JPII 10 (2) (2021) 282-291

Jurnal Pendidikan IPA Indonesia

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

EFFECTS OF ISLAMIC SCIENTIST HISTORY ON SEVENTH GRADERS' UNDERSTANDINGS OF NATURE OF SCIENCE IN A THAI ISLAMIC PRIVATE SCHOOL

R. Safkolam[1], P. Khumwong*[2], C. Pruekpramool[3], A. Hajisamoh[4]

[1]Doctoral student in Science Education, Faculty of Science, Srinakharinwirot University, Thailand
[2,3]Science Education Center, Faculty of Science, Srinakharinwirot University, Thailand
[4]Faculty of Science Technology and Agriculture, Yala Rajabhat University, Thailand

DOI: 10.15294/jpii.v10i2.26668

Accepted: October 15th 2020. Approved: June 29th 2021. Published: June 30th 2021

ABSTRACT

Societies and cultures influence students' understandings of the Nature of Science (NOS). An approach to promote an accurate understanding of the nature of science is to manage the learning based on students' contexts through the integration of their social, cultural, and religious stories. Hence, this study investigated the pedagogical effects of Islamic scientist history on seventh graders' understandings of the nature of science in an Islamic private school, Yala Province, Thailand. Through a mixed-methods convergent design, data were collected from 30 seventh graders in an Islamic private school of Yala who were selected through a convenience sampling. The instruments were: (1) a NOS questionnaire; and (2) a semi-structured interview on the understanding of the nature of science. The quantitative data were statistically analyzed using mean, standard deviation, and a dependent t-test. The qualitative data were analyzed through content analysis and categorized into three groups based on the views of the nature of science: Informed Views (IV), Transitional Views (TV), and Naive Views (NV). Results revealed that the students who learned from the history of Islamic scientists had gained higher mean scores on the understanding of the nature of science at the .05 significance level and transformed their views from Transitional (TV) and Naive (NV) to Informed (IV) in every aspect of the nature of science. This can be summarized that applying the history of Islamic scientists with the explicit reflective NOS teaching is practical in Islamic private school. To make this change happen in the unique school context, science teachers must devote time to analyzing the NOS hidden in the history of Islamic scientists. In addition, another Islamic context, such as local Islamic wisdom, could also promote the understanding of the NOS for students in private Islamic schools.

Keywords: nature of science; history of Islamic scientists; explicit reflective approach; Islamic private school

INTRODUCTION

Understanding the Nature of Science (NOS) is an element that defines a scientifically literate individual and the ultimate goal of learning science (Abd-El-Khalick, 2013; Next Generation Science Standards [NGSS], 2013; McDonald & Abd-El-Khalick, 2017; Michel & Neumann, 2017). An accurate understanding of NOS can lead to meaningful science learning, understanding of science, scientific interests, and abilities to establish scientific knowledge (Clough, 2018). Although NOS is vital in science learning, researchers discovered that students' understandings of NOS remain insufficient and inaccurate (Sagsaard et al., 2014; Karakas, 2017; Wicaksono et al., 2018).

By reviewing approximately five decades of research related to the teaching and learning Nature of Science (NOS), it is accepted that explicit reflective instruction is the best way to learn the nature of science (Lederman, 2007). Many researchers have reported the effectiveness of the explicit reflective approach (e.g., García-

*Correspondence Address
E-mail: pinitk@g.swu.ac.th

Carmona & Dı´az, 2016; Williams & Rudge, 2016; Gathong & Chamrat, 2019). However, many influencing factors of such misconceptions were identified, e.g., science content presented in textbooks (Ayik & Costu, 2020), science teachers' understanding of NOS (Buaraphan, 2018; Lederman & Lederman, 2019) as well as social and cultural factors (Alghamdi & Malikan, 2020). Different cultures play roles in shaping a distinct understanding of NOS (Sutherland & Dennick, 2002). This condition especially applies to religions, which usually produce tremendous effects on understanding (Wan et al., 2013; Nelson et al., 2019). Coping with this conflict is a complex challenge for science educators contemplating how to meet this challenge and deal with the teachers' and students' concerns about the harming of religious belief (Afalo, 2018). In order to enhance students' understanding of NOS in a particular culture, explicit reflective instruction must be revisited. It would be better to learn NOS based on students' cultural backgrounds (Das et al., 2019). In cultures where religion has a significant influence on peoples' lives, such as Islamic culture, the development of science curricula should be made regarding context associated with religion (Mansour, 2010; Afalo, 2018). A further research study should examine how to develop students' understanding of NOS in the context of different culturally rich countries.

