Investigating the Nature of Science: An Empirical Report on the Teacher Development Program in Thailand

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ABSTRACT

Nature of Science (NOS) is a basic of understandings how science concerns human lives and social development. If nature of science is loss in the science education and its implementation, the concept of science learning is failed in science education philosophy. Preservice teachers are initial key factors to introduce and implement NOS for those students. This study investigates understandings of nature of science of preservice science teachers from bachelor study in science education program. Participants are 121 preservice science teachers who enrolled in the second semester in academic year 2017 from a university in 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. Correlation was also studied for testing different understandings. The findings indicated their understandings to meet the goal of science education, understandings need to embed NOS in curriculum and instruction. Some understandings of participants seem to be not understandable. It needs more discussion and explorations for future enhancement of understandings of NOS through teacher preparation program.

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

INTRODUCTION

Science concerns our lives in such the ways of working and living, plays its important role in our society based on the reliable knowledge and productive procedures. Even though, knowledge in the modern world moved with innovative technology and modern facilities. The basic and advance knowledge are decided to use science for proofing. The heart of science is not only methods, but also drives by nature of science to all. It helps students learn to think and do like scientists work in their honor project. Scientific knowledge is constructed and emerged by various kinds of methods and explanations (Dagher & Erduran, 2016). The explorations in the dimension of scientists think and do can be testable and confidentially approved. Due to process of science produce scientific knowledge, make us to have productive elements, and influence to technological and social movements (kind, 2016). The way of learning science, technology, and social development can be distributed by education. However, scientists are member of society and work for social progress in variety of explorations (Taber, 2017). They have to hold nature of science (NOS) as a key to be scientists. According to nature of science is not new to society, but it embedded to way of thinking and doing for answering how to be good or great. That is, long recommendation to make teachers and students to have instructional approaches through nature of science and promote inquiring minds to science classroom.

Science is necessary for curriculum and instructional practices, it considered methods and process of knowing and explaining the natural phenomena. Empirical knowledge in nature is employed by observations in science, make inferences and explain artifacts. It is characterized by its reliable explanatory and predictive powers which scientists used it in systematically. The views and process of science through standard practicing, is a part of society and make product of knowledge as well as technology. The product of science will be influenced by societal and cultural beliefs and also will reflect to social values as well as viewpoints to positive science. Inquiry is a significant tool for scientists to produce scientific knowledge, it is also crucial tools for science classroom because it makes students learn science through reliable methods and process of science (Fritiani *et.al.,* 2016; Parmin *et.al.*, 2016). It leads student to have knowledge and understanding in science upon requirement of personal decision making, participation in cultures, and scientific attitudes (Widowati *et.al.*, 2017). They can predict, observe, describe, explain, and discuss about natural phenomena, be able to evaluate the quality of information on the basis of its source. The methods used to generate knowledge to enhance suitable attributes at all sectors of community and social responsibility (Chowdhury, 2018).

As we known, science is important subject and process of working in the modern life. Science teaching needs to implement of how science think and do in our society (Widowati *et.al.*, 2017). The answer of science no need only answer, but question and process to correct question is also required. The aims of science education helps students understand nature of science and important for all citizens to know. Nature of science that is common to the most science curriculum and distinction of instruction. McComas and Olson (1998) provided the characteristics of nature of science as well as students make it understandable. Science is an attempt to explore and explain natural phenomena that are surroundings students, people from different cultures contribute to science by the reliable knowledge and its explanation, scientific knowledge has a tentative character, it tend to be changed if there are new evidences, scientific knowledge relies heavily, but not entirely, on observation, experimental evidence, rational arguments and skepticism.

Science is flexible to do, there is no one way to do science, there is no universal step-by-step scientific method, it should make public, new knowledge must be published clearly, it emerges from observations, observations are theory laden, creativity makes science developed, scientists are creative experts, science is dynamics, it builds in both an evolutionary and a revolutionary way for social development with people needed. Also, scientists are member of community, they are expert who require accurate record-keeping, peer review and reproducibility to society, they make science is part of social and cultural traditions, science and technology are relevant, it can be impacted each other, science is affected by the social directions and historical setting, and laws and theories serve different roles in science, theories do not become laws even with additional evidence.

