JPII 8 (1) (2019) 32-38

Jurnal Pendidikan IPA Indonesia

http://journal.unnes.ac.id/index.php/jpii

INVESTIGATING THE NATURE OF SCIENCE: AN EMPIRICAL REPORT ON THE TEACHER DEVELOPMENT PROGRAM IN THAILAND

V. Prachagool[1] and P. Nuangchalerm*[2]

[1,2]Faculty of Education, Mahasarakham University, Thailand

DOI: 10.15294/jpii.v8i1.17275

Accepted: November 29th, 2018. Approved: March 25th, 2019. Published: March 28th, 2019

ABSTRACT

Nature of Science (NOS) is a basic of understandings on how science concerns human lives and social development. If the nature of science is lost in science education and its implementation, the concept of science learning is failed in science education philosophy. Pre-service teachers are the initial vital factors to introduce and implement NOS for their future students. This study investigates understandings of nature of the science of pre-service science teachers from bachelor study in science education program. Participants were 121 preservice science teachers who enrolled in the second semester in the academic year 2017 from a university in the northeast of Thailand. Questionnaires via Google Forms were used for data collection. Descriptive statistics and qualitative data were provided. Data were analyzed and grouped by level of understandings of NOS. A correlation was also studied for testing different beliefs. The findings indicated that NOS needs to be embedded in the curriculum and instruction to achieve the goal of science education. Further discussion and exploration are required for the enhancement of NOS through the teacher preparation program.

Keywords: nature of science, teacher development, teacher preparation, understanding

INTRODUCTION

Science concerns our lives in such ways of working and living; also, plays an essential role in our society based on reliable knowledge and productive procedures. Even though, knowledge in the modern world moved with innovative technology and modern facilities. The primary and advance knowledge are decided to use science for proofing. The heart of science is not only methods but also driven by the nature of science to all. It helps students learn to think and do scientists work in their honor project. Scientific knowledge is constructed and emerged by various kinds of methods and explanations (Dagher & Erduran, 2016). The process of science in emerging scientific knowledge has generated us to have productive elements, influence on technological and social movements (Kind, 2016). The way of science learning, technology, and social development can be distributed by education. However, scientists are a member of society and work for social progress in a variety of explorations (Taber, 2017). They have to hold the nature of science (NOS) as a key to be scientists. The nature of science is not a newly introduced concept that embeds the way of thinking for being good or excellent science students, educator, or scientist.

Science is necessary for curriculum and instructional practices as it considers methods and process of knowing and explaining natural

***Correspondence Address**
E-mail: prasart.n@msu.ac.th

phenomena. Observations in science employ empirical knowledge in nature, make inferences and interpret artifacts. It is characterized by its reliable explanatory and predictive powers which scientists used it systematically. The views and process of science through standard practicing is a part of society which makes a product of knowledge as well as technology. The product of science will be influenced by societal and cultural beliefs and also will reflect on social values as well as viewpoints to positive science. An inquiry is a significant tool for scientists to produce scientific knowledge. It is also a crucial tool for the science classroom because it makes students learn science through reliable methods and process of science (Fitriani et al., 2016; Parmin et al., 2016). Moreover, it leads students to have knowledge and understanding in science upon a requirement of personal decision making, participation in cultures, and scientific attitudes (Widowati et al., 2017). They can predict, observe, describe, explain, discuss natural phenomena, and evaluate the quality of information by its source. These skills are beneficial to generate knowledge to enhance suitable attributes in all sectors of the community and social responsibility (Chowdhury, 2018).

As we know, science is an essential subject and a process of working in modern life. Science teaching needs to comprehend how science thinks and works in our society (Widowati et al., 2017). Science not only demands answers but also questions and process in correcting items. The aims of science education help students understand the nature of science and are essential for all citizens to know. Furthermore, McComas & Olson (1998) explained science as an attempt to explore and explain the natural phenomena surrounding students. Scientific knowledge has a tentative character as it tends to be changed if there are new pieces of evidence. Scientific knowledge relies heavily upon, but not entirely, observation, experimental evidence, rational arguments, and skepticism. Science is flexible yet cannot be generalized as each science learning encounters different issues emerging from the surroundings.

