Pre-service chemistry teacher’s view about the nature of science and technology

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Abstract. This study aims to determine the view of pre-service chemistry teacher on fourth, sixth and eighth semester about the nature of science and technology. The aspects of View of Nature of Science and Technology (VNOST) include: (1) the characteristics of science and technology; (2) the purpose of science and scientific research; (3) characteristics of scientific knowledge and scientific theory; (4) how to acquire scientific knowledge and scientific theory; and (5) the relationship of science and technology. This study uses descriptive method, which involves 59 students of one State University in Ambon City, Indonesia. Data were collected by VNOST questionnaire. At the first aspect, students view science as a knowledge, such as principles, laws and theories, while technology as the application of science. The second aspect is seen as a part of explaining the change of nature. The third aspect, students consider as the scientific perspective of the scientists. The fourth aspect is regarded that scientific knowledge is obtained by re-examining previous knowledge. At the last aspect, students hold that the relationship of science and technology can affect society. The implications will be used as a rationale for developing a NOST-oriented chemistry teacher education.

1. Introduction
Learning 21st century is a learning that integrates literacy skills, knowledge skills, skills and attitudes and mastery of technology. Literacy becomes the most important part of the learning process [1]. This is the ability of literacy (especially science literacy) is one of the demands of 21st century competencies that must be possessed by learners [2]. The challenges faced in science education in Indonesia are the low literacy skills of Indonesian learners as seen in the 2015 Program for International Student Assessment (PISA) results. The score achieved by Indonesian learners is below the average of international achievements [3]. Therefore, it is important to note and improve. Improving literacy skills of science must pay attention to the characteristics / nature of science (NOS). The essence of science is an important element of scientific literacy [4]. The nature of science describes what science is, how it works, how scientists work, and the interaction between science and society. As an important element of science literacy, knowledge of the nature of science is widely acknowledged as one of the main objectives of chemical education to be improved. An increased understanding of the nature of science can be done, if the technological aspects are noticed, because the nature of science cannot be properly understood without the role of technology (Nature of Technology, NOT) [5].

Gardner reveals that the relationship of science and technology can be seen from four perspectives, namely: (1) science is present first than technology, this view is based on the fact that technology used by humans is based on the laws, concepts and theories found by science; (2) technology is present first
than science, this view is based on assumptions that assume the development of science today is due to human experience in using the tools and the need to understand the concept of the tool; (3) technology and science are two independent things where scientists and technologists are two groups of people who have different goals and methods and produce different products; (4) science and technology have a two-way interaction between both. This view assumes that scientists and technologists study each other for the sake of development of each field. Science problems can bring about new technological developments, on the other hand technological problems can be a new field of science research [6].

Important at all levels of science education is an adequate understanding of the Nature of Science and Technology (NOST) and its interaction with society [7]. Understanding the nature of science and technology is believed to help science teachers in teaching/guiding their learners to understand the concept of science and to describe the relationship of science and technology more fully [8]. Revealing five main aspects related to NOST that need to be understood by pre-service science teacher, that is; (1) the characteristics of science and technology, (2) the purpose of science and scientific inquiry, (3) the characteristics of knowledge and scientific theory, (4) how to acquire scientific knowledge and scientific theory and (5) the relationship between science and technology [7]. These aspects of NOST are also an important component of the science literacy tested in the PISA study [3]. Therefore science teachers are obliged to pursue better ways to improve students' understanding of the nature of science and technology [7]. Thus it becomes very important to explore how pre-service science teachers (especially pre-service chemistry teachers) conceptualize NOST. Because the views of teachers (pre-service teachers) directly or indirectly affect students' views [7].

