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WORD COUNT 2900 TIME SUBMITTED 06-MAY-2020 12:06PM
PAPER ID 58355587

International Journal of Advanced Science and Technology
Vol. x, No. x, (2019), pp. xx-xx

Preservice Elementary Teachers' Nature of Science: Explicit, Implicit, or…?

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Abstract

Most of preservice elementary teachers' have misunderstood about aspects of nature of science (NoS). In fact, teachers' understanding of NOS have an impact on learning in the classroom teaching. Purposes of this research are: (1) to know their misunderstood of NoS aspects; and (2) to make an alternative practices that improved their NoS. This research used survey method design. Beliefs about nature of science questionnaire was used as research instrument. The questionnaire currently being developed to break the ground for future cross-sectional research on the nature of science. The questionnaire taps from aspects of nature of science as knowledge, process, attitude, and social dimension. The 56-item NoS questionnaire was administered to a sample of 223 (18% male and 82% female) preservice elementary teachers. The validity of the instrument (questionnaire) used a test construct validity with expert judgment reference and the empirical validity. Data analysis used descriptive with percentage. The main findings were as follows: (1) some aspects of NOS (hypothetico-deductive testing, durable, tentative,) are more misunderstood than others (science as product of imagination and creativity, natural phenomena, social and cultural embeddedness, scientific knowledge is open to revision with the latest evidence, science affects human social life, and scientific method). The misunderstood of NoS aspect can be reduced through explicit-reflective learning, NoS Paedagogical Content Knowledges (PCK), and inquiry and natures of science, technology, and engineering (INSTE) course..

Keywords: *Nature of Science; preservice elementary teachers'; explicit-reflective learning; NoS PCK; INSTE course*

1. Introduction

Nature of Science (NoS) is an understanding of science as knowledge, process, attitude, and social change [1,2]. NoS as knowledge is durable, not absolute or

ISSN: 2005-4238 IJAST

uncertain [3]. Besides, science knowledge is tentative because the subject of knowledge changes with the discovery of the latest facts or reconceptualization of the facts [3-5] or due to natural change (tentative nature) [6-7] .

Knowledge of science is based on a relation or link between the theory and the laws of science [4][8], but there are different kinds of knowledge with the roles within science [9-10] or in other words "distinct kinds of science knowledge" [8]. Then science knowledge has required the imagination and creativity [4][7][11] through observed phenomena and their interpretations [5][12-13].

Knowledge of science is objective as well as subjective or theory-laden [5][8][12] depending on the background of the study or field that practiced [8][13]. Nevertheless, science differs from technology and engineering techniques but influences each other's development [10]. Knowledge of science are empirically-based or based and /or generated from observations and drawing conclusions about natural phenomena [4][8-9][13], which supported the theory and law [6][11-12]. Knowledge of science is also reliable [14], or believed after through empirical testing to become a theory [2][11].

Science knowledge is influenced by assumptions and prior knowledge and theory-laden researchers [7][9], using an inductive approach and hypothetico-deductive testing [2][10]. Then knowledge of science is a subject of knowledge that undergoes a series of stages of change [15]. Therefore science is self-corrections and open to revised due to the development of the latest facts [10][15]. Besides, NOS is scientific knowledge tentativeness [2][7-8][12] and the uncertainty of evidence [16] as well as the process of generating knowledge, always subject to reexamination make knowledge science evolving [1].

Improved teachers' NOS understanding of knowledge and understanding have been practiced widely. The results of the study indicated both of students and teachers who received formal education in science have a naïve and inadequate view of NOS [17-19]. Teachers who teach science can not understand the clear idea of the nature of science [17]. Therefore, the purpose of the science education program is to enhance teachers' preservice view of the nature of science [7][20-23].

2. Methodology

Research methods have used survey method with cross-sectional survey design. The object of this research is the nature of science aspects misunderstood. Beliefs about nature of science questionnaire was used as research instrument. The questionnaire currently being developed by cross-sectional research on the nature of science. The questionnaire taps from aspects of nature of science as knowledge, process, attitude, and social dimension.

Instrument

The research instrument used a belief NoS questionnaire were developed by Chaerun et. al includes science as products (20 items), science as a process (18 items), science as an attitude (10 items) and science as a result of social dimensions (8)[24]. The coefficient validity of statements that are selected using the product moment with the criteria higher than 0.3 and the coefficient of reliability of the instrument using Cronbach Alpha higher than 0.6. Data obtained by questionnaires (questionnaires) with a Likert scale. Measurements are based on the scores obtained from questionnaires on the nature of Science (components of the nature of science: products, processes, social, and attitudes) of preservice elementary school teachers, observations and interviews.