The scientific community and school science accept NOS to grow the scientific mindset (Nuangchalerm, 2010). Other than that, NOS helps future science teachers understand about what science should be and communicate science to their future students (Sinatra & Hofer, 2016). Teacher preparation program is one of the ways to improve pre-service science teachers' understanding of NOS. The program needs to help pre-service teachers retain appropriate conceptions of nature of science, increase their confidence and improve their abilities to effectively deliver science instruction to their school practicum and future by taking into account the teaching skills (Bell et al., 2016; Özer et al., 2019; Demirdöğen, 2016; Ertmer & Ottenbreit-Leftwich, 2010; Rofe et al., 2016). The program is not only focused on content knowledge but also pedagogical decisions. Moreover, the reinforcement of their understanding of the nature of science during the program could reveal what they should know and practice as both educators and scientists (Fakhriyah et al., 2017; Saefullah et al., 2017; Setiawan et al., 2017; Hanuscin, 2013; Nuangchalerm & El Islami, 2018).

This study investigated the pre-service science teachers' understanding of NOS. Three years of research explained how they perceive the nature of science before school practicum. It also referred to further curriculum and instructional practices which they used in the science classroom. The findings are discussed to promote NOS in their beliefs and instructional practices.

METHODS

This study investigated pre-service teachers' understandings of NOS in science education program. Reliable procedures and methods for this research are provided here.

There were 121 bachelor education in general science program, in the even semester of 2017 (January to April), Faculty of Education, from a university in the Northern Region of Thailand. The purposive selection was employed for picking the participants. They should achieve a grade average higher than 3.00 as the recommendation of the Teacher Council of Thailand to be good teachers in the future school. The general demographics of the participants are shown in Table 1.

Table 1. General Demographic of Participants

Variables		Year 1 (n=32)	Year 2 (n=43)	Year 3 (n=46)	Total (n=121)
Sex	M	5 (15.62%)	11 (25.58%)	8 (17.39%)	24 (19.83%)
	F	27 (84.38%)	32 (74.42%)	38 (82.61%)	97 (80.17%)

The participants provided their understandings of NOS throughout the questionnaires. The data sources included a different year of study, but the questionnaires consisted of the same items and purposes. The questionnaires adopted the Likert 4 scaling (Highly agree (HA), Agree (A), Disagree (DA), and Highly disagree (HDA)) with an open-ended question used as the research tools. There were 25 questions relevant to the understanding of NOS. The items were adapted from various research studies focusing on the definitions of well-known science educators and related organizations, i.e., Bartos & Lederman (2014), Erduran & Dagher (2014), Demirdöğen et al. (2016), Allchin (2013), and Akerson et al. (2019). The questionnaires were provided in Google Forms for convenience implication (Bhalerao, 2015). Pre-service teachers in different years of study were asked to reflect upon their perception and understandings. The participants' responses to the questionnaires were studied in their understandings of NOS. The responses were placed into the percentage of Highly agree (HA), Agree (A), Disagree (DA), and Highly disagree (HDA) in each item. The data were analyzed and grouped by level of NOS understandings. The correlation was also studied for testing the different perceptions.

RESULTS AND DISCUSSION

The participants showed their understandings of NOS in various perceptions which are presented in Table 2.

