

Biology Teacher's understanding of Nature of Science (NOS)

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Abstract *This study aims to determine the understanding of high school biology teachers about the nature of science. Teacher understanding was measured using the View of Nature of Science (VNOS) form C instrument developed and refined from VNOS form B to measure the understanding of the nature of science of secondary biology teachers. Understanding the nature of science needs to be owned by science students and teachers to avoid any misconceptions about science. Research on understanding the nature of science teachers of science is still not widely carried out in Indonesia. This qualitative study using VNOS Form involved 9 Biology teachers who taught in high schools from different schools. The VNOS Form C which has been translated into Indonesia version was administered into respondents by using google form. Ten questions represent the 14 aspects of VNOS Form C. Based on the results of the data analysis, it is concluded that VNOS form C can be used to measure the understanding of the nature of science for biology teachers. However, the study showed that most biology teachers still in the status of naïve understanding about nature of science rather than eclectic and informed understanding. This study imply the need of improvement of teacher understanding of nature of science. [BIOLOGY TEACHER'S UNDERSTANDING OF NATURE OF SCIENCE (NOS)] (J. Math. Nat. Sci., 1(2): 35 - 39, 2021)*

Keywords:
Nature of Science,
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Teacher

Introduction

Education in Indonesia have developed then lead to focus on scientific literacy-based classroom. According to Budiningsih et al. (2015) one of scientific literacy aspects is investigating nature of science. Nature of Science (NOS) is a knowledge about how science works (Listiani and Kusuma, 2017). Abd-El-Khalick et al. (1998) presented concept of nature of science referred to science epistemology that science as the way of knowing and or value, trust related to scientific knowledge development. The importance of understanding nature of science is to know that science can change, came from nature, subjective, human inference-based, creative, social-cultural, differentiate between observation and interference, and search whether any relationship between law and theory (Abd-El-Khalick et al., 1998; Listiani and Kusuma, 2017).

There are many aspects of nature of science such as subjectivity into changes, tentative, subjektif and theory laden; inference, creativity and imagination, social and cultural embeddedness of science, difference between observation and inference, and relationship

between scientific theories and law (Abd-El-Khalick and Lederman, 2000). Implementing aspects of nature of science in Biology classroom can hopefully influence students understanding of science. Because learning biology is not only through reading text (Listiani and Kusuma, 2017). Effective learning Biology needs awareness of the nature about how students learn and the nature of learning material to help students understand science well, and they can differentiate nature science among others sciences. (Putri et al., 2016). Therefore, science teacher should have appropriate understanding about nature of science. This study aims to investigate Biology teacher's understanding of nature of science.

Research Methodology

This qualitative study implement the VNOS instrument form C developed and finalized by Abd-El-Khalick et al. (1998, 2002) then adopted in Indonesian version. The VNOS form C, consisted of ten open ended questions was administered into nine Biology teachers who teach in Senior High School around North Sumatera by using Google Form. The VNOS instrument consist of

nine aspects of nature of science as shown in table 1.

Based on literature study concerning NOS there are aspects implemented in previous includes Empiris Base, Tentative, Theories and Law, Socio Cultural Embeddedness, Creativity, Scientific Method, and Subjective (Widodo et al., 2019). Modification from VNOS-B into VNOS-C have been completed by Abd-El-Khalick et al. (2002, 2020) by detailing previous six aspects in VNOS-B into 14 aspects in VNOS-C.

VNOS-B has been modified and extended by adopting item 3, 1, 2, 5, and 7, and adding five new items. VNOS-C is eligible for graduates and

secondary science teachers. It is used to measure understanding of nature of science concerning aspects of empirical NOS, the scientific method, general structure and aim of experiments, role of prior expectations in experiments, validity of observationally-based theories and disciplines, scientific theories of nature, functions of, logic of testing, difference and relationship between theories and laws, tentative NOS, creative and imaginative NOS, inference and theoretical entities, subjective or theory-laden NOS dan social and cultural embeddedness of science (Abd-El-Khalick et al., 2002).

Table 1. Aspects of Nature of Science (Abd-El-Khalick et al., 2002).

No.	Aspect to be studied	Item number
1.	Empirical NOS	1
2.	The Scientific Method	1
3.	General structure and aim of experiments	2
4.	Role of prior expectations in experiments	2
5.	Validity of observationally-based theories and disciplines	3
6.	Scientific theories of Nature	4
7.	Functions of	4
8.	Logic of testing	5
9.	Difference and relationship between theories and laws	5
10.	Tentative NOS	5,4,1
11.	Creative and imaginative NOS	10
12.	Inference and theoretical entities	6,7
13.	Subjective or theory-laden NOS	8
14.	Social and cultural embeddedness of science	9

Results

Teacher's respond into VNOS-C instrument are analyzed by using NOS rubric developed by Irez (2004, 2006) to classify teachers answer into three category such as naïve, eclectic, and informed responds.

