Examining Indonesian pre-service chemistry teachers’ views of nature of science and technology (VNOST)

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Abstract. This study aims to examine the views of the nature of science and technology (VNOST) of the pre-service chemistry teacher. The participants comprised 23 6th semester students at one of the state universities in Semarang, Indonesia. This study utilized a questionnaire and qualitative approach to gathering data. The NOST questionnaire consists of eight multiple-choice items, comprising of four aspects: definitions of science and technology, the epistemology, the internal sociology of science, and the external sociology of science. It was found that 78% of students had incomplete but legitimate views on the definition of science. They only viewed science as a study of principles, laws, and theories in biology, physics, and chemistry or body of knowledge without considering the scientific process behind it. Meanwhile, the remaining 22% consider science includes an investigative process and the process of resulting knowledge. Generally, the majority of the pre-service chemistry teachers still have lack comprehension of defining science and technology both epistemologically and sociologically. Thus, the results showed that pre-service chemistry teachers still need to improve their views of the nature of science and technology.

1. Introduction

The vast development in science and technology has significantly transformed our daily life. The majority of innovative technology is used to produce an instrument that enables us to gain new knowledge. Technology supports scientist activities and sciences provide an idea to develop a new technology [1]. Thus, science and technology affect society and vice versa.

Evolving better decisions making skills based on science and technology issues affect society, held totally an idea of the nature of science (NOS). These offer the primary conception of scientific literacy [2,3]. It purposes to improve people’s decisions progressively impacted by the development and the products of science and technology [4]. Thus, both science and technology are two associated grounds in society activities [5].

Science and technology are two different parts but related to each other. Both are not required to distinguish as separated science and technology lessons [6]. Because of great meaning to comprehend the nature of science and technology (NOST) in our daily life, thus it is crucial for students must have appropriate views on NOST [7]. Having an appropriate understanding of NOST would improving scientific and technological innovation’s ability [8].

Indonesian students’ ability regarding science and technology innovation indicated by the rational ranks on the global competitiveness index (GCI) and the global index innovation (GII). Indonesia ranks
at 85 out of 127 countries of scientific and technology outputs [9,10]. Other than that, the technological readiness aspect ranks at 75 out of 148 countries [11]. Few researchers concluded that matters thing to integrating NOST in science curriculum [12,13]. Consequently, the teacher’s views of NOST impact teachers’ perceptions of science teaching practices in the classroom [14,15].

The researchers on the pre-service chemistry teachers’ understanding of NOST have been reported widely in the researchers. It showed that they have lack information about many aspects of NOST in science teaching [16,17,18]. The pre-service teachers still held on naïve and merit views of NOST. They prefer familiar science as the body of knowledge than consider as investigating as behind of the process gain scientific knowledge. However, the information about pre-service teachers’ comprehending of NOST and the integration with science practice in Indonesian is still limited.

Comprehending chemistry subject obliges students to drive between macroscopic, submicroscopic and symbolic views of the matter. Many researchers have delivered the students’ misconceptions in some chemistry subjects [19,20]. Which includes various topics on chemical practices and the consideration of how chemistry affects society [21]. Hence, the nature of chemistry is one component of the NOS. Therefore, it is pivotal to exploring Indonesian pre-service chemistry teachers’ views of NOST to get the relevance between teachers’ conceptions and their teaching practices.

2. Methods
This study was attended by 23 students of chemistry education in one of the state universities in Semarang. All students were in the 6th semester, especially those who passed the physical chemistry, organic chemistry, and inorganic chemistry course. Expecting the students have had the views of NOST along with their study.

The questionnaire was adapted from the Views on Science-Technology-Society (VOST) instrument [22]. The VOST instrument showed a reliable and valid instrument. Some of those questions are selected and modified both in structure and format. Before used, the questionnaire was translated into the Indonesian language and validated by the experts. The questionnaire adjusted for this study has consisted of eight multiple-choice items belong to four aspects of NOST. They are the definitions of science and technology, the epistemology, the internal, and the external sociology of science [23,17].

Students’ views on each item were categorized as R for realistic, HM for merit and N for naïve. ‘Realistic’ expresses legitimate views on NOST. ‘Merit’ expresses several legitimate points although not being completely appropriate. Meanwhile, ‘Naïve’ reflects inappropriate views or not legitimate regarding the NOST [17]. Data obtained were analyzed using a frequency distribution to know the dominant in student’s views of NOST.

3. Results and Discussion
The views of students regarding NOST are delivered in Table 1. These results showed that generally the views were scattered from naïve to realistic in all statements.

| Aspect of NOS                  | VNST Questionnaire Statements                                                                 | Students’ Views |
|-------------------------------|------------------------------------------------------------------------------------------------|-----------------|
| Definitions of science and technology | Science is….                                                                                     | 21.7% 78.3% 0.0% |
|                                | Technology is….                                                                                  | 34.8% 60.9% 4.3% |
|                                | The relationship between science and technology is….                                              | 60.9% 30.4% 8.7% |
| Epistemology                  | Many scientific models (for example models of an atom) has characteristic….                       | 17.4% 56.5% 26.1% |
3.1 Views about Definition of Science and Technology

This aspect discussed the definition of science, the definition of technology, and the correlation between science and technology. Table 1 shows only 21.7% of students had realistic views about the definition of science. They agreed with the statement that science is a research and discover knowledge. The other stated that science is finding the unknown and resulting in new knowledge about the world. Both views are appropriate because science refers to the activities science such as observing and inferring belong to the scientific process and constructing scientific knowledge [24]. Most of the students (78.3%) hold on merit views because they consider that science as a study of principles, laws, and theories in chemistry or a body of knowledge. Without realizing the process behind gain scientific knowledge such as empirical evidence, scientific theories, laws, and hypotheses.