In southern Thailand, most citizens are Muslim, only believe in Allah, and regard him as the creator of everything in the universe (Lillahkul & Supanakul, 2018). Most students in this area attend Islamic private schools that offer simultaneously secular-Islamic education (Vongmontha, 2012; Saree et al., 2018) under the supervision of the Ministry of Education through the combined administration of the Basic Education Core Curriculum BE 2551 (2008) and the Islamic Education Curriculum BE 2546 (2003) (Baka, 2011). From a preliminary study done in the research site, it was found that science teachers in three Islamic private schools in Yala, a province in southern Thailand, taught the nature of science implicitly, as they only emphasized students' authentic experiments and practices and neglected to provide information, Islamic context, and discussion about the aspects of the nature of science (Safkolam et al., 2017). As a result, such a learning approach could not promote an adequate understanding of the nature of science. A solution to these problems is an inclusion of social, cultural, and religious stories relevant to students' context in the learning (Mansour, 2010; Afalo, 2018; Fitriani & Fibriana, 2020).

Fouad et al. (2015) and Afalo (2018) suggested that the history of famous Islamic scientists should be incorporated into the Nature of Science learning for Islamic students. This approach can significantly decrease the conflict between science and religion. Accordingly, Mansour (2010) has also suggested that the Islamic view and the received view of science share the same methodology. They both involve experimentation, observation, and theoretical work. However, limited numbers of researches had integrated Islamic context, especially the history of Islamic scientists, into NOS learning.

The explicit reflective teaching using the history of science can be taught through multiple pedagogical strategies (e.g., vignettes, science stories, case studies of scientific history, and scientific narratives) for students across educational levels from kindergarten to higher education (Stinner et al., 2003). If appropriately applied, any of these strategies can tangibly promote an understanding of NOS. Considering the fact that (1) there are limitations to individually study Islamic scientists as thorough information on a single Islamic scientist is unavailable; (2) records of specific studies lack an illustration on how a scientific concept was developed in series; (3) a single Islamic scientific story or event already includes multiple scientists contributed a story. Hence, the case studies of scientific history become a sound strategy to learn NOS in Islamic scientists in this research.

This study deployed explicit reflective NOS teaching as a baseline. It is a practical approach to promote NOS understanding. However, there was a limited number or no research done on applying the case studies of Islamic scientific history with the approach. It is noteworthy to explore further based on a research question of "how does the history of Islamic scientists affect the 7th-grade students' nature of science understanding?" Consequently, this study aimed to quantitatively and qualitatively compare students' understanding of the NOS before and after learning through an explicit reflective approach using Islamic scientist history in an Islamic private school, Yala Province, Thailand.

METHODS

This research employed a mixed-methods convergent design (Creswell, 2018) where quantitative and qualitative data were simultaneously collected, compared, and interpreted. The justification behind the choice of this design was that it was able to provide a comprehensive answer to the research question and improve the construct validity.

The studied group was thirty seventh-graders in an Islamic private school of Yala province, Thailand. It was the only class under the first researcher's supervision, so it was selected through convenience sampling. Since these students are culturally distinctive from those in other regions, their understanding of NOS might subsequently differ, especially when religion plays a significant role in shaping such an understanding (Wan et al., 2013). Consequently, the researcher was keen to explore further into this student group. The intervention was a learning unit based on the history of Islamic science titled "Learn Science with Islamic Scientists". It was created aligning with the science standards and indicators in the basic education core curriculum B.E.2551 (Ministry of Education, 2008) and NOS emerging from the history of selected Islamic scientists. The learning unit introduced multiple historical case studies of the Islamic scientists, i.e., Jabir ibn Hayyan, Ibn al-Haytham, and Al-Farsi. It took 15 hours to complete the unit (3 hours a week). The learning process was adapted from multiple studies (Lin & Chen, 2002; Stinner et al., 2003) to include the following five steps.