NOS is accepted by the scientific community and school science to making growth habit of mind in science. It also justifies to necessary elements, requisite of learning for scientific literacy (Nuangchalerm, 2010). NOS helps students to understand of what science should be, and also communicate science to society (Sinatra & Hofer, 2016). The program for teacher preparation be able to incubate nature of science as well. If they had no understanding NOS and reject it from the teacher preparation program, especially preservice teacher in science program. We cannot hypothesize how science will be implemented to curriculum and instruction. These are concerned within describing how science works in knowledge society. NOS make it relevant to scientific worldview, scientific inquiry, and role of science in our society. We cannot reject scientific world view in our views towards beliefs, is based on the assumption to natural and physical worlds. NOS makes us to understanding phenomena with careful observation and practices science as it should be. Observations are heart of science, if we lack of observation, we have no science. Observation used to create science and related productive knowledge.

The teacher preparation program needs to help preservice teachers retain appropriate conceptions of nature of science (Özer *et.al.*, 2019). Based on assumption with understanding of nature of science and cognitive competence, preservice teachers can increase their confidence and improve their abilities to effectively deliver science instruction to their school practicum and future (Bell *et.al.,* 2016). The teacher preparation program in science is not only focused on content knowledge, but also pedagogical decision is need to classroom. However, curriculum and instructional management are emphasized on competency of students to have necessary skills (Demirdöğen, 2016). Nature of science leads students to learn of what they should know and practice as scientists. Then, they will be literate person, or scientific literacy perceived (Fakhriyah *et.al.*, 2017; Saefullah *et.al.*, 2017; Setiawan *et.al.,* 2017; Islami *et.al.*, 2018; Nuangchalerm & Islami, 2018).

Students cannot articulate many aspects of NOS or scientific knowledge if they ignore understandings of NOS. It influenced to a large extent and instructional practice by understandings of teachers. Despite preservice teachers are initially used as a key success to introduce NOS into classroom and let student to have understanding of NOS. Preservice teachers are regarding to facilitate understanding of NOS and mediate student to meet the understanding of NOS. They have positively minded to science and tend to be understandings of NOS as well. If they hold an informed understanding of NOS, it may not affect pedagogy in the science classroom. In addition, they have to play roles in both

curriculum developers and pedagogy users in science classroom. They present idea that scientific knowledge through direct observations and culture of science (Rofe *et.al.,* 2016).

Preparing a professional teacher need to look quality of teacher students who introduce disciplines into classroom and some expected attributes (Prachagool *et.al.,* 2016). Preservice teacher development is initial point, especially understandings of NOS for science education program. This study investigates understandings of NOS of preservice teachers in science education program. Three year of study is studied and explained of how they perceive nature of science before employing these elements to school practicum. It also referred to further curriculum and instructional practices which they used in science classroom. The findings will be discussed to understandings of NOS and way to promote NOS into their beliefs and instructional practices.

METHODS

The study investigates understandings of how preservice teachers in science education program perceived understandings of NOS. Three years of study are employed by surveying through questionnaires and its correlation data. Reliable procedures and methods for this research are provided here.

Participants

Three years of program of study are investigated how they perceived nature of science. Participants in this study were 121 bachelor teacher students of education in general science program, in the second semester of 2017 (January to April), Faculty of Education, from a university in Northern Region of Thailand. The purposive selection is employed for describing and interpreting. They are selective participants based on the concept of science teacher students. Most of them are female in all year of study and they have to take course with those program designed with long 5-year of study. They should take grade average higher than those 3.00 because learning commitment, responsibility, and also Teacher Council of Thailand regulated them to be good teachers in the future school. General demographic of participants can be 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	Male	5 (15.62%)	11 (25.58%)	8 (17.39%)	24 (19.83%)
	Female	27 (84.38%)	32 (74.42%)	38 (82.61%)	97 (80.17%)

For the Year 1 of preservice teachers, they are entranced to the program by process of premium selection through Commission of Higher Education that calls " Teacher for Local Development Program" . They have to get GPAX

in high school much more than 3.00 and purpose to be a good or great teacher for Thais. Then, they have to study in a target university as Commission of Higher Education recommended. Year 1 students are mostly assumed that high grade or premium preservice teacher who aims to be science teacher in the future should be promise teacher characteristics. However, the scientific attitudes or attributes for teachers are not decided by the university. For the Year 2 and 3 of preservice teachers, they are entrance to the education program by various kinds of methods and university concerned to process of entrance. They are directly selected by portfolio and interviewing with project " Phet Sema" , characters of science teachers in which faculties needs. Some of them are entrance by central admission. Also, quota selection by university needs in such sport, culture, and good boy or girl project are considered to recruit for teacher preparation program.