Participants

The subjects of this study were students who took the Basic Concepts of Science course. There two hundred and twenty three students of pre-service elementary teachers' were participated in this study. One hudred and eighty two females and the rest were males. The educational background of the participants are science senior high school (17 males/ 80 females), non science (18 males / 73 females), science vocational school (4 males / 4 females), and non science (2 males / 16 females), and 9 females from religion school.

Data Analysis

Test the validity of the instrument (questionnaire) in this study using a test construct validity with expert judgment reference and the empirical validity. Empirical validity item were chosen by the product moment correlation rough numbers with criteria higher than 0.3. Thus, data analysis used descriptive analysis in comparing percentage of students who misunderstood about the nature of science based on previous education background.

3. Results and Discussion

NOS understanding of preservice elementary teachers' shown in Table 1. The results indicate that their NOS understanding still needs to improved. Most of them considered that science is a collection of facts and theories that do not change and humans are not able to change it.

Table 1. Preservice Elementary Teachers' Misunderstood about Nature of Science

Nature of Science Aspects	Misunderstood (%)	
	Science	Non Science
Science as a product	35.68	33.39
Science as process	44.38	51.38
Science as attitude	22.75	19.5
Social dimensions of science	20.7	11.25

Table 1 have shown preservice elementary teachers' misunderstood about NoS. Research result indicated that high school background did not influenced their view about NoS. Participant with non science background have fewer misunderstand about NoS as social dimension than other. But they were more misunderstood about science as process. In fact, teachers must have clear understanding of the nature of science and how to teach it [6].

Table 2. Preservice Elementary Teachers' Misunderstood about Science as Product

Science as a Product	Misunderstood (%)	
	Science	Non Science
Durable and tentative	58	53.75
Natural Science and Consistency	46.25	45.25
Natural phenomena	33.33	39
Science as product of imagination and creativity	28.5	8
Objectivity	17	23.33
Technology as part of Science	31	31

The profile of preservice elementary teachers' misunderstood about science as a product shown in Table 2. The results showed the school background did not affect their

view of the nature of science as a product (technology as part of science, natural phenomena, natural science and consistency, durable and tentative), except the aspect of science as product of imagination and creativity. Participant with non science background have fewer misunderstand three time about it than other.

Table 3. Preservice Elementary Teachers' Misunderstood about Science as Process

Science as a Process	Misunderstood (%)	
	Science	Non Science
Empirically-based	45	41
Way of knowing	26.5	24.5
Hypothetico-deductive testing	76	98
Scientific approach	30	42

The profile of preservice elementary teachers' misunderstood about science as a process shown in Table 3. This table indicates that a lot of them, especially that non science background, have misunderstood about hypothetico-deductive testing. Participants have views if the research result is contradictive or reject their hypothesis, they should change it. They also have misunderstood about scientific approach higher than have science background.

Table 4. Preservice Elementary Teachers' Misunderstood about Science as Attitude

Science as an Attitude	Misunderstood (%)	
	Science	Non Science
Skepticism	19.5	17.5
Way of knowing	26	21.5

The profile of preservice elementary teachers' misunderstood about science as a attitude shown in Table 4. This table indicates have no effect of high school background on their misunderstood about skepticism and open to new ideas. There one fifth of participants have views that scientists never changes they opinion about the universe, especially from student with science background. There also have opinion that scientists has satisfied with they found, but they believe in outstanding issues easily.

Table 5. Preservice Elementary Teachers' Misunderstood about Science as Social Dimension

Science as Social Dimension	Misunderstood (%)	
	Science	Non Science
Scientific knowledge is open to revision with the latest evidence	9.90	9
Way of knowing	11.5	13.5

The profile of preservice elementary teachers' misunderstood about social dimension of science shown in Table 5. This table indicates that little participant have misunderstood about NoS as social dimension. Some of them, especially with science background, have views that science could not change along with the latest findings about the concept and recent science result could not used to revise or complement the previous concept.

Preservice teachers with non science background have misunderstood on some NoS aspects higher than other [24]. This is inline with BouJaoude & Abdel-Khalick statement that teachers only teach science as a product of knowledge regardless of the nature of science aspects of the other [25]. Similarly, BouJaoude found that most teachers and students have a traditional view of the NOS because it comes from an emphasis on

science and ignore the content of epistemology and sociology of science in its curriculum [26].

Most of Turkish students surveyed by Sormunen & Koksal have shown misunderstood about the empirical basis of science, observation and inference, subjectivity of scientists, social and cultural embeddedness, creativity in science, theories and laws and tentativeness [27]. Research involved 50 preservice teachers' who received 6 hours training of NOS showed no change misconception. Thus, Beck-Winchatz & Parra concluded that cognitive conflict can be used to reduce misunderstood [28].