Table 2. NOS of Preservice Teachers

	Item	Highly Agree	Agree	Disagree	Highly Disagree
1	Science can describe concrete knowledge, natural phenomena, and natural surroundings	44 (37.93%)	64 (55.17%)	6 (5.17%)	2 (1.72%)
2	Natural phenomena often show the same pattern, and it is understandable	9 (7.83%)	76 (66.09%)	23 (20.00%)	7 (6.09%)
3	Scientific knowledge can be changed if additional evidence can explain much more than the prior knowledge	77 (70.00%)	33 (30.00%)	0 (0.00%)	0 (0.00%)
4	We remember scientific law because it is accurate and has been proven many times	13 (11.11%)	44 (37.61%)	43 (36.75%)	17 (14.53%)
5	We use the process of science for making consideration of which picture in the gallery is the best	3 (2.54%)	14 (11.86%)	56 (47.46%)	45 (38.14%)
6	There are some phenomena which cannot be investigated by scientific methods	51 (46.79%)	55 (50.46%)	3 (2.75%)	0 (0.00%)
7	Scientists try to explain and predict phenomena accurately even though what they all explain is undescribable	17 (15.04%)	75 (66.37%)	19 (16.81%)	2 (1.77%)
8	Scientists use their knowledge to describe and predict phenomena based on evidence	43 (38.74%)	68 (61.26%)	0 (0.00%)	0 (0.00%)
9	Scientific knowledge will be reliable when evidence is enough	61 (52.14%)	47 (40.17%)	9 (7.69%)	0 (0.00%)
10	Scientists deny imagination and creative thinking to explore new knowledge	0 (0.00%)	8 (6.78%)	63 (53.39%)	47 (39.83%)
11	Scientists employ only creative thinking for designing innovations and inventions	5 (4.31%)	32 (27.59%)	74 (63.79%)	5 (4.31%)
12	Science cannot explain the world and all about the world, but it can predict what will happen with the world	28 (25.23%)	74 (66.67%)	5 (4.50%)	4 (3.60%)

13	Scientists will repeat their experiments to reduce some mistakes	86 (74.14%)	28 (24.14%)	2 (1.72%)	0 (0.00%)
14	Scientists aware and ignore bias that will appear in the process of interpretation	82 (73.87%)	28 (25.23%)	0 (0.00%)	1 (0.90%)
15	Personal opinions emerge from the diversity of demographic, sex, beliefs, or previous experiences which do not influence scientific works	31 (26.50%)	48 (41.03%)	36 (30.77%)	2 (1.71%)
16	Scientists explore their knowledge through the same methods and explicit procedures	6 (5.08%)	61 (51.69%)	45 (38.14%)	6 (5.08%)
17	Scientific knowledge comes from experiments only	2 (1.72%)	30 (25.86%)	70 (60.34%)	14 (12.07%)
18	Scientific knowledge or explorations are products of scientists, and the needs of society and community culture are not related	1 (0.85%)	0 (0.00%)	75 (64.10%)	41 (35.04%)
19	Scientists work lonely under setting laboratory	4 (3.51%)	14 (12.28%)	78 (68.42%)	18 (15.79%)
20	Scientists are social partners, on behalf of experts who understand and criticize phenomena even though no more shows opinions and feelings	9 (7.63%)	30 (25.42%)	66 (55.93%)	13 (11.02%)
21	Scientists must publish what they explore to public society	56 (49.56%)	54 (47.79%)	3 (2.65%)	0 (0.00%)
22	Scientists research by taking responsibility for benefits than those moral and ethics	3 (2.52%)	26 (21.85%)	60 (50.42%)	30 (25.21%)
23	Science and technology are the same things	15 (12.71%)	86 (72.88%)	15 (12.71%)	2 (1.69%)
24	Science and technology influence society movements and society influence the development of science and technology	69 (58.47%)	49 (41.53%)	0 (0.00%)	0 (0.00%)
25	Scientists work in their laboratory even though social needs do not influence the scientists	2 (1.68%)	16 (13.45%)	78 (65.55%)	23 (19.33%)
	Total (%)	25.20	36.93	28.36	9.51

They highly agreed (HA) with item which truly shows their understandings of NOS such as (a) scientific knowledge can be changed, if additional evidence can explain much more than that prior knowledge; (b) scientific knowledge is reliable when evidence is enough; (c) scientists will repeat their experiments to reduce some mistakes; (d) scientists aware and ignore bias appear in the process of interpretation; (e) scientists must publish what they explore to public society; (f) Science and technology influence society movements, and society influences the development of science and technology.