Data collection and analysis

The participants provided their understandings NOS throughout the questionnaires. Data sources included different year of study, but questionnaires are the same items and purposes. Questionnaires of understandings of NOS is Likert 4 scaling (Highly agree (HA); Agree (A); Disagree (DA); and Highly disagree (HDA)) with an open-ended questionnaire used as the research tools. It consists of 25 questions relevant to the understanding of NOS. The items were adapted from various research studies, understandings of NOS items are specifically focused on the definitions of well-known science educators and related organizations i.e., Bartos & Lederman (2014); Erduran & Dagher (2014); Demirdöğen *et.al.* (2016); Clough (2018); Akerson *et.al.* (2019). These definitions are adapted and created to ask preservice teachers as well as they are connecting to the questionnaires.

The questionnaire on understandings of NOS enabled the researcher to investigate participants among year of study. Questionnaires were made by using Google Forms for convenience implication. Google Forms was one of the most important tools having great relevance to social science in general and data collection methodology (Bhalerao, 2015). The questionnaires respond to participants were systematically targeted. The online questionnaires via Google Forms collect online data from preservice teachers who are connected with internet. Preservice teachers in different year of study were asked to reflect upon their perception and understandings in dependently answered. The participants' responses to the questionnaires were studied in their understandings of NOS. The responses were placed into percentage of Highly agree (HA), Agree (A), Disagree (DA), and Highly disagree (HDA) in each items. Data were analyzed and grouped by level of understandings of NOS. Correlation was also studied for testing different understandings.

RESULTS AND DISCUSSION

The participants showed their understandings of NOS in various perceptions. The extinctions understandings of NOS of preservice teachers were shown in Table 2. They are highly agreed (HA) to item which showing their understandings of NOS, scientific knowledge can be changed, if additional evidences can explain much more than those prior knowledge; scientific knowledge will be reliable when evidences are enough; scientists will repeat their experiments

to reduce some mistakes; scientists aware and ignore bias that it will be appeared in the process of interpretation; scientists must to publish of what they explore to public society; science and technology influence to society movements, and society influence to development of science and technology.

They are agreed (A) to item which showing their understandings of NOS, science can describe concrete knowledge, natural phenomena, and other surroundings; natural phenomena are often showed the same pattern and it can be understandable; there are some phenomena which we cannot investigate by scientific method; scientists try to explain and predict phenomena in accurately even though what they all explain will not be describable; scientist use their knowledge to describe and predict phenomena based on evidences; science cannot explain about world and all about world, but it can predict what will be happened with the world; personal opinions emerged from diversity of demographic, sex, beliefs, or previous experiences which not influence to working of scientists; scientists explore their knowledge through the same methods and explicit procedures; and science and technology are same things.

Table 2. *NOS of preservice teachers*

Item	Highly Agree	Agree	Disagree	Highly Disagree
1. Science can describe concrete knowledge, natural phenomena, and other surroundings	44 (37.93%)	64 (55.17%)	6 (5.17%)	2 (1.72%)
2. Natural phenomena are often showed the same pattern and it can be understandable	9 (7.83%)	76 (66.09%)	23 (20.00%)	7 (6.09%)
3. Scientific knowledge can be changed, if additional evidences can explain much more than those prior knowledge	77 (70.00%)	33 (30.00%)	0 (0.00%)	0 (0.00%)
4. We are often remember in scientific law because it is accurate and proved in many times	13 (11.11%)	44 (37.61%)	43 (36.75%)	17 (14.53%)
5. We use process of science for making a consideration of which picture in gallery is the best	3 (2.54%)	14 (11.86%)	56 (47.46%)	45 (38.14%)
6. There are some phenomena which we cannot investigate by scientific method	51 (46.79%)	55 (50.46%)	3 (2.75%)	0 (0.00%)
7. Scientists try to explain and predict phenomena in accurately even though what	17 (15.04%)	75 (66.37%)	19 (16.81%)	2 (1.77%)