Step 1: engagement; the teacher grabbed the students' attention with problematic questions faced by scientists, lesson-related problems, and articles on the history of a specific Islamic scientist. Step 2: search for answers; the students examined the history of Islamic scientists and discussed them with the entire class. The teacher led the discussion with questions on the nature of science discovered in the history of these Islamic scientists. Either the students or the teacher simulated an experiment similar to the one conducted by the historical scientists. The teacher stood by to offer suggestions, facilitate the students, and asked them exploratory questions about the experiments when some issues were worth an explanation. Upon completing the experiments, the entire class concluded and discussed the results. Step 3: knowledge and conceptual expansions; the students presented different inferences proposed by the scientists and referred to historical events when scientists proposed conflicting inferences within the scope of the lessons. The teacher encouraged them to discuss further by asking questions. Step 4: exchanges of ideas; the students shared ideas and drew connections to the scientific concepts extracted from history. The teacher introduced additional scientific concepts that are relevant to the students' learning interests. Step 5: conclusions and reflections on the nature of science; The class members collaborated to summarize scientific concepts and reflect on the nature of science found in scientists' records.

The study employed two research instruments, a NOS questionnaire and a semi-structured interview on the understanding of NOS. The NOS questionnaire composed of 28 items employed a 5-level Likert scale: strongly agree, agree, neither agree nor disagree, disagree and strongly disagree. The items included positive and negative statements which were adapted from multiple measures for understanding NOS, including Views of Nature of Science C (VNOS-C) (Lederman et al., 2002), the Student Understanding of Science and Scientific Inquiry (SUSSI) (Liang et al., 2008), and the Views on Science and Scientific Inquiry (VOSSI) (Reid-Smith, 2013). The items covered three domains of the nature of science (i.e., the scientific worldview, scientific inquiry, and scientific enterprise) and seven measurable aspects (i.e., NOS 1: science can explain natural phenomena, NOS 2: science knowledge is tentative, NOS 3: scientific knowledge requires empirical and verifiable evidence, NOS 4: scientific methods can vary without fixed procedures, NOS 5: social and cultural influences affect scientists' conducts, NOS 6: observations and inferences, and NOS 7: science relies on imagination and creativity). The content validity of the NOS questionnaire was verified by three experts in the field of science education. The index of item-objective congruence is in the range between 0.67-1.00. After trying out with 30 seventh-grade students, Cronbach's alpha reliability coefficient was calculated and equaled 0.822.

The interview questions were open-ended and formulated from the constructed NOS questionnaire. Two questions were extracted from each aspect. While the students were interviewed, they were given opportunities to explain their previous questionnaire responses further. The questions were asked with an emphasis on the students to explain why. The interview questions were tried out with seventh-grade students to check the language usage and how well students understand the questions.

Researchers autonomously collected quantitative and qualitative data. Before learning, the students were asked to complete the questionnaire. The derived data were generated to mean scores on the understandings of NOS, which were subsequently classified into the three groups based on their pre-learning views towards the nature of science using Niyomwong's (2015) criteria as shown in Table 1 (quantitative criteria). Later, six student representatives of each group were selected to participate in the interviews on each aspect. The interviewees were asked for permission for audio recordings. Afterward, the students resumed their learning through the five lessons on the history of Islamic scientists. After learning, the students once again answered the NOS questionnaire. The researcher subsequently ran interviews with the same six student representatives. The responses from the NOS questionnaire were scored and calculated to mean scores and standard deviation to analyze quantitative data. For the positive items, strongly agree, agree, neither agree nor disagree, disagree, and strongly disagree were scored 5, 4, 3, 2, and 1 respectively and vice versa for the negative items. Then, the pre-test and post-test mean scores of overall and individual aspects were compared using a dependent t-test.

