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Nature of science questionnaire for students, Indonesian version: factor analysis, reliability and validity

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Abstract. There are already many questionnaires on the nature of science that are used in general, but it is still very rare for Indonesian version. This study developed an Indonesian version of questionnaire on the nature of science for students. The questionnaire consists of 27 items with nine dimensions as result of literature study. The questionnaire was validated by 12 experts with improvements to several items. Questionnaire is reliable with 11 items are valid. Factor analysis shows that this questionnaire consists of ten dimensions that is not in accordance with the grid arranged. Excess dimensions of factor analysis occur because these dimensions are closely interrelated so that their indicators are difficult to differentiate. This tested questionnaire can be used to see the students' views on the nature of science. To compile the next questionnaire on the nature of science, we recommend that the dimensions be simplified; the dimensions that are closely related should be made into one.

1. Introduction

The declining interest of students to study science is the global trend that occurs almost all over the world. Research analysis showed that the interest decline in the fields of science and technology occurred almost throughout the world [1]. This decline has been in discussions since 2003 [2]. This decline even became a discussion at an OECD conference. Indonesia with a very large population also experienced the same thing. The interest for career in the science among Indonesian children is still low, with a ratio of 1: 7 and more female students, as concluded from the PISA survey released by the OECD in 2015 [3]

Many articles explain that one of the reasons for the decline in students' interest in science is the low level of scientific literacy, because nature of science is not understood by students at all levels. The nature of science is an important component in scientific literacy [4]. The low science literacy is due to the lack of understanding about the property of science and how to obtain science [5] or known as the nature of science according to Lederman [6]. The tentative property of science and the development of science as human activity, if understood by students, will make them interested in learning science [7]. If students know that the nature of theory and law in science, for example, is tentative or not fixed, students will be interested in pursuing science in the hope that they will form a new theory or law in the field of science. Science developed by human activities will also encourage students to pursue it in the hope of making a career in this field.



The nature of science (NOS) can be taught explicitly or implicitly, preferably starting from low grade level of elementary schools for example. Elementary school students can indeed learn the ideas of NOS [8]. Providing experience in science research based on the NOS for elementary school students can be a very good start in developing science literacy skills [9]. Students generally have a scientific identity and choose a field to pursue at the secondary school level and at the beginning of high school [10]. It would be very good if since elementary school students have understood the NOS correctly with the hope of influencing their choice in middle and high school

Teachers are the spearheads for instilling the nature of science to students at all grade levels. Teachers who understand correctly the nature of science will naturally be able to build an understanding for the nature of science in students. Preparing prospective teachers who have the ability to teach the nature of science is very important. Teacher candidates will be able to incorporate forms of NOS in the learning that they manage, when they themselves clearly understand the concept of NOS [11]. As a first step it is very important to recognize how the prospective teachers understand about the nature of science, for the basis to determine dimensions and ways to teach the nature of science to prospective teachers. It is very important to develop a questionnaire to gauge the views of prospective teachers about the nature of science.

2. Nature of Science Theoretical Framework

If we want to explore the definition for the nature of science, we will find various definitions. This happens as a result of the non-permanent nature of science. Definition and fixed boundaries for the nature of science must not exist or should be avoided [12]. The nature of science as epistemology of science, science as a way of knowing or the values and beliefs that exist in the development of scientific knowledge [6, 13] describes the nature of science as epistemological values and assumptions of science [7].

Researchers [6, 8, 13, 14] view science from its very nature as consisting of several dimensions. In general, the nature of science consists of seven themes which can be referred to as dimensions, namely tentative science, based on evidence (empirical) from observation or inference, subjective, involving creativity and imagination, influenced by the socio-cultural environment, in the form of scientific theories and laws and scientific methods [13, 15]. Through these aspects, it can be concluded that science always produces and depends on empirical evidence. The experimental method is not the only way to obtain scientific knowledge. Scientists use inductive reasoning and deductive hypothesis testing. Scientists will always conduct observations and draw conclusions. There is no single step scientific method in all scientific disciplines. Laws and theories related but they are different types of scientific knowledge. Science has a creative component. Observations, ideas, and conclusions in science are not entirely objective. The subjective (theory-laden) aspect of science sometimes plays a role both positively and negatively in scientific inquiry. Historical and sociocultural factors influence the practice and direction of science. Science and technology influence each other but they are not the same. Scientific knowledge is tentative but durable. Science and its methods cannot answer all questions; there are limits to the types of questions that might be proposed in scientific framework [13, 15].