they all explain will not be describable				
8. Scientist use their knowledge to describe and predict phenomena based on evidences	43 (38.74%)	68 (61.26%)	0 (0.00%)	0 (0.00%)
9. Scientific knowledge will be reliable when evidences are 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 employed only creative thinking for designing innovations and inventions	5 (4.31%)	32 (27.59%)	74 (63.79%)	5 (4.31%)
12. Science cannot explain about world and all about world, but it can predict what will be happened 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 it will be appeared in the process of interpretation	82 (73.87%)	28 (25.23%)	0 (0.00%)	1 (0.90%)
15. Personal opinions emerged from diversity of demographic, sex, beliefs, or previous experiences which not influence to working of scientists	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, needs of society and community culture are not related	1 (0.85%)	0 (0.00%)	75 (64.10%)	41 (35.04%)
19. Scientist works in lonely under setting laboratory, if many scientists may be difficult to conclude	4 (3.51%)	14 (12.28%)	78 (68.42%)	18 (15.79%)
20. Scientists are social partners, on behalf	9	30	66	13

of expertise who understand and criticize on phenomena even though no more showing opinions and feelings	(7.63%)	(25.42%)	(55.93%)	(11.02%)
21. Scientists must to publish of what they explore to public society	56 (49.56%)	54 (47.79%)	3 (2.65%)	0 (0.00%)
22. Scientists do research by taking responsibility to benefits than those moral and ethics	3 (2.52%)	26 (21.85%)	60 (50.42%)	30 (25.21%)
23. Science and technology are same things	15 (12.71%)	86 (72.88%)	15 (12.71%)	2 (1.69%)
24. Science and technology influence to society movements, and also society influence to 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 are not influence to scientists	2 (1.68%)	16 (13.45%)	78 (65.55%)	23 (19.33%)
Total (%)	25.20	36.93	28.36	9.51

They are disagreed (DA) to item which showing their understandings of NOS, we use process of science for making a consideration of which picture in gallery is the best; scientists deny imagination and creative thinking to explore new knowledge; scientists employed only creative thinking for designing innovations and inventions; scientific knowledge comes from experiments only; scientific knowledge or explorations are products of scientists, needs of society and community culture are not related; scientist works in lonely under setting laboratory, if many scientists may be difficult to conclude; scientists are social partners, on behalf of expertise who understand and criticize on phenomena even though no more showing opinions and feelings; scientists do research by taking responsibility to benefits than those moral and ethics; scientists work in their laboratory, even though social needs are not influence to scientists. However, they are highly disagreed (HDA) over 30% to item which showing their understandings of NOS, we use process of science for making a consideration of which picture in gallery is the best; scientists deny imagination and creative thinking to explore new knowledge; and scientific knowledge or explorations are products of scientists, needs of society and community culture are not related.

To understand, preservice teachers show their understandings of NOS in different degree of agreements. Researcher employed Pearson correlation testing its relationship between HA, A, DA, and HDA. Result revealed that agreements correlated in positive and negative as it showing in Table 3.

Table 3. *Correlation of degree of agreements in understandings*

	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 showed that the degree of agreements of preservice teachers in understandings of NOS had positive correlation between highly agree (HA) and disagree (DA); disagree (DA) and highly disagree (HDA) at .01 level of statistical significance. Despite correlated information, while negative correlation is found by they had a correlation 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 in preservice teachers. Preservice teachers had different in understandings of NOS seems to be varied.

Preservice teachers show their understandings of NOS in the way of they perceived. Three year of study seems to be not different. They argued that NOS is the combination of worldview, process of knowledge construction, and its product or process influence to social values. It is significant to make views in positive towards science, relevant to scientific literacy, make a social development, and create scientific citizens. To understandings of NOS, they are highly agreed with to knowledge of science that are rigorously developed, it tend to be changed in dynamics, if scientists present more additional evidences for explaining much more than those prior knowledge. NOS refers to the epistemology and sociology of science, science as a way of knowing, values and beliefs inherent to scientific knowledge through process of knowledge development (Sinatra & Hofer, 2016).

