STUDENTS' CONCEPTIONS OF THE NATURE OF SCIENCE

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Abstract - This study investigated the understanding of the nature of science of junior high school students in South Sulawesi. A cross-sectional survey method was implemented in this study. A total of 72 students were selected randomly in cluster from several schools in South Sulawesi, Indonesia. The instrument was a combination of 28 item likert scale and 7 items of open-ended questionnaires related to seven aspects: tentativeness, empirical, creativity imagination, observations and inferences, scientific theories and laws, subjectivity, and social-cultural context. The results indicated that students' understanding of the nature of science was intermediate, suggesting that there are still possible chance for improvement.

Keywords - Junior high school, students' conceptions, nature of science

I. INTRODUCTION

Science emphasizes teaching that aims to develop science literacy so that science is not only used for teaching but must surpass it. According to BSNP (2010) the purpose of science learning is to be a vehicle for learners to learn about themselves and the environment, as well as the prospect of further development in applying it in everyday life. The PISA (Program for International Student Assessment) (ODEC, 2013) defines science literacy as the capacity to use scientific knowledge, identifies questions and draws factual and data-based conclusions, understands the universe, and makes decisions on the impacts of human activities. The National Research Council (1996) suggests that science literacy also includes understanding the nature of science, scientific activities, and the role of science in society and private life. To increase science literacy, Erdoğan (2004) argues that an understanding of Nature of Science (NOS) should be an important goal in the education curriculum. NOS is regarded as an integral part of scientific literacy which is the main goal of science education goals (Mattews in Vesterinen, 2011). Understanding of the nature of science (NOS) becomes an adapted as one of the characteristics expected of students who have science literacy, where students can play a role in developing the understanding of concepts, principles, theories and processes of science and realize the complex relationship between science, technology and society (Abd-El-Khalick & BouJaoude, 197). The findings in the study show that a better understanding of the nature of science (NOS) can improve the mastery of concepts in science learning (Smith, Maclin, Houghton, & Hennessey, 2000 ; Sandoval, 2005; NRC, 2011 in Peoples, 2012) and encourage learning outcomes student science as a whole.

II. LITERATURE REVIEW

Akerson (2008) states that NOS is an epistemological and sociological view of what science is and how to develop it. There are seven aspects of NOS that can be implemented in the curriculum and learning science. school students can access such knowledge that is relevant to everyday life. The NOS aspects include: (1) science / knowledge is tentative, (2) empirical-based science (partially derived from observations of the universe), (3) subjective science (theory-laden) interpretation of groups or individuals, (4) science always uses inference, imagination and human creativity (especially in finding explanations), (5) science / scientific knowledge is influenced by society and culture where scientific knowledge is applied, (6) observation and inference, and (7) the function and relationship between scientific theory and scientific law (Schwartz & Crawford, 2003; Lederman et al., 2002; Rahayu, 2016)

III. DETAILS EXPERIMENTAL

The type of research is a combination of quantitative and qualitative research that aims to determine the understanding of the nature of science of junior high school students. This research is designed to collect and analyze data to answer how the current students' understanding of the nature of science?
Sample of this study is 74 students of Junior High School (SMP) from several schools in South Sulawesi. Consists of 29 men and 45 women selected randomly of cluster. Data were collected using validated instruments from previous studies that were adapted from Students' Ideas about Nature of Science (SINOS) as instituted by Chen et al. (2013) and the Students Understanding of Science and Scientific Inquiry (SUSSI) developed by Liang et al. (2008) for Likert scale items and the Views of the Nature of Science questionnaire (VNOS-D) (Lederman et al., 2002) for the open ended questionnaire. Consisting of 7 items of questions representing each aspect of NOS and 37 items of positive and negative statements to be responded by students from gradations strongly agree, agree, disagree and strongly disagree. Both of these instruments will be used as tools to identify the understanding of the nature of science students

covering 7 aspects namely the tentative, empirical, subjective, creative, observation, scientific theories and laws, social and cultural context. The instrument was translated into Indonesian and validated by an expert. The scoring rubric was adapted from the one created by its original developers of SUSSI (Liang et al. 2008). The scoring rubric contained positive and negative views. The positive (+) ones represented the views that are consistent with the current international science education reform documents, and the negative (−) ones represented students' naïve views on the different aspects of NOS. For each positive response, points were given from 1 to 4. For the likert skale items, the students' view were classified as naive, intermediate, and informed. Naïve views, if none of the four responses scored more than three; intermediate views, if one or more than one (but not all) of the four responses were either more, equal to or less than three; and informed views, if all of the four responses received more than three.

As for scoring for each question item on an open-ended questionare using a rubric adapted from a study conducted by Yoon et al. (2014), where the rubric is a scoring modification for the VNOS-D rubric written by Akerson and Donnelly (2010).

Table 1. Sample section for open-ended questionnaires

	(0)	(1)	(2)	(3)
Classification	There is no response they state that they do not know: the response does not address the prompt	Answers that showed lack of understanding of a concept	Answers show some understanding of a concept, but then also show persistent misconceptions	Answers show more complete understanding, and there are no contradictory answers present in instrument responses or other data sources
Tentativeness	There is no response they state that they do not know	Science does not change	As we learn more or have new technology science changes	science changes as we learn more or as scientists reinterpret existing data

IV. RESULTS AND DISCUSSION

Based on the result of Likert scale item and open-ended questionnaire analysis as shown in table 2 and 3.