The result showed that Biology Teacher's understanding of nature of science have various level of responds, beginning with naïve, eclectic, into informed of responds concerning on nature of science. All respondents have no knowledge about validity of observationally-based theories and disciplines and lack of knowledge concerning aspect of general structure and aim of experiments and role of prior expectations in experiment as shown in figure 1.

Discussion

The first question of VNOS-C consist of three aspects includes tentative NOS, empirical NOS, and the scientific method. This is because science is impermeable, can change by curiosity to answer question or skepticism about fact through observation and scientific work. This differentiate

natural science from others science like religion. There are two respondents who lack of knowledge (eclectic respond) and seven respondents who well knowledge (informed respond). The eclectic responds are only argue that science is a natural science with formula and statutes, science is embedded with religion but it doesn't explain how science differ from others disciplines like religion and philosophy.

Here is example of two group of responds on this aspect. The group of eclectic responds said:

"Science is a knowledge includes discussion about nature and actually embedded with religion, but its different orientation."

While the group of informed responds said:

"Science is a knowledge which study universe and its contents. Science is different because scientific works search causal effect and search the influence of something toward others based on scientific methods."

The aspect measured by second questions is general structure and aim of experiments, and role of prior expectations in experiments. All respondents are lack knowledge about

experiment. They noted that scientific experiment aims to verify hypothesis or previous theory through conducting experiment. They don't explain that experiment is a controlled way to verify and manipulate interesting object while controlling all other factors to keep same

conditions, lead scientists believe whether their theory have valid or not. Therefore, in controlling experiment scientists should know what the result will happen through their verification method and have common figure about what is searching.

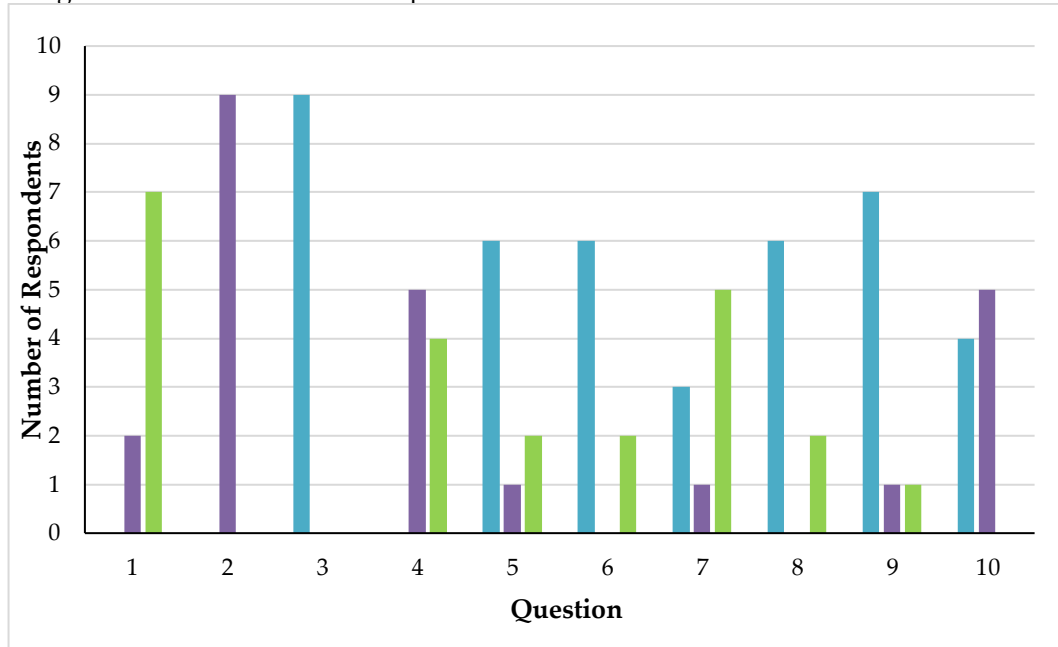


Figure 1. Biology Teacher's understanding of Nature of Science (NOS), where yellow color is not yet knowledge, green color is lack of knowledge, and blue color is well knowledge.

The third question of VNOS-C instrument concern Validity of observationally-based theories and disciplines. The question about does the development of scientific knowledge require experiment and how is the example. All respondents don't know that the development of scientific knowledge require experiment. They all tend to note that science should be followed by experiment to verify the knowledge. But the development of scientific knowledge doesn't always require experiment. For example, Darwin's theory about human evolution could not be verified directly because of observable data, like fossil and formation stone are not provided.

The fourth instrument of VNOS-C concerns about aspects of scientific theories of nature, and functions of theory. Someone idea can only be proven by considering evident which keep effort to defense. Theories set general explanation framework as basic for developing certain hypothesis. Theory can also promote a set of knowledge through stimulating hypothesis and research which support current theory or lead to new theory. There are five respondents who lack

of knowledge and four respondents have known these aspects. Most of them don't include example to support their arguments.