2. Method
The method used in this research is descriptive method. Descriptive method is a research method that describes the characteristics of a particular sample or phenomenon [9]. In this study the data or information collected is about the views of pre-service chemistry teacher about the nature of science and technology. The subjects consisted of 59 students from a population of 195 pre-service chemistry teacher randomly selected. Students are taken from 3 semesters that is fourth semester, consist of 20 students; sixth semester, consisting of 20 students and eighth semester, consisting of 19 students in the department of Chemistry Education, Pattimura University. The instrument used in this study was developed by Tairab and Aikenhead in the form of questionnaires about views on the nature of science and technology. This instrument consists of ten items. For items one through nine require respondents to choose from the views given in accordance with their beliefs. While items ten requires respondents to provide a written view of the difference between science and technology. The questionnaire items are developed on the basis of the nature of science and technology, grouped into five aspects, namely (1) the characteristics of science and technology, (2) the purpose of science and scientific research, (3) the characteristics of scientific knowledge and scientific theory, (4) how to acquire scientific knowledge and scientific theory, and (5) the relationship between science and technology. The options for each item in the questionnaire are classified as R ‘Realistic’, HM ‘Has Merit’ and N ‘Naive’. The ‘Realistic’ view is an appropriate view of the nature of science and technology. The ‘Has Merit’ view is a view that is not entirely appropriate, but reflects a sensible view. While the ‘Naive’ view seen as a view that is not relevant or not in accordance with the nature of science and technology. In practice, the subjects of the study were given a questionnaire that worked for 45 minutes. The data were then collected and analyzed for each item by using the frequency distribution to characterize the trend from the respondent's view of the nature of science and technology. The results of the analysis are described descriptively.

3. Result and discussion
3.1. Characteristics of science and technology
The first aspect is the view of pre-service chemistry teacher of the characteristics of science and technology. This aspect consists of three items, namely the understanding of science and scientific theory, as shown in table 1.
The third item on the understanding of technology. Chemical prospective students (50% of fourth semester students, 55% of sixth semester students and 63.2% of eighth semester students) view technology as a science application, a view marked by Rubba and Harkness as ‘has merit’. Few students have expressed their view that technology is creating, designing, developing and testing objects such as scientific instruments, tools and instruments, which are views with ‘realistic’ categories. The fact that no student chooses a choice ‘I do not know’ (part of the choice in the ‘naïve’ category) suggests that the majority of pre-service chemistry teacher are convinced by the choice of technology as the application of science. This view is corroborated by statements written by students when asked to write down their views on differences in science and technology (tenth items). The following quote is an example of that view:

S4: Technology is the result of the application of science knowledge in order to help and help the life of living things.
S6: Technology is the application of science that is useful to improve human life.
S8: Technology is a tool used as an application of science.

The view that technology is the application of science is a very dominant view held by science educators and has strong cultural roots. To justify this, people tend to point to artefacts and scientific discoveries, such as atomic physics that have produced nuclear power plants. Garner also reveals that the educational system tends to place science as the main subject while technology takes precedence, so technology is regarded only as an applied science. Garner poses a clear distinction about science and technology and advocates a perspective on the contributions of scientists and technologists [6]. The views expressed by the pre-service chemistry teacher regarding the nature of technology in this study, have major implications in teaching and learning science education, especially chemical and technological education. Pre-service teachers should be encouraged to make a clear distinction between science and technology so that their students can realize the complexity and interactive nature of the science and technology relationships, because without such distinction, students will not have a proper
and broad understanding of it. One way to add a richer and clearer understanding of science and technology is to learn about the history of science and technology, as this may illustrate the importance of science to technology and the importance of technology to science (specially chemistry) [7].

3.2. The purpose of science and scientific research

The second aspect is about the purpose of science and scientific research. This aspect consists of two items namely the purpose of science and scientific research. Data obtained from the research results are shown in table 2.

Table 2. Pre-service chemistry teacher’s view of the purpose of science and scientific research.

| Items                  | Pre-service fourth semester | Pre-service sixth semester | Pre-service eighth semester | All          |
|------------------------|-----------------------------|----------------------------|-----------------------------|--------------|
|                        | f  | %  | f  | %  | f  | %  | f  | %  | f  | %  | All          |
| The purpose science    |    |    |    |    |    |    |    |    |    |    |              |
| Realistic              | 8  | 40 | 10 | 50 | 8  | 42.1| 26 | 44.1|
| Has Merit              | 7  | 35 | 6  | 30 | 11 | 57.9| 24 | 40.7|
| Naïve                  | 5  | 25 | 4  | 20 | 0  | 0   | 9  | 15.2|
| Scientific research    |    |    |    |    |    |    |    |    |    |    |              |
| Realistic              | 15 | 75 | 11 | 55 | 4  | 21.1| 30 | 50.8|
| Has Merit              | 3  | 15 | 4  | 20 | 10 | 52.6| 17 | 28.8|
| Naïve                  | 2  | 10 | 5  | 25 | 5  | 26.3| 12 | 20.4|