Table 2. Result of Likert-scale item data analysis

Aspects of NOS	Naive (%)	Intermediate (%)	Informed (%)
tentative	58.3	41.7	0
empirical	37.5	62.5	0
subjective	37.5	45.8	16.7
creative	41.7	50	8.3
observation	62.5	29.2	8.3
theory and low	54.2	45.8	0
cultural and social	33.5	62.5	4

Tentativeness

Based on the Likert scale item analysis, more than 50% of the students are at the naive level and none of the respondents reached the informed level. The majority of them assume that science is an accurate knowledge based on experiments, where such knowledge will not be changed. Similar results were seen in open-ended questinnaire, 8% of students were unable to write responses to items for that aspect, and 32% of students held naive views. Sample student response to this item:

"Theories of science are obtained through accurate experiments before they are finally believed by many people, it makes science unchanged" (S no.38)

"Science is based on observed data and has been proven and agreed upon by many scientists, science will not be replaced" (S no. 17)

Those who agree that science may change, including explaining that:

"Knowledge of science runs dynamically and there is a possibility that a theory that has been believed will change in the future because of a more relevant discovery. It is also related to the development of technology. "(S no. 7)

In general, students' NOS understandings are at the naive views level where students assume science knowledge will not change as it has been proven through experiments accompanied by strong explanations.

Table 2. Results of data analysis of open-ended item questionnaires

Aspects of NOS	Non-classifiable (%)	Naive (%)	Intermediate (%)	Informed (%)
tentative	8	32	44	16
empirical	12	28	64	16
subjective	8	32	52	8
creative	8	12	68	12
observation	8	36	48	8
theory and low	12	44	40	0
cultural and social	20	28	44	4

Empirical

table 2 shows, 62.6% of students get intermediate views category, 37.5% of students get naive views and 0% of categorized students are informed based on analysis performed on likert scale items. Student approval even reached 92% on one item that agreed that "Among different scientific theories, the acceptance of scientific theory depends on experimental evidence". While in the open-ended questionnaire where the students answer the question "What, in their view, is the science?" And about 64% of students get a intermediate view. Some of the student responses are:

"Science is different from other disciplines because science is closely related to everything around us like biology" (S no. 52)

"Because science emphasizes more on the knowledge of experiments and supporting data whereas other sciences are not as systematic as science" (S no. 31)

"Science is a form of learning and our understanding of the environment and other creatures. Other discipline is not like that "(S no. 22)

Interestingly, some respondents, instead of responding according to the expected researchers, there is an answer to the question by referring to students' attitudes toward science.

"Science is a science much more difficult to understand than any other discipline" (S no.9-27-33).

As explained by Lederman and Khishfe's VNOS-D Research Copy Items and Item Descriptions (2002), this question aims to explore students' views regarding science as a discipline to address questions about the natural world, the role of science in providing explanations for natural phenomena, and the role that empirical evidence plays in science that separates science from other 'ways of knowing.' Nevertheless, when answering this question, several students in this study appeared to discuss their attitudes toward science rather than knowledge about the NOS.

Subjectivity

Based on the likert questionnaire, most (45.8%) of the students are in the intermediate views category, 37.5% are categorized as naive views and the other 16.7% are informed. The majority of the students bilieve that subjectivity in science is unavoidable. The percentage of students who agreed on the aspects of subjectivity as part of the NOS was seen in the students' response to one of the 4 items of likert scale statements reaching 84%. They agree that "when scientists from different research areas observe the same experiment, they are interested in different things and so they make different observations and come to different conclusions".

The student response on the open ended questionnaire also showed 32% of the total respondents were in the naive views category, 52% of students held intermediate views, 8% of the students responded "sorry miss, i dont know", categorized as non-classifiable and 8% held informed views.

Some sample answers of students who respond that subjectivity as part of the NOS can not be avoided, among others:

"In making decisions, including in science. there is the possibility that people will not be in one thought because of many factors "(S No. 6)

"Different knowledge and experience will affect the way a person perceives a problem" (S no. 61)

On the contrary, some students assume that science is something based on observed methods and facts so that the subjectivity factor is something to be avoided. Their responses include:

"As long as they (scientists) investigate the same thing with the correct method then the result will be the same" (S no. 53)

In general, the majority of students held intermediate views where they assume that subjectivity is part of the nature of science.

CONCLUSIONS

The study results showed that students' understandings of the nature of science was at intermediate level, suggesting that there are still possible room for improvement. It is recommended for the teacher to improve students' understanding of the nature of science. We realized that there is a necessity to emphasize an explicit approach (Khishfe and Abd-El-Khalick 2002) as an alternative to develop students' views of NOS, rather than through an implicit approach whereby Indonesian students are expected to understand NOS automatically when the science lessons are delivered through inquiry learning. Many science educators and researchers argue that an explicit approach of addressing NOS better increases the effectiveness of understanding of NOS than an implicit approach (Abd-El-Khalick and Lederman 2000; Bell, Bell, Matkins and Gansneder 2011; Khishfe 2008; Schwartz, Lederman and Crawford 2004). In an explicit approach, the aspects of NOS are mentioned explicitly in the objectives of the lesson, and the students are provided an opportunity to discuss and reflect on the aspects of

NOS. In an implicit approach, there is an assumption that the students will learn NOS automatically when students are engaged in inquiry activities while learning science.

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