Here is the different of two group of responds on this aspect. The group of eclectic responds said: "Some theories must be changed along with development of science and technology."

While the group of informed responds said: "Yes it is to perfect provided theory. For example on theory of cell invention by Purkinje, it is said that each living cell has cell fluid then Felix Dujardin name it as protoplasm."

The aspect of logic of testing, difference and relationship between theories and laws, and tentative NOS mentioned on fifth question discussed about difference between scientific laws and theories. Scientific laws same as theories which are tentative can change sometime if there is false or lack of data then lead and change into new knowledge. The difference between theory and law is that scientific laws describe quantitative between phenomena such as the attraction of the universe to an object. While scientific theories are made of concepts in accordance with general or beyond observation

and propose new explanation model to the world. In the aspect logic of testing most theories have unobservable case and have circumstantial evidence so that it is possible to see whether the theory is valid (Abd-El-Khalick et al., 2002).

There are various responds classified into naive (6 respondents), eclectic (1 respondent), and informed (2 respondents). The naive respondents only mentioned "Theory is only argument while law the truth has been proven." The eclectic respondents explain that "Scientific theory is an explanation about an aspect that is repeatedly tested and confirmed by using experiment. Scientific law, as I know, is more mathematical formulated such as Newton Law, Gravity Law". The informed respondents noted "Theory is as explanation about one phenomena while scientific law is a description about phenomena such as relativity theory, gravity law."

The sixth and seventh questions of VNOS-C instrument related the same aspects inference and theoretical entities. The sixth question concerns theoretical certainty proposed by scientists about atom structure. While the seventh question concern definition species as group of organism that have same characteristics then are possible to reproductive activity to produce new offspring.

The teacher various responds into sixth question can be classified into two group of responds: naive respond (6 respondents) and informed respond (2 respondents), the rest is 1 respondent who doesn't answer. The naive respondents explain that theory of atom structure mentioned in sixth question is still known but it doesn't explain specific evident about the way scientists determine atom structure. Here the difference between the two responds.

The naive respondents said:

"Nowdays the theory is most trusted and used"

The informed respondents said:

"Very believable. There is current evident of quantum mechanics can formulate periodic element that exist and used in chemistry until now."

The teacher various responds into seventh question can be classified into three group of responds: naive (3 respondents), eclectic (1 respondent) and informed (5 respondents). This showed that Biology Teachers have had right view into NOS concerning aspect inference and theoretical entities supported by questions related to biology about species. The informed responder's view about this aspect is as follow:

"It was very specific, both based on the study of molecular, physiology, metabolic and metabolomic. therefore a species can be found and classified in taxa."

The teacher's respond into aspect of subjective or theory-laden NOS asked in eight questions of VNOS-C instrument can be classified into two group: naive respond (6 respondents) and informed respond (2 respondents) the rest one respondent didn't answer this question. Most respondents don't understand why the two group of scientists who accessed and used the same data can produce different conclusion. According to Abd-El-Khalick et al. (2002) concerning this aspect is as follow:

"The two conclusion may be interpreted differently resulted from the same data. Different scientists may give their different explanation based on their background and education or based on their feel as inconsistent from others idea."

The ninth questions focus on Social and cultural embeddedness aspect of science, having two meanings, that is culture in society and culture into science itself (Yulita et al., 2019). Concerning this aspect of question respondents seem are not aware that science is influenced by social, politics, economy, and religious aspects as well. For the example evolution theory which is decline in France, but it is supported in Germany. This is elements of national, social, and culture of science. One of naive teacher's respond said:

"Science is universal because all people in the world should understand the same science."

The final aspect asked in VNOS-C instrument is creative and imaginative of NOS. Most respondent have no idea that scientists use creativity and imagination during investigation to produce explanation make sense about its data and possible others questions to answer. When asked do scientists use imagination and creativity in their research, they said:

"No, because they use scientific method based on scientific thinking."

Some aspects of nature of science are not known by senior high school Biology teachers. This can lead to misconception such as difference between theory and law. If there is no knowledge about definition of theory and law then it as assumed that they have hierarchical relationship where one is higher than another (Abd-El-Khalick et al., 2002).

This study also showed that teacher's scientific knowledge and attitude are still lack and need improvement through innovative continuing professional development program (Kartal et al., 2018). According to Husamah et al. (2016) science includes product, process, and attitudes which could not be separated each other. The process of

science teaching learning need educator to maximize student's potency and abilities.

Conclusion

VNOS-C instrument can be used to investigate teacher and students understanding about nature of science. Biology teacher's understanding of nature of science mostly still in the status of naive understanding compared to eclectic and informed understanding. This study imply the need of improvement concerning on teacher understanding about nature of science in order to better teaching in science classroom and better view about universe.

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