Table 2 shows that for the purpose items of science, students (44.1% of all students) hold that the purpose of science is to understand, explain and interpret the continuous change of nature and its characteristics, views that are considered ‘realistic’. On the other hand, 15.2% of students express the purpose of science as something that has been discovered and considered a truth, a view that is considered ‘naïve’. Whereas when students are asked to choose a view of scientific research, 50.8% of all students believe that the purpose of scientific research is to explain why things can happen. The interesting thing is that about 20.4% of students assume that the purpose of scientific research is to make new discoveries, views that are considered ‘naïve’. Although most chemistry professors have a ‘realistic’ and ‘has merit’ perspective on the goals of science and scientific research, but when connected with technology, this view is often confusing between science and technology, particularly about the social purpose of both.

3.3. Characteristics of scientific knowledge and scientific theory

The third aspect is about scientific knowledge and scientific theory, which consists of two items. The data obtained are presented in table 3. Table 3 shows that the majority of the three student groups (93.2%) regard scientific knowledge as a scientific perspective, the ideas and interpretations of scientists from the past, views that are considered ‘realistic’. This view supports the view that science is a collection of facts or collections of knowledge that explain the world and the purpose of research is to collect as much data as possible [7]. Interestingly, about 6.8% of students did not show a view of scientific knowledge (‘naïve’ category). If the pre-service chemistry teacher’s view is associated with this, it will have major implications for teaching and learning chemistry. For example, learning will be more focused on content-oriented (chemical) science teaching and less emphasis on chemistry as a process of inquiry [7].

The view of the pre-service chemistry teacher on scientific theory is as the most precise interpretation and explanation proved by scientists, as well as scientific theory considered to be proven facts through experiments, views considered ‘has merit’ (75% of fourth semester students, 85 % of students in the sixth semester and 84.2% of students in the eighth semester). This view suggests that pre-service chemistry teachers still have confusion between scientific theories and scientific facts. This view is in line with Rubba and Harkness’s (1993) opinion that science/chemistry teachers often visualize the relation between theory, law and fact as developmentally related [10].
Table 3. Pre-service chemistry teacher’s view of characteristics of scientific knowledge and scientific theory.

| Items            | Selected answer categories | Pre-service fourth semester | Pre-service sixth semester | Pre-service eighth semester | All |
|------------------|---------------------------|----------------------------|---------------------------|----------------------------|-----|
| Scientific       |                           |                            |                           |                            |     |
| knowledge        | Realistic                 | 18                         | 90                        | 20                         | 100 | 17 | 89.5 | 55 | 93.2 |
| Has Merit        | 0                         | 0                          | 0                         | 0                          | 0   | 0  | 0     | 4  | 6.8  |
| Naïve            | 2                         | 10                         | 0                         | 0                          | 0   | 2  | 10.5 | 4  | 6.8  |
| Scientific       |                           |                            |                           |                            |     |
| theory           | Realistic                 | 0                          | 0                         | 0                          | 0   | 0  | 0     | 0  | 0    |
| Has Merit        | 15                        | 75                         | 17                        | 85                         | 16  | 84.2 | 48 | 81.4 |
| Naïve            | 5                         | 25                         | 3                         | 15                         | 3   | 15.8 | 11 | 18.6 |

3.4. How to acquire scientific knowledge and scientific theory

The fourth aspect is about the statement of how to acquire scientific knowledge and scientific theory. The data obtained are presented in table 4. It shows that the highest percentage of statements approved by pre-service chemistry teacher (59.3% of all students) about obtaining scientific knowledge and scientific theory is to review the results of previous studies, to find out the truth and new research will be examined by scientist others, views that are considered to ‘has merit’. On the other hand, there are 3.4% of total students who do not know how to obtain scientific knowledge and scientific theory (views considered ‘naïve’). This view has implications for the study of chemistry. Like, students will be vulnerable to false arguments and have difficulty in building scientific knowledge. Therefore, it is important to teach chemistry by paying attention to its epistemological side or how to acquire scientific knowledge and scientific theory [11].