The findings indicated that preservice teachers had strongly extinctions understandings of NOS. As beliefs and culture of science, scientific knowledge can be changed, if additional evidences can explain much more than those prior knowledge; scientific knowledge will be reliable when evidences are enough; scientists will repeat their experiments to reduce some mistakes; scientists aware and ignore bias that it will be appeared in the process of interpretation; scientists must to publish of what they explore to public society; science and technology influence to society movements, and society influence to development of science and technology. That is, its nature of science in our daily lives and society-based learning (Erduran & Dagher, 2014; Bell *et.al.,* 2016). Science activities and social movements cannot cracked from those science education because it is a significant tools of knowledge construction. Nature of science covered views, process of inquiry, and social movements which it should be embedded in science curriculum and instructional strategies.

Due to participants understood that science can describe concrete knowledge, natural phenomena, and other surroundings; natural phenomena are often showed the same pattern and it can be understandable. This understanding pointed that they had positive attitudes toward science. It might want to invite NOS into science classroom and most courses of program study allowed them to meet real science. Also, there are some phenomena which we cannot

investigate by scientific method; scientists try to explain and predict phenomena in accurately even though what they all explain will not be describable; scientist use their knowledge to describe and predict phenomena based on evidences; science cannot explain about world and all about world, but it can predict what will be happened with the world; personal opinions emerged from diversity of demographic, sex, beliefs, or previous experiences which not influence to working of scientists; scientists explore their knowledge through the same methods and explicit procedures; and science and technology are same things (Erduran & Dagher, 2014; Faikhamta, 2016). These are process of science which preservice science teachers perceived and uptake to their classroom in the school practicum and coming science classroom.

However, they are disagreed (DA) with the concrete understanding, we cannot make a decision in quantitative like science do for judging which picture in gallery is the best; scientists deny imagination and creative thinking to explore new knowledge; scientists employed only creative thinking for designing innovations and inventions. That is surprisingly, they perceived that they disagreed with needs of society and community culture are not related. It may results from the global cooperation in new era, no one deny community or process and product of sciences. Scientist works are social partners, on behalf of expertise who understand and criticize on phenomena even though no more showing opinions and feelings. Scientists had to take a responsibility to benefits than those moral and ethics. The ways to promote understandings of NOS should be specific focus on NOS content, allows teacher students to participate in hands-on NOS activities, prepare an introductory NOS readings, employ multiple forms of reflection, exposure to NOS content, use the presentation of NOS content, practice in the evaluation of NOS data, analyse science standards in terms of NOS content, and enhance NOS instructional experiences (Adibelli-Sahin & Deniz, 2017).

Accordingly, understandings of NOS in 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 that teachers implemented NOS instruction, teachers need to use multiple forms of instruction. Because of scientific knowledge is subjective, and it is subject to change (Cansiz *et.al.*, 2017). Also, Jain *et.al.* (2018) reviewed the literature on the general understanding of NOS indicated that preservice teachers who have never undergone explicit learning of NOS had naïve understanding. We cannot reject science as dynamic knowledge, tend to be change based on explicit evidences. If they do concentrate more subject, NOS will be low implementation because the modern world is expanding with information and big data. Now technological pedagogical content and knowledge or TPACK is necessary for preservice teachers, it prepares them to bridge the gap between subject matters, pedagogy, and technology to their students.

CONCLUSION

To conclude, preservice teachers had indicated their understandings to meet the goal of science education, understandings need to embed NOS in curriculum and instruction. Finding is initially guided research in some understandings that preservice teachers are not clearly understandings. It is very interested in the confusion or misunderstandings of NOS in preservice teachers which questions about these are in future study in terms of various

methods in general and specific courses. Curriculum should promote NOS as well as instructional practices engage NOS by suitable ways.

REFERENCES

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.

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: preservice 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*(3&4), 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.

Clough, M. P. (2018). Teaching and learning about the nature of science. *Science & Education,* 27(1-2), 1-5.

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 preservice 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.

Faikhamta, C. (2016). PSMT pre-service science teachers' understandings of nature of science. *Journal of Education, Prince of Songkla University, 27*(2), 21-37.

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.

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.

El Islami, R. A. Z., Nuangchalerm, P., & Sjaifuddin, S. (2018). Science process of environmental conservation: Cross national study of Thai and Indonesian pre-service science teachers. *Journal for the Education of Gifted Young Scientists*, *6*(4), 72-80.

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). Preservice 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.

Prachagool, V., Nuangchalerm, P., Subramaniam, G., & Dostal, J. (2016). Pedagogical decision making through the lens of teacher preparation program. *Journal for the Education of Gifted Young Scientists*, *4*(1), 41-52.

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.

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