They agreed (A) with item indicating their understandings of NOS, they are: (a) we use the process of science for making a consideration of which picture in the gallery is the best; (b) science can describe concrete knowledge, natural phenomena, and other surroundings; (c) natural phenomena often show understandable, the same pattern; (d) there are some phenomena which we cannot be investigated by scientific methods; (e) scientists try to explain and predict phenomena accurately even though what they all explain is indescribable; (f) scientists use their knowledge to describe and predict phenomena based on evidence; (g) science cannot explain the world and all about the world, but it can predict what will happen with the world; (h) personal opinions emerged from diversity of demographic, sex, beliefs, or previous experiences which do not influence scientific works; (i) scientists explore their knowledge through the same methods and explicit procedures; and (j) science and technology are the same things.

They disagreed (DA) with item which does not reflect their understandings of NOS such as (a) we use process of science for making a consi-

deration of which picture in gallery is the best; (b) scientists deny imagination and creative thinking to explore new knowledge; (c) scientists employed only creative thinking for designing innovations and inventions; (d) scientific knowledge comes from experiments only; (e) scientific knowledge or explorations are products of scientists; (f) the needs of society and community culture are not related; (g) scientist works in lonely under setting laboratory if many scientists may be difficult to conclude; (h) scientists are social partners, on behalf of expertise who understand and criticize on phenomena even though no more shows opinions and feelings; (i) scientists do research by taking responsibility to benefits than those moral and ethics; (j) scientists work in their laboratory even though social needs do not influence scientists. Moreover, they highly disagreed (HDA) over 30% to item that totally unrelated to their understandings of NOS, they are (a) scientists deny imagination and creative thinking to explore new knowledge; and (b) scientific knowledge or explorations are products of scientists, needs of society and community culture are not related.

To the extent, the researchers employed the Pearson correlation testing to find out the relationship between HA, A, DA, and HDA. The results revealed that agreements correlated in positive and negative as shown in Table 3.

Table 3. The Correlation of Agreements Degree in NOS Understanding

	HA	A	DA	HDA
HA	-	.204	.834**	-.647**
A	.204	-	-.657**	-.707**
DA	.834**	-.657**	-	.716**
HDA	-.647**	-.707**	.716**	-

** statistical significance at .01 level

Table 3 showes that the degree of agreements of pre-service teachers in understandings NOS had a positive correlation between highly agree (HA) and disagree (DA); disagree (DA) and highly disagree (HDA) at .01 level of statistical significance. Despite the correlated information, a negative correlation was found between highly agree (HA) and highly disagree (HDA); agree (A) and disagree (DA); agree (A) and highly disagree (HDA). The findings indicated that the degree of agreements is very interested in the confusion or misunderstandings of NOS. The pre-service teachers' understanding of NOS seems to be varied.

Pre-service teachers showed their understandings of NOS in the way they perceived. They argued that NOS is the combination of worldview, the process of knowledge construction whose product and process influence social values. Moreover, they comprehended that NOS refers to the epistemology and sociology of science, science as a way of knowing, values and beliefs inherent to scientific knowledge through the process of knowledge development (Sinatra & Hofer, 2016). The participants comprehended that science could describe concrete knowledge, natural phenomena, and other surroundings. In other words, it pointed that they have had positive attitudes towards science and more specifically, their knowledge of science teaching and learning (Erduran & Dagher, 2014; Bell et al., 2016; Abd-El-Khalick & Akerson, 2009). Moreover, they mostly agreed on the aspect required during the process of science beneficial for science classrooms. Furthermore, they disagreed (DA) that the needs of society and community culture are not related. It may result from the global cooperation in the new era which no one denies community or process and product of sciences.

The ways to promote understandings of NOS should specifically focus on the NOS content which allows pre-service science teachers to participate in hands-on NOS activities, prepare an introductory NOS readings, employ multiple forms of reflection, expose the NOS content, use the presentation of NOS content, practice in evaluating the NOS data, analyse science standards in terms of NOS content, and enhance NOS instructional experiences (Adibelli-Sahin & Deniz, 2017). Accordingly, the understanding of NOS in the teacher preparation program must invite questioning, thinking, discussing, and reflecting by various methods of instruction. Herman et al. (2017) found that several factors were associated with the extent to the implementation of NOS instruction and that teachers need to use multiple forms of instruction since scientific knowledge is subjective and dynamic (Cansiz et al., 2017). Besides, Jain et al. (2018), on their review of general understanding of NOS, indicated that pre-service teachers who have never undergone explicit learning of NOS had a naïve understanding. We cannot reject science as a dynamic knowledge. However, if science teachers concentrate on more subjects, the NOS will be low implemented. Now, technological pedagogical content and knowledge or TPACK are necessary for pre-service teachers since it prepares them to bridge the gap between subject matters, pedagogy, and technology to their students.

