EXAMINING JUNIOR HIGH SCHOOL STUDENTS' VIEWS OF THE NATURE OF SCIENCE AND TECHNOLOGY

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Abstract - This study aims to examine junior high school students' views of the nature of science and technology (NOST). The participants include 125 junior high school students in one of schools in Bandung, Indonesia. The NOST questionnaire consisted of 8 multiple choice items including four aspects: definitions of science and technology, epistemology, the internal sociology of science, and the external sociology of science. The data from the questionnaire were analyzed using frequency distribution to characterize trends in the students' views. The results revealed that generally junior high school students had inadequate views regarding nature of science and technology. The study is of great significance to the teachers in order to emphasis the aspects of NOST in science learning.

Index Terms - Epistemology, Nature of Science and Technology, View

I. INTRODUCTION

Science and technology become integral parts of today's century. Technology, which is developed from scientific discoveries, has changed and still continue to change our society [1]. Today, human activities are assited by technologies as well as some human decisions are based on the knowledge of science. Because of the great influence of science and technology on our lives, it is crucial for students to have an appropriate understanding about the nature of science and technology and their interactions with and within society [2]. Some educators agreed about the importance of integrating the nature of science and technology into science curriculum [3][4].

Nature of science and technology (NOST) refers to an understanding about the role of specific constructs and essential features in the process of knowledge-building of science and technology [5]. NOST also can be interpreted as characteristics of processes and products of scientists and engineers, including potential value of the products [2]. Understanding about nature of science and technology help students to develop their scientific inquiry skills and technology design as well as their metacognition, thus they can be more effective in their work and become competent decision makers in the future [2].

Regarding to the significant role of NOST, it becomes important to explore how students conceptualise the nature of science and technology [4]. The previous researches among countries showed that students' understanding of the nature both of science and technology was still inadequate [1],[6]-[13]. The related research has been conducted in Indonesia showed that some pre-service teacher had naïve views in the aspects of NOST [14], whereas teachers' views and understanding about NOST would influence the way they portray science in their classroom as well as influence students' understanding [4],[15]. Therefore, it becomes very interesting to explore the conceptual position of students in Indonesia with regard to how they view science and technology. The present study focuses on examining the views of students' NOST among junior high school students in Indonesia.

II. METHODOLOGY

A. Participants

Participants were 125 junior high school students in one of schools in Bandung. They consisted of students in grades 7, 8 and 9 who enrolled in the second semester of the academic year 2018.

B. Instrument

The data for the present study were collected using the nature of science and technology questionnaire. This questionnaire was selected and modified both in structure and format of scoring from the Views on Science-Technology–Society (VOSTS) instrument [16]. The VOSTS instrument has been shown as reliable and valid instrument when used with secondary school students [16]. The questionnaire consisted of 8 multiple choice items, covering the following aspects of nature of science and technology: definitions of science and technology, epistemology (nature of scientific models and nature classification scheme), the external sociology of science (mutual interactions with science, technology and society), and the internal sociology of science (scientific decision and technological decision) [16],[17]. Before used, questionnaire was translated into Indonesian language and validated by the experts.

C. Data analysis

Students' views in each item were classified as R 'realistic', HM 'has merit' and N 'naive'. 'Realistic' expresses an appropriate view about the nature of science or technology. 'Has merit' reflects a plausible view, although not being completely appropriate. Meanwhile, 'naive' expresses a view that is not

appropriate to the nature of science or technology [17]. Data obtained were analyzed for each of the items using frequency distribution to characterize trends in the students' views of the nature of science and technology.

III. RESULTS AND DISCUSSION

The views of students regarding the nature of science and technology are presented in Table I. These results showed that generally the views were spread from naive perspectives to more realistic in all statements.

A. Views about Definitions of Science and Technology

There were 3 items related to the definitions of science and technology, including definition of science, definition of technology, and interdependence of science & technology. Only 13.6% of students hold realistic views about definition of science. They agreed with the statement that science is a systematic investigative process and the resulting knowledge. The others stated that science is exploring the unknown and discovering new things about the world. Both views are appropriate because science actually unites both the processes and products of science, thus science can be defined as a process of constructing scientific knowledge [18],[19]. Furthermore, 80.8% of students hold merit perspectives because they only viewed science as a study of fields such as biology, chemistry and physics or a body of knowledge, such as principles, laws, and theories. Meanwhile, 5.6% students hold naïve views. Some of them claimed that science is an organization of people called scientists who have ideas and techniques for discovering new knowledge. Other students defined science as inventing and designing things. This statement is wrong because this is definition of technology. Even, there were students who didn't know the definition of science.

Related to the question about definition of technology, about 24.8% students displayed realistic view that technology refers to inventing, designing, developing and testing things such as appliances, tools and scientific instruments. Another realistic view stated that technology is the process of manufacturing and the underlying know-how. Most of students (69.6%) expressed merit views. Some of them believed in technology as manufactured artifacts, while others argued that technology is application of science. The concept of technology does not only relate to the devices as products of technology, but it is also associated with the knowledge of its use, application and the process in developing the product [20], [21]. Thus, the view about technology as the process of making the product is appropriate. However, 5.6% students still hold naïve views for this item. They believed that technology is very similar to science.

