS to students can be given even since students are still in kindergarten. The advantage of teaching students about NOS early is students have an understanding of NOS and scientific literacy from an early age. Thus, students will get used to solve various problems related to science in their daily lives as they grow older.

4. Conclusion
Students' NOS understanding has improved after receiving the treatment. The improvement of students' understanding of NOS in both classes only reached the intermediary view on four aspects of NOS, except in the social and cultural aspects where there are students who held an informed view after receiving explicit-reflective learning with the SSI context. It cannot be concluded that explicit-reflective learning with the SSI context is more effective in increasing students' NOS understanding
than explicit-reflective learning in the context of scientific content. However, it can be inferred that explicit-reflective learning with the SSI context can develop students’ NOS understanding.

5. References
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