CONCLUSION

In conclusion, the pre-service teachers had indicated their understandings of NOS to meet the goal of science education in Thailand. Most of them have agreed on the right statements about NOS yet further reinforcement is in the air particularly to integrate the NOS in curriculum and instructional practices.

REFERENCES

Abd-El-Khalick, F., & Akerson, V. (2009). The Influence of Metacognitive Training on Pre-service Elementary Teachers' Conceptions of Nature of Science. *International Journal of Science Education*, *31*(16), 2161-2184.

Adibelli-Sahin, E., & Deniz, H. (2017). Elementary Teachers' Perceptions about the Effective Features of Explicit-Reflective Nature of Science Instruction. *International Journal of Science Education*, *39*(6), 761-790.

Akerson, V. L., Elcan Kaynak, N., & Avsar Erumit, B. (2019). Development of Third Graders' Identities as'' Persons Who Understand Nature of Science'' through a Gravity Unit. *International Journal of Research in Education and Science*, *5*(2), 450-456.

Allchin, D. (2013). Teaching the Nature of Science. *Perspectives and Resources. St. Paul, MN: SHiPS Education Press*.

Bartos, S. A., & Lederman, N. G. (2014). Teachers' Knowledge Structures for Nature of Science and Scientific Inquiry: Conceptions and Classroom Practice. *Journal of Research in Science Teaching*, *51*(9), 1150-1184.

Bell, R. L., Mulvey, B. K., & Maeng, J. L. (2016). Outcomes of Nature of Science Instruction along a Context Continuum: Pre-service Secondary Science Teachers' Conceptions and Instructional Intentions. *International Journal of Science Education*, *38*(3), 493-520.

Bhalerao, A. K. (2015). Application and Performance of Google Forms for Online Data Collection and Analysis: A Case of North Eastern Region of India. *Indian Journal of Extension Education*, *51*(3and4), 49-53.

Cansiz, M., Cansiz, N., Tas, Y., & Yerdelen, S. (2017). Turkish Version of Students' Ideas about Nature of Science Questionnaire: A Validation Study. *International Journal of Progressive Education*, *13*(1), 42-51.

Chowdhury, M. (2018). Emphasizing Morals, Values, Ethics, and Character Education in Science Education and Science Teaching. *MOJES: Malaysian Online Journal of Educational Sciences*, *4*(2), 1-16.

Dagher, Z. R., & Erduran, S. (2016). Reconceptualizing the Nature of Science for Science Education. *Science & Education*, *25*(1-2), 147-164.

Demirdöğen, B. (2016). Interaction between Science Teaching Orientation and Pedagogical Content Knowledge Components. *Journal of Science Teacher Education*, *27*(5), 495-532.

Demirdöğen, B., Hanuscin, D. L., Uzuntiryaki-Kondakci, E., & Köseoğlu, F. (2016). Development and Nature of Pre-service Chemistry Teachers' Pedagogical Content Knowledge for Nature of Science. *Research in Science Education*, *46*(4), 575-612.

Erduran, S., & Dagher, Z. R. (2014). Reconceptualizing Nature of Science for Science Education. In *Reconceptualizing the Nature of Science for Science Education* (pp. 1-18). Springer, Dordrecht.

Ertmer, P. A., & Ottenbreit-Leftwich, A. T. (2010). Teacher Technology Change: How Knowledge, Confidence, Beliefs, and Culture Intersect. *Journal of research on Technology in Education*, *42*(3), 255-284.

Fakhriyah, F., Masfuah, S., Roysa, M., Rusilowati, A., & Rahayu, E. S. (2017). Student's Science Literacy in the Aspect of Content Science?. *Jurnal Pendidikan IPA Indonesia*, *6*(1), 81-87.