Table 1. Criteria for the Groups of Nature of Science Understanding, Descriptions, and Mean-Score Classification

Groups of NOS Understanding	Qualitative Criteria	Quantitative Criteria (Mean Scores)
Inform view: IV	Students' explanations are entirely consistent with the currently accepted aspects of NOS.	3.41-5.00
Transitional view: TV	Students' explanations are partially consistent with the currently accepted aspects of NOS.	1.71-3.40
Naive view: NV	Students' explanations are entirely inconsistent with the currently accepted aspects of NOS, irrelevant to the questions, or completely missing.	Below 1.71

For qualitative data, the interviews were transcribed and analyzed by a content analysis (Schreier, 2012) to classify the students into the three groups based on their views of NOS using criteria as shown in Table 1 (qualitative criteria). The results were then validated for reliability by thesis advisors and NOS experts. The number and percentage of students in each group were counted. Further, changes in pre-and post-learning NOS understanding were compared to explain the students' transformation of the understanding of NOS. The interview data were recorded in number codes, e.g., Student 10 and Student 23, and to avoid traces of identifiable information such as the students' names. Eventually, both the quantitative and qualitative results were combined, compared, and interpreted to conclude and display the effects of Islamic scientist history on seventh graders ' understanding of the nature of science in an Islamic private school context.

RESULTS AND DISCUSSION

Based on the research instruments used in this study, the students' pre and post-understanding of the nature of science were collected via a questionnaire and a semi-structured interview. The results from the questionnaire revealed that the post-test mean scores were higher than the pre-test ones at the .05 statistical significance level overall and aspect, which can be seen in Table 2.

Table 2. The Comparison of the Pre-test and Post-test Mean Scores of the Understanding of NOS

Aspect of NOS	n	k	Pre-test		Post-test		t	p
			M_1	SD	M_2	SD		
NOS 1	30	28	2.37	0.83	4.34	0.43	-14.008*	.000
NOS 2	30	28	2.70	0.37	4.14	0.33	-15.568*	.000
NOS 3	30	28	3.03	0.31	4.02	0.67	-11.644*	.000
NOS 4	30	28	2.40	0.68	4.22	0.72	-9.825*	.000
NOS 5	30	28	2.92	0.36	4.39	0.46	-12.472*	.000
NOS 6	30	28	2.63	0.44	4.29	0.65	-13.119*	.000
NOS 7	30	28	2.33	0.85	4.66	0.62	-13.642*	.000
Overall	30	28	2.62	0.32	4.29	0.44	-21.363*	.000

*p < .05

The two representatives of each group (IV, TV, and NV) were selected to participate in the interviews on each aspect. The interview findings indicate that before learning about the history of Islamic scientists, most students had Naive Views (NV) of science in all the NOS aspects. More specifically, every student (100%) had Naive Views (NV) of NOS in four aspects (i.e., scientific knowledge is tentative, scientific methods can vary without fixed procedures, social and cultural influences affect scientists' conducts, and science relies on imagination and creativity). Whereas most of them (66.67%) equally had Naive Views (NV) of NOS in three aspects (i.e., science can explain natural phenomena, scientific knowledge requires empirical and verifiable evidence, and observations and inferences). Furthermore, none was found to have Informed Views (IV) of NOS. The interview findings are presented in Table 3.

Table 3. Percentages of the Students' View of NOS Before and After Learning According to the Interviews

Aspect of NOS	Frequency (Percentage) of Students' View of NOS Before and After Learning					
	IV		TV		NV	
	Before	After	Before	After	Before	After
NOS 1	0 (0.00)	6 (100.00)	2 (16.67)	0 (0.00)	4 (66.67)	0 (0.00)
NOS 2	0 (0.00)	6 (100.00)	0 (0.00)	0 (0.00)	6 (100.00)	0 (0.00)
NOS 3	0 (0.00)	6 (100.00)	2 (33.33)	0 (0.00)	4 (66.67)	0 (0.00)
NOS 4	0 (0.00)	6 (100.00)	0 (0.00)	0 (0.00)	6 (100.00)	0 (0.00)
NOS 5	0 (0.00)	6 (100.00)	0 (0.00)	0 (0.00)	6 (100.00)	0 (0.00)
NOS 6	0 (0.00)	5 (83.33)	2 (33.33)	1 (16.67)	4 (66.67)	0 (0.00)
NOS 7	0 (0.00)	6 (100.00)	0 (0.00)	0 (0.00)	6 (100.00)	0 (0.00)