In this study we define the nature of science as a characteristic or property of science and the way science is obtained. This definition is an assumption on the definition from [13, 15]. To make it easier to understand the nature of science's dimensions we use dimensions grouped by definition into two groups. Dimensions related to the property or characteristics of science and the way the science is obtained. The grouping is the characteristics of science (tentative, empirical, and subjective, in the form of theory and law, related to social and culture) and the way science is obtained (creativity, scientific methods, observation and interference). The NOS' dimensions were used to form indicators and statement items in order to measure the NOS understanding of students who are science teacher candidates from Javanese ethnic background.

3. Method

The nature of science questionnaire used was developed in part by adapting and translating the nature of science questionnaire which had generally been used in the world. This nature of science questionnaire consisted of 27 items on Likert scale, in the form of statements. This questionnaire could be said to be new even though there were parts that were adapted but in the Indonesian language that did not yet exist. The theoretical framework for the development of instruments to assess this nature of science was based on nine dimensions; eight general dimensions which were broken down into nine by researchers. The dimensions used were the general dimensions of scientific knowledge property as proposed by Lederman and others [6, 13, and 15]. Declarative statement items described certain nature of science dimensions. Respondents gave their personal level of belief or agreement with a five-point Likert scale [8], namely 1 = strongly disagree, 2 = disagree, 3 = unsure, 4 = agree, and 5 = strongly agree.

This nature of science instruments which had been compiled based on a literature study, and then was going through validity test for their contents by nine colleagues with master degree and two experts. Instruments then decide to be able to be used with several improvements, especially the arrangement of sentence for the statements.

This questionnaire was then given to 177 samples, students of mathematics and natural science in education and pure-science study programs at Semarang State University and Walisongo Semarang State Islamic University. Questionnaires were distributed in the form of a Google form that was accessed by respondents on the Google form' URL.

Data analysis was conducted using Cronbach alpha coefficients [16] on SPSS version 16.0 for Windows to determine the instruments reliability. To check whether items were arranged according to the theory, Confirmatory Factor Analysis (CFA) was conducted.

4. Results and Discussions

The 27 items compiled put through the CFA test are as in Table 1.

Table 1. Instrument Grids for NOS Indonesian Version

Dimension	Indicators	Statements (item no.)
Empirical	Observation for scientific knowledge claims	Scientific concepts and inventions can stimulate new questions and sometimes new problems. (1)
	Experimental data supports scientific claims, but do not prove it.	Science, because it is based on empirical evidence, is testable and deniable. (2) The requirement for evidence to support important scientific claims in science and in everyday life. (16)
	Record the condition of the phenomenon as it is without discussion related to theory or law	Science is mostly concerned with gathering facts about natural phenomena. (4) Science is a way to identify and collect facts to improve understanding about natural phenomena. (27)
Inference	Explanation of the causes of the phenomenon	Scientific explanations are based on empirical observations or experiments. (10)
	Concluding observations	Scientific explanation contents must be able to be proven. (20)
Tentative	Scientific knowledge can change with new data or re-evaluation of existing data.	After scientists have successfully developed a theory, the theory can be changed if new evidence is found and valid.(7)
		Scientific theories change with new ways of looking at old evidence. (9)
		Scientists always provide temporary answers to questions. (11) Something that has been extensively researched and "scientifically proven" can no longer change again. (18)