The dissenting opinion expressed by Akerson & Volrich which showed that the ability of teachers who have not received training on the nature of science, then get the opportunity to intern and teach the NOS is guided, was not only successful in understanding the conceptualization of the NOS for himself, but he was also able to teach the ideas of science to elementary students where he served [29]. McDonald found that learning the NOS through scientific argumentation proved to be effective to improve the understanding of NOS concepts elementary school teacher. Good scientific arguments emphasize the role of the NOS in science teaching load [30].

The results of Chaerun et al. study indicated that teachers who only teach science as a product, by ignoring the three other aspects, cause students to only memorize concepts without seeing the contextuality of concepts received with real life [24]. Based on the results of the questionnaire data analysis, supported by observations and interviews, it was concluded that the teacher had not yet applied science learning based on the full nature of science. Some teachers with a background in science education understand the nature of science as an attitude and process, but in learning they only follow the demands of the curriculum.

Matkins & Bell develop learning about the science of global warming and Howe in the matter of the nature of science-based medicine [31-32]. They found that the contextualization of the nature of science through phenomena that occur at this time and is controversial, it is effective in helping to improve preservice teachers' conceptions of understanding the NOS and develop awareness about their socio-scientific issues.

Learning of NOS can be done implicitly or explicitly. Abd-El-Khalick & Lederman and Haukoos & Penick stated that NOS learning is done implicitly, in consideration of NOS is the result of learners' engagement when students conduct scientific learning (science-based activities) [17][33]. However, some studies show that the essence of science that is taught explicitly more effectively to develop the concept of NOS [17][34-35].

The study of NOS must be done explicitly because the essence of science is the framework of the concept of science that includes historical, philosophical and sociological. However, explicit learning has limitations because it does not contextual [31]. Besides, Seung et al. argued that the essence of science learning is done explicitly and contextual that prospective teachers can integrate the understanding of NOS by teaching science [35].

Bell et al. suggested that combining explicit and implicit learning of NOS provides promising results[36]. NOS understanding of 70 high school teachers in the US increased significantly and substantially after attending a two-semester science teacher training. Besides, four science teachers for the education of children with special needs have increased understanding of the nature of his science and be able to use both approaches in improving students' understanding of the nature of their [37].

Teachers should enhanced understanding of the nature of their science through training and education [17][38]. Training of NOS proves effectively to helping teachers develop an informed concept of NOS [38]. It can become deep understanding in their memories and be applied in the learning process. Through learning strategy essence of science is right proven to improve the understanding of the nature of science pre-service

primary school teachers [6][39-40], and it able to apply that understanding in their learning process later [6][41].

Through explicit-reflective learning the NOS proved to increase understanding of the nature of teacher science and reduce their misunderstood [42]. It improved of their NOS understanding significantly occurs in some aspects, such as empirically science, theory-laden, creative-imaginative and social-cultural embeddedness. However, these changes not significantly in the tentative aspects of science and the relationship between law and scientific theory. The nature of science that informed will improve students understand that science is not just a collection of facts, principles and laws that must be memorized [44-46]. The element of the nature of science relevant to science education is science is tentative, empirical, theory-laden, imaginative and creative, influenced by socio-cultural values. The modern science curriculum also contains the relationships and functions of the theory and law of science, the difference between observation and inference, the use of scientific methods in building knowledge.

Kruse et al. developed Course on Nature of Science Pedagogical Views and Rationales [47]. The course namely Inquiry and Natures of Science, Technology, and Engineering (INSTE). The three-credit science methods courses, both elementary and secondary, introduced NOS concepts as an introduction to effective science teaching during the first 3–4 weeks of the course.

According to Bartholomew et al. is important for teachers to develop knowledge about NoS and scientific processes before they can effectively teach science in the classroom[49]. Abd-El-Khalick & Lederman stated that teachers must have what is called 'NOS PCK' [17]. To be able to teach the nature of science, teachers not only need to have a proper understanding of the nature of science but also need to have Pedagogical Content Knowledge. In addition, Schwartz & Lederman highlights the importance of strong linkages between the subject-matter knowledge, the nature of science, and pedagogical knowledge for teachers to succeed perform teaching and learning of NOS in the classroom [48].

Gerber et al. stated the fundamental purpose of learning science is to improve the scientific literacy of students, helping them develop an understanding of the concepts and transfer them to new situations when solving a problem [49]. Cil and Çepni defines one of the objectives of science education as helping students to develop their awareness of the NoS[50]. The depth of understanding of the NoS and knowledge about the subject content knowledge is practically considered important in guiding the instructional practice them[48][51-52]. This teacher in the classroom to support students in determining the future (including aspiration) them.

3. Conclusion

Understanding the nature of science affects the way of view of science and how to teach it. Pre-service elementary teachers need to be equipped with such understanding to not just understand the concept to be taught. Climate and learning environment should be facilitated to support the development of that understanding. Choosing a learning approach such as cognitive conflict can be used to reduce misunderstood the nature of science and also will determine the success of preservice elementary teachers' in understanding the concept of science

References

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