Based on the results from Table 3, after learning about the history of Islamic scientists, it was found that every student (100%) had Informed Views (IV) in six aspects, except for observations and inferences in which the majority (66.67%) had Informed Views (IV) and the minority (16.67%) had Transitional Views (TV). After learning, interview results showed that the numbers of students with Transitional Views (TV) and Naive Views (NV) significantly decreased in all aspects when compared to those of the before learning results. This result is compatible with the dependent t-test.

Moreover, table 4 suggested that before learning, most students had Naive Views (NV) in every aspect of NOS. This result is consistent with the quantitative result. What further know is the reason behind the students' responses. Some of them drew connections to religious beliefs when supplying reasons on three aspects, i.e., science can explain natural phenomena, scientific knowledge is tentative, and requires empirical and verifiable evidence. After learning, most students developed Informed Views (IV) of NOS, and this transformation of perspective reflected that they gained a better understanding of NOS after studying the history of Islamic scientists. We know that the history of science with explicit reflective teaching can promote NOS understanding, as many researchers have done and reported the effectiveness of using the history of western science with explicit reflective instruction (Garcı´a-Carmona & Dı´az, 2016; Williams & Rudge, 2016; Gathong & Chamrat, 2019). However, teaching NOS in a rich culture of Islamic students had to be adapted to meet the Islamic context. In a rich-culture society, it is difficult for students to distinguish between "the social", "the religious," and "the scientific" (Kim & Hamdan Alghamdi, 2020). The researchers decided to use Islamic scientists as role models to reflect the nature of science in their context. The 5-step learning process was adapted and applied to the class in order to promote students' understanding of NOS. This process lets students practice and learn by themselves. Each learning activity reflects the nature of science combined with the history of Islamic scientists and scientific concepts providing opportunities for all students to reasonably and scientifically discuss and do the experiments. This learning process is based on the theory of constructivism emphasizing how students construct their own knowledge and understanding to make meaningful learning to students (Olusegun, 2015). The following is the samples of individual results of the students' interviews on the NOS aspects that are presented in Table 4.

Table 4. The Interviews Findings by Aspect Before and After Learning

Aspects of NOS	Before learning	After learning
NOS 1	"Allah is the creator who gave birth to the Earth and the universe. Everything is already explained in the Quran." (Student 1) (NV)	"Science can be used to explain different natural phenomena through observing, inferring, and experimenting. Al-Farsi experimented on the rainbow. He observed, experimented, and interpreted that the rainbow has three colors." (Student 1) (IV)
	"While studying science, the teacher said that science is the knowledge that can explain different natural phenomena... Only Allah would know and explain everything." (Student 25) (TV)	Science can explain the occurrences of rainbows, cloud formations, and rain through experimentation and observation. For instance, Al-Farsi experimented on the rainbow and found that the rainbow has three colors." (Student 25) (IV)
NOS 2	"No one can discover a planet but Allah." (Student 10) (NV)	"Scientists have been trying to research observations, experimentation, and interpretations. More planets could be discovered. Knowledge of science can constantly change. When scientists unveil new information supplied with verifiable evidence, obsolete knowledge is removed." (Student 10) (IV)
	"Scientists might no longer find planets in the future." (Student 26) (NV)	"Since scientists are constantly researching and experimenting, there is a higher chance of discovering more planets. Knowledge of science can be changed if newer information contradicts the old one, and there is clear and reliable evidence to support it. For instance, Ptolemy once made a vague inference about how humans see objects. However, Ibn al-Haytham ran experiments and observations until clear evidence was found. Consequently, Ptolemy's inference was refuted." (Student 26) (IV)
NOS 3	"Science does not need evidence." (Student 4) (NV)	Scientists rely on evidence to confirm their findings. People trust them with evidence. When Jabir experimented on perfume extraction from roses, he used rose water as supporting evidence." (Student 4) (IV)
	Science must have evidence because it is used to prove that the findings are reliable. Some matters cannot be explained by science because it is Allah's business, and so, there is no evidence to support." (Student 11) (TV)	"Scientists need evidence. Evidence makes people trust them. It proves that the discovery is real. Jabir's experiment on gold extraction discovered gold dissolving acid." (Student 11) (IV)
NOS 4	"There is no other scientific method, except for experimentation, that would help scientists discover scientific knowledge." (Student 10) (NV)	"Scientists have many ways to uncover scientific knowledge such as observing, experimenting, and interpreting." (Student 10) (IV)
	"The steps within a scientific method cannot be switched around. They must be in sequence." (Student 23) (NV)	"Scientific methods have unfixed steps. A method can either start by observing or stating a problem. When Al-Farsi experimented on the rainbow, he began by stating a problem. Ibn al-Haytham also began by observing the mosque upside down." (Student 23) (IV)