For the item about relationship between science and technology, almost half of students (48.8%) expressed realistic views. They argued that science and technology are intertwined, where scientific research leads to practical application in technology and technological developments increase the ability to do scientific research. Relationship between science and technology is described as two-way interaction or bi-directional interaction, where both of them are closely linked and contribute to each other [22],[23]. Science contributes to technology in terms gives new knowledge which serves as a source of new technological ideas, while the role of technology on science is as a source of otherwise unavailable instrumentation and techniques needed to address novel and difficult scientific questions more efficiently [23]. However, 36% of students hold view that were not being completely appropriate. They argued that science is the basis of technological advances, though it's hard to see how technology could aid the science. Another merit view is science and technology are different, but they linked so closely, thus it's hard to tell them apart. Furthermore, more than 15% of students viewed science and technology are more or less the same thing. This view is absolutely not relevant with the nature of science and technology.

B. Views about Epistemology

There were 2 questions related to the epistemology, including nature of scientific models and nature of classification scheme. Different from the previous items, on the item about scientific models, half of students (50.4%) hold naïve view. They thought that scientific models are copies of reality. Meanwhile, 12.8% of students though that scientific models are not being copies of reality- a view that is relevant with the nature of scientific methods and the others (36.8%) who had merit view argued that scientific models come close to being reality. These responses indicate that some students are not familiar with the epistemology of models. Based on the nature of models, no scientific models are realistic, since their goal is not to mirror, but to map the reality [24]. Scientific models are not like a real thing, but they emphasis some key features. They often look as simplified representations of reality [25]. Therefore, scientific models are never compared with reality, but only with some other models of reality [24].

For the item about nature of classification scheme, almost half of students (48.8%) displayed realistic view that there could be many correct ways to classify the nature because science is tentative. Nobody knows the way nature really is, thus scientist classify the nature according to their theories or perceptions [26]. As a consequence, many ways of classification are probably made by scientist. About 44.0% of students expressed that scientist classify the nature in the most simple and logical way, which was seen as a plausible view. On the other hand, 7.2% of students reflected naive view that classification match the nature really is. However, the facts, classification of nature does not

always match up [27].

C. Views about the Internal Sociology of Science

Question about the aspect of internal sociology of science consists of 2 items, including scientific decision and technological decision. There were 29.6% of students who had realistic view. They argued that scientists' decisions to accept or not the theory and models are based on whether they have been successfully tested many times.

Table I. The Percentages of Students' Views about Nature of Science and Technology (NOST)

Aspects of NOST	VNOST Questionnaire Statements	Students' views (%)		
		Realistic	Has Merit	Naïve
Definitions of science and technology	Science is….	13.6	80.8	5.6
	Technology is….	24.8	69.6	5.6
	The relationship between science and technology is….	48.8	36.0	15.2
Epistemology	Many scientific models (for example models of atom) has characteristic….	12.8	36.8	50.4
	Scientists classify something (for example elements in periodic table) according to….	48.8	44.0	7.2
The internal sociology of science	How do scientists decide that a theory or model in science is acceptable or not?	29.6	64.8	5.6
	When a new technology is developed, it may or may not be put into practice. The decision to use a new technology depends on….	22.4	61.6	16.0
The external sociology of science	The relationship between science, technology, and society is….	56.8	28.8	14.4

High percentages of students (64.8%) hold merit views. Their major argument was scientists' decisions are based solely on the observable facts. Nevertheless, naïve views were also apparent with 5.6% of students thought that theory or model proposed by scientists must be true.

Related to the question about technological decision, 22.4% of students expressed that decision to use a new technology depends on personal viewpoint, since what is advantage to some people may be a disadvantage to others - a view that is appropriate. More than half of students (61.6%) hold merit view. Their major argument was decision to use a new technology depends mainly on the benefit to the society. Furthermore, 16% of students regarded many new technologies are developed to make money or gain power. The acceptance towards new technologies can be influenced by several factors, including cost, benefits of technology, need for technology,and social influence [28]. However, decision whether to use or not new technologies depends mainly on the personal perspective [29].

D. Views about the External Sociology of Science

The external sociology of science aspects refers to the relationship between science, technology, and society. Different from previous responses, in this item, more than half of the participants (56.8%) expressed the realistic views. Their major view was science and technology affect society and in turn society affects science and technology. This statement is relevant about the relationship between science, technology and society [4]. Other realistic statement was the prosperity of the nation depends on science and technology progress. Nevertheless, 28.8% of students had merit view. Some of them agreed with the view that technology may bring environmental problems while the others argued that science and technology often make our lives healthier, easier, and more comfortable. On the other hand, 14.4% of students hold naïve view that science, technology and society are independent, they do not affect each other.

These research findings indicate that generally, the views of junior high school students about nature of science and technology were inadequate. The majority of students hold merit and naïve views in almost all surveyed aspects of nature of science and technology. Inadequate understanding about nature of science and technology can be caused by several factors, including: 1) curriculum guidance does not require the teaching of the nature of science and technology [1]. Generally, teachers focus the learning only on the content and do not present the history and philosophy of science [30], 2) textbooks used in schools commonly present factual material as a rhetoric of conclusions, but the relationship between science and technology is often ignored [30], 3) teachers' lack understanding about nost. Previous research conducted in in Bandung, Indonesia showed that the teachers' understanding about nature of science was relatively same as their students' understanding [31]. The implications for future teaching is the teachers are expected to emphasis the knowledge about the nature of science and technology in science learning, besides the content and procedural knowledge.

CONCLUSION

The study results showed that generally the views of junior high school students about nature of science and technology were still inadequate and shallow. Most of students expressed merit and naïve viewpoints in almost all aspects of NOST. It is recommended for the science teacher to explicitly explain about the nature of science and technology in the classroom.

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