Table 4. Pre-service chemistry teacher’s view of how to acquire scientific knowledge and scientific theory.

| Items             | Selected answer categories | Pre-service fourth semester | Pre-service sixth semester | Pre-service eighth semester | All |
|-------------------|---------------------------|----------------------------|---------------------------|----------------------------|-----|
| The correct       | Realistic                 | 5                          | 25                        | 16                         | 80  | 1  | 5.3 | 22 | 37.3 |
| statement         | Has Merit                 | 15                         | 75                        | 4                          | 20  | 16 | 84.2 | 35 | 59.3 |
| Naïve             |                           | 0                          | 0                         | 0                          | 0   | 2  | 10.5 | 2  | 3.4  |

3.5. Relationship of science and technology

The fifth aspect is about the relationship of science and technology. The data obtained are presented in table 5. It summarizes the views of pre-service chemistry teacher about the relationship of science and technology. Pre-service chemistry teacher (37.3% of all students) assume that science and technology affect society, and on the other hand societies also affect the development of science and technology. In addition, science and technology can help solve the problems faced in society. This view shows the interaction between science, technology and society. Although the views of respondents are relatively ‘realistic’, students also tend to view science and technology from the negative side, that technology innovation and science development cause environmental problems (11.9% of students choose from ‘has merit’ category). Similarly, very few students (18.6% and 20.3% of the ‘has merit’ category) view the role of science and technology in the prosperity of a nation and its contribution to human life. On the other hand, the interesting thing is that about 11.9% of all students hold that science, technology and society are not related to each other so that they do not affect each other. This view has major implications for chemistry teaching and learning. According Tairab (2001) to overcome this, then in learning should adopt the approach of science-technology-society and emphasize the interdependence between science, technology and society. Thus it is possible for pre-service chemistry teacher and their students to better understand the relationship of science, technology and society [7].
4. Conclusion

Based on the results of research conducted it can be concluded that in general pre-service chemistry teacher either fourth, sixth or eighth semester have the same view about nature of science and technology (NOST). The view of science is more oriented to content and processes while technology is the application of science. Related to the relationship of science, technology and society, students do not look on the positive side even there are also some students who assume there is no relationship between science, technology and society so it does not affect each other. The view suggests that pre-service chemistry teacher still have inadequate understanding of NOST. This has implications for learning, since 21st century learning is a learning that integrates science literacy and technological mastery. It can therefore be suggested that in science learning (especially chemistry) for pre-service chemistry teacher, to be more emphasizing and connecting science / chemistry, technology and society so that students can have clearer views and better understanding and richer about the nature of science and technology and its relationship with society. It is hoped that pre-service chemistry teacher can channel them to students so as to enable them to improve students’ abilities about the nature of science and technology that are essential elements of science literacy science and the demands of 21st century competence.

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Table 5. Pre-service chemistry teacher’s view of the relationship of science and technology.

| Items                  | Selected answer categories | Pre-service fourth semester | Pre-service sixth semester | Pre-service eighth semester | All     |
|------------------------|---------------------------|-----------------------------|---------------------------|-----------------------------|---------|
| The correct statement  | Realistic                 | 7                           | 35                        | 7                           | 35      | 42.1   | 22      | 37.3   |
|                        | Has Merit                 | 10                          | 50                        | 11                          | 55      | 9      | 47.4   | 30      | 50.8   |
| statement              | Naïve                     | 3                           | 15                        | 2                           | 10      | 2      | 10.5   | 7       | 11.9   |

Table 5. Pre-service chemistry teacher’s view of the relationship of science and technology.

| Items                  | Selected answer categories | Pre-service fourth semester | Pre-service sixth semester | Pre-service eighth semester | All     |
|------------------------|---------------------------|-----------------------------|---------------------------|-----------------------------|---------|
| The correct statement  | Realistic                 | 7                           | 35                        | 7                           | 35      | 42.1   | 22      | 37.3   |
|                        | Has Merit                 | 10                          | 50                        | 11                          | 55      | 9      | 47.4   | 30      | 50.8   |
| statement              | Naïve                     | 3                           | 15                        | 2                           | 10      | 2      | 10.5   | 7       | 11.9   |