Dimension	Indicators	Statements (item no.)
Science theory and law		A scientific theory is not supported by as much scientific evidence as a law of science. (13) If a theory continues to be tested and proven to be valid, the theory will turn into a law. (23) Theories are laws that are immature or unproven. (24)
Subjectivity	Different interpretations of the same data	Different scientists may get different solutions from research investigations on the same problem. (3) Scientists work together in the formulation of new scientific knowledge and sometimes disagree with each other about their ideas and explanations. (15) Science is not truth or facts because truth or facts can mean different things to different people. (17) Scientists often try to prove their own ideas. (19) Bias occurs when scientists believe something will happen before they make an observation. (25)
Creativity	The imagination of a scientist about empirical data Ideas at each stage of scientific work	Human imagination cannot be involved in the creation of new scientific knowledge. (6) Scientists must use creativity and art in developing new theories about the natural world. (22)
Social and cultural	Subjectivity of groups who review science is limited.	Dissents between scientists are considered as weaknesses of science. (8) The acceptance of new scientific knowledge is very easy and there is little controversy. (20) Scientists work together in the formulation of new scientific knowledge and sometimes disagree with each other about their ideas and explanations. (25)
Scientific Method	Community influence on science	Scientific research can be influenced by race, gender, nationality, or the religion of the scientists. (14) Scientific solutions cannot be based solely on personal opinions, beliefs, or judgments. (5) Scientific knowledge has been developed through empirical based research and it is considered the best form of knowledge. (12) Scientific explanation contents must be able to be proven. (21) Science differs from other knowledge because science requires evidence, emphasizes the use of empirical standards, logical arguments, and doubts. (26)

The Bartlett test results showed KMO 0.747, alpha coefficient 0.70 or higher is ideal for research tools [17]. Bartlett's Test of Sphericity produced 1.007E3 with sig 0.00 showed that test factor analysis could proceed.

According to the initial analysis with SPSS 16.0 for windows there was no problematic item because all items had values above 0.3, appropriate according to field recommendations [18]. The communalities table showed that all items had values above 0.5 so that they could be used for further analysis and all items could explain the dimensions of the variables. There were ten factors that could represent dimensions because the eigenvalue was greater than 1, namely factors 1 to 10. The results in the component matrix table were used to see the loading factor with the distribution of items.

The analysis results showed that there are ten components or factors, while the grid compiled from the literature study resulted in only nine (empirical, observation, inference, tentative, theoretical and legal science, subjectivity, creativity, social culture, scientific method), so there was one excess factor. This happens because there were items that were not in accordance with the dimensional definition of the nature of science, due to the lack of accuracy in translating into Indonesian. The items were also scattered not in accordance with the grid that had been compiled or not in accordance with the theory, indeed the dimensions of the nature of science were interrelated [19]. The definition of the nature of

science, which - if translated - included two dimensions, namely the dimensions of the characteristics of science and the way in which science is obtained, made the items interrelated. Statement number 14 that said "Scientific research can be influenced by gender, nationality or religious faith" was in the tenth component and was an excess component or dimension so that this statement could be said to have no dimensions. The eighth dimension, social and culture, did not have a statement, because this dimension was very similar to the dimensions of subjectivity so it would be very difficult to distinguish. The accumulation of items in the dimension one was because empirical was indeed a requirement for many other dimensions such as observation, inference, scientific methods, theory and law so that it was difficult to distinguish. Correlations analysis carried out also shows that special and general concepts of the NOS are interrelated and exist in the same area [20].

4.1. Questionnaire Reliability and Validity

The test results with the value of Cronbach' Alpha 0.552, so it could be said that the instruments are reliable. Looking at the Pearson correlation value and compared them with r table, it was found that from 27 items there were 16 invalid items.

Questionnaires for measuring the nature of science that are widely used throughout the world when translated into different languages must be tested for reliability and validity because we will use the questionnaire in different socio-cultural conditions which of course will affect the test results

5. Conclusion

Questionnaire on the nature of science as an adaptation of the previously compiled questionnaires by this researcher is reliable and valid to use. Factor analysis shows nine of these dimensions are interrelated so they are quite difficult to distinguish.

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