NOS 5	"The work of a scientist is not relevant to societies." (Student 3) (NV)	"The work of a scientist is relevant to societies and communities. They work with the goals of societies and communities. When Jabir experimented in a laboratory, some people despised his work and burned down his laboratory. Although he could not continue with the experiment, he did not stop there and kept trying." (Student 3) (IV)
	"A scientific discovery only begins from a scientist's interest." (Student 10) (NV)	"The works of scientists are relevant to communities and societies. They work for the communities. Jabir experimented with perfume extraction to offer people in the community an opportunity to bath with rose water." (Student 10) (IV)
NOS 6	"Making observations and inferences rely on the same parts of the body." (Student 8) (NV)	"Observations, experimentation, and making inferences are essential to scientists. When I experimented with extracting perfume from roses, I observed the boiling water with crushed rose. I watched a video about an experiment on gold dissolving acid. When white acids were mixed, I observed and noticed that the solution turned orange. It takes eyes, nose, and maybe all the five sensory units to observe, and we are not to use our opinions. However, if you want to make an inference, you can explain the results from the observation and add your knowledge and opinions. For instance, in the experiment on the occurrence of the rainbow, colors should be observed." (Student 8) (TV)
	"Scientists make observations and inferences...Making observations and inferences are not different because both use the same parts of the body." (Student 11) (TV)	"Making observations differ from making inferences because observations rely on senses obtained from ears, eyes, noses, tongues, and skins to create an explanation. Making inferences used observed results and existing knowledge to create an explanation. When experimenting occurrence of the rainbow, a flashlight provided light to the glass of water and paper for the background. Three colors were observed. While using the flashlight, we used our eyes to observe and noticed the three colors. However, the rainbow has seven colors. The room was too bright, and that gave use three colors. This explanation is how inference is made because we already know that the rainbow has seven colors." (Student 11) (IV)
NOS 7	"Imagination and creativity have nothing to do with science. "Science is only about experimenting." (Student 3) (NV)	"We do not see the shapes of atoms in the naked eyes. So, it takes imagination and creativity. If the experiment cannot be simply explained, scientists need to use imagination and creativity. Science requires imagination and creativity." (Student 3) (IV)
	"Scientists only use experiments. Using imagination is the expression of personal ideas without evidence, and that makes it unreliable." (Student 11) (NV)	"Scientific knowledge is established through many methods, and it does not only apply to experimentation. Sometimes, it takes imagination and creativity to get the right information. When Al-Farsi experimented on the occurrence of the rainbow, he used a round glass instead of rain droplets. It means that he based his experiment on imagination and creativity until he was able to explain that the rainbow has three colors." (Student 11) (IV)

Both quantitative and qualitative results revealed that the case study of Islamic scientists' history helped the students developed more Informed Views (IV) of NOS. In this study, the students had the opportunity to take an active role in the discussion, debates, and do scientific experiments, which resemble what the Islamic scientists with strict adherence to Islam performed scientifically in the context of Islam. This learning pattern was proven to promote the understanding of NOS. Reflecting on ideas about science while learning allows students to associate NOS with events in everyday life (Tolvanen et al., 2014; Nur & Fitnat, 2015; Wolfenburger & Canella, 2015; Thiangchanthathip, 2016).

At the same time, as scientific work had done in Islamic social context by Islamic scientists, students could accept how the Islamic scientists with strict adherence to Islam mitigated the formerly intense ideological conflicts between science and religion and began to accept and recognize the nature of science according to Islamic culture and context (Tabel et al., 2011; Winslow et al., 2011). The reason relies on the suggestion of Costa (1995) and Meyer & Crawford (2011), who said that when science classrooms embrace real-life cultures, meaningful learning is possible. If a student comes from a background that aligns with the scientific way of knowing, science instruction will uphold their worldviews.

Although, using the history of Islamic scientists could provide students with an informed view in almost all aspects of NOS, except in the aspect of observation and inference, which some students had held transitional views even after learning. Before learning, students perceived that observation and inference were similar. After learning, they could explain and distinguish observation from inference but could not give a clear example of inference even though this aspect was included in all lessons. Students were asked to identify differences between those two terms emerging from the historical case studies, but they seldom reflected on their practical experiences. It might be a limitation of this study.

CONCLUSION

This study suggests that a case study of Islamic scientists' history can promote NOS understanding among Islamic students. The students who learned from the history of Islamic scientists the students increased mean scores on the understanding of the nature of science at the .05 significance level and transformed their views from Transitional (TV) and Naive (NV) to Informed (IV) in every aspect of the nature of science. It can be concluded that integrating the history of Islamic scientists and the explicit reflective NOS teaching is a helpful teaching method to promote students' understandings of NOS, especially in a particular context like Islamic private schools. For Thailand and countries with an Islamic context included, these research results will enable people who are involved in the education administration and management sector to look back into science teaching and learning. These could lead to a change in educational policy related to promoting the nature of science to the students in the unique school context in the future. Furthermore, the synthesized formula could be implemented in curricular development to promote the understanding of the nature of science for students in private Islamic schools.

ACKNOWLEDGMENTS

The researchers would like to express gratitude to Srinakharinwirot University and Yala Rajabhat University for their funding support, and the thesis advisors who kindly reviewed and made suggestions to this research article, as well as the school administrators, the teachers, and the students at a private Islamic school in Yala Province who lent their unstinting cooperation with the data collection.

REFERENCES

Abd-El-Khalick, F. (2013). Teaching with and about the nature of science, and science teacher knowledge domains. *Science & Education*, *22*(9), 2087-2107.

Afalo, E. (2018). Changes in the perceptions of the nature of science and religious belief. *Issue in Education Research*, *28*(2), 237-253.

Alghamdi, A. K., & Malikan, M. (2020). Saudi science teachers' perceptions of cultural factors influencing elementary students' science learning. *Cultural Studies of Science Education*,15,1143-1167.

Ayik, Z. & Costu, B. (2020). A study on demonstration of the nature of science in science textbooks: history and philosophy of science perspectives. *Jurnal Pendidikan IPA Indonesia*, *9*(3), 451-464.

Baka, M. (2011). *The Integration of contents and learning standards for the level 3 of Islamic private schools in southern border provinces of Thailand.* (Doctoral dissertation, Songkhlanakarin University)

Buaraphan, K. (2018). In-service science teachers' common understanding of nature of science. *OIDA International Journal of Sustainable Development*, *6*(5), 17-37.

Costa, V. B. (1995). When science is "another world: relationships between worlds of family, friends, school, and science. *Science Education*, *79*(3), 313-333.

Creswell, J. W. & Plano Clark, V. L. (2018). *Designing and conducting mixed methods research* (3rd ed.). Singapore: SAGE.

Clough, M. P. (2018). Teaching and Learning About the Nature of Science. *Science & Education*, *27*, 1-5.

Das, P. M., Faikamta, C. & Punsuvon, V. (2019). Bhutanese students' views of nature of science: a case study of culturally rich country. *Research in Science Education*, 49, 391-412.

Fitriani, E., & Fibriana, F. (