Related to the definition of technology, about 34.8% of students hold realistic views that technology expresses to creating, scheming, developing and evaluating things such as tools and scientific instruments. Another realistic view of students conveyed that technology is the process of engineering and the underlying knowledge. Meanwhile, 60.9% of students talk about merit views. They believe in technology as manufactured artifacts, while others argued that technology is the practice of science. Yet, technology is not only about artifacts of the human creating of something but also related to technological knowledge in our lives [25]. Indeed, the comprehending of technology how people change nature surrounding to served people’s needs, and to expand people’s capability [26]. Thus, the views on technology as the process of making the product is proper. However, 4.3% of students still hold on naive views for this item. They believe that technology is very similar to science.

Different from the previous items, more than half of students (60.9%) revealed on realistic views towards the correlation between science and technology. They believed science and technology are intertwined, where scientific research supports a new application in technology then technological developments rise the ability to conduct scientific research. Furthermore, science and technology involved in reciprocal interaction, the interactions seem like a beneficial way with one another [27]. Thus, both of them contribute to each other and sometimes as unintended ways. Moreover, 30.4% of students believe in merit views means they do not have proper views completely. They argued that science is the fundamental of technological advances, though it needs the effort to know how technology could assist science. The other students who believe in merit views conveyed that science and technology are unlike, but they linked so closely, thus it’s hard to tell them apart. Furthermore, 8.7% of students viewed science and technology as more and less the same thing. That view is not related to science and technology’s item.

3.2 Views about Epistemology

Table 1 shows this aspect discussed the nature of scientific models and the nature of the classification scheme. More than half (56.7%) of students had merit views, they thought that models are closer familiar to reality. Meanwhile, 26.1% of students had not legitimate or naïve views about the scientific models. They agreed models are duplicates of reality and show the reality is. Only 17.4% of students had realistic views.
views. They believe that models are not similar to reality and help to explain the limitation in constructing knowledge. Science models do not address how knowledge constructed but only as human reasoning how we think about the world [28]. They made the basic analysis of the condition, possibilities, and limits of our knowledge for gaining processes, that may lead in linguistically view on nature is [29]. Therefore, scientific models are never the same with reality usually, own only some of the characteristics of the real thing [30].

Related to the nature classification scheme, about 60.9% of students displayed realistic views which is there could many ways to classify nature because science is tentative. Science knowledge could be change along with the new observations of existing observation of the natural world [31]. As a consequence, many ways of classifications went by evidence, the scientific activities and probably conducted by the scientist. About 8.7% of students express merit views convey the scientist classify nature most simply and logically, which was seen as a legitimate view. On the other hand, 30.4% of students reflected the naïve view stated that classification match nature is.

3.3 Views about Internal Sociology of Science
This aspect discussed the internal sociology of science including scientific and technological decisions. Table 1 shows the high percentage of the students’ views (65.2%) believes in realistic views. They argued that scientists’ decisions to accept or not the theory and models are based on they have been successfully tested many times. Examining the scientific theory do-over to gain a rationales explanation until no one denied thus such theory [32]. Meanwhile, 30.4% of students hold merit views. Their argument said that scientists’ decisions are based only on the evidence of the natural world which is observed. Yet, naïve views arise about 4.3% of students stated that theory or model proposed by scientists must be true. Every scientific activity needs evidence to support the theory, although scientist is not always true [32].

About 21.7% of students had realistic views on this question. They agreed that the choice to use a technology determined by a personal viewpoint since what is an advantage to some people may be a disadvantage to others. The need to use technology requires understanding and taking responsibility both of the environment and ourselves [25]. Furthermore, the major answer holds merit views is about 78.3% and none of the naïve views. They mean, the choice to use a technology determined by the benefit to society. The benefits thing of technology appears on how we use to some extent, then shape ourselves become what we are [25].

3.4 Views about External Sociology of Science
This aspect discussed the correlation between science, technology, and society. These items convey about the views of students regarding science and technology impact society and in turn, society impacts science and technology. Table 1 shows only 8.7% of students had realistic views. Some students view science and technology affects each other. Other students taught that science and technology can solve global problems simultaneously. Technology conduct the activities scientist and science brings knowledge to develop a new technology [1]. Nevertheless, almost all students hold merit views. About 87.0% expressed that science and technology frequently make our lives easier and calm while others argued that technology may cause environmental issues. On the other hand, 4.3% of students hold naive view believe that science, technology, and society separately.

Comprehending the views of NOST correctly is the basis of scientific literacy. The knowledge of this concept was constructed by engaging in science-related activities of the five senses in observation and investigation [33]. These research findings indicate that pre-service chemistry teachers have inadequate views of NOST. The majority of students hold merit and naïve views in almost all items. Inadequate comprehending of the nature of science and technology effect of: first, the lack of experience of students in science activities. Some knowledge requires the learner go to beyond experience that cannot be reached by five senses [33]. Second, separating between science and technology in the instructional goals. Teaching nature of science and technology does not have to be an additional topic, yet it can be integrated into what teachers are doing now that facilitates the students’ understanding of subject matters [5]. Third, not provided the achievement assessment of understanding NOS. We know that almost all students concern about what the content will be on the test and how their learning along
will be evaluated [34]. This means that the achievement assessments (format, content, time, methods) have a serious impact on determining what, when and how students study [35].

4. Conclusion
Examining students’ thinking about science, technology, and society to define the correct concepts of students of science and technology. Generally, pre-service chemistry teachers’ views of NOST were still inadequate. Most of the students expressed a view as merit and naïve for each item of NOST. The explicit approaches engaging the NOS in teaching can address the views of NOST issues among students. It offers the students the alternative framework for considering to construct NOS understanding.

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