Fitriani, N. R., Widiyatmoko, A., & Khusniati, M. (2016). The Effectiveness of CTL Model Guided Inquiri-based in the Topic of Chemicals in Daily Life to Improve Students' Learning Outcomes and Activeness. *Jurnal Pendidikan IPA Indonesia*, *5*(2), 278-283.

Hanuscin, D. L. (2013). Critical Incidents in the Development of Pedagogical Content Knowledge For Teaching the Nature of Science: A Prospective Elementary Teacher's Journey. *Journal of Science Teacher Education*, *24*(6), 933-956.

Herman, B. C., Clough, M. P., & Olson, J. K. (2017). Pedagogical Reflections by Secondary Science Teachers at Different NOS Implementation Levels. *Research in Science Education*, *47*(1), 161-184.

Jain, J., Abdullah, N., & Lim, B. K. (2018). The Tentativeness of Scientific Theories: Conceptions of Pre-Service Science Teachers. *MOJES: Malaysian Online Journal of Educational Sciences*, *2*(2), 37-44.

Kind, V. (2016). Pre-service Science Teachers' Science Teaching Orientations and Beliefs about Science. *Science Education*, *100*(1), 122-152.

McComas, W. F., & Olson, J. K. (1998). The Nature of Science in International Science Education Standards Documents. In *The Nature of Science in Science Education* (pp. 41-52). Springer, Dordrecht.

Nuangchalerm, P. (2010). Engaging Students to Perceive Nature of Science through Socioscientific Issues-Based Instruction. *European Journal of Social Sciences*, *13*(1), 34-37.

Nuangchalerm, P., & El Islami, R. A. Z. (2018). Comparative Study between Thai and Indonesian Novice Science Teacher Students in Content of Science. *Journal for the Education of Gifted Young*

Scientists, *6*(2), 23-29.

Özer, F., Doğan, N., Yalaki, Y., Irez, S., & Çakmakci, G. (2019). The Ultimate Beneficiaries of Continuing Professional Development Programs: Middle School Students' Nature of Science Views. *Research in Science Education*, 1-26.

Parmin, Sajidan, Ashadi, Sutikno, Maretta, Y. (2016). Preparing Prospective Teachers in Integrating Science and Local Wisdom through Practicing Open Inquiry. *Journal of Turkish Science Education (TUSED)*, *13*(2), 3-14.

Rofe, C., Moeed, A., Anderson, D., & Bartholomew, R. (2016). Science in an Indigenous School: Insight into Teacher Beliefs about Science Inquiry and Their Development as Science Teachers. *The Australian Journal of Indigenous Education*, *45*(1), 91-99.

Saefullah, A., Samanhudi, U., Nulhakim, L., Berlian, L., Rakhmawan, A., Rohimah, B., & El Islami, R. A. Z. (2017). Efforts to Improve Scientific Literacy of Students through Guided Inquiry Learning Based on Local Wisdom of Baduy's Society. *Jurnal Penelitian dan Pembelajaran IPA*, *3*(2), 84-91.

Setiawan, B., Innatesari, D. K., Sabtiawan, W. B., & Sudarmin, S. (2017). The Development of Local Wisdom-Based Natural Science Module to Improve Science Literation of Students. *Jurnal Pendidikan IPA Indonesia*, *6*(1), 49-54.

Sinatra, G. M., & Hofer, B. K. (2016). Public Understanding of Science: Policy and Educational Implications. *Policy Insights from the Behavioral and Brain Sciences*, *3*(2), 245-253.

Taber, K. S. (2017). Knowledge, Beliefs And Pedagogy: How the Nature of Science Should Inform the Aims of Science Education (And Not Just When Teaching Evolution). *Cultural Studies of Science Education*, *12*(1), 81-91.

Widowati, A., Nurohman, S., & Anjarsari, P. (2017). Developing Science Learning Material with Authentic Inquiry Learning Approach to Improve Problem Solving and Scientific Attitude. *Jurnal Pendidikan IPA Indonesia*, *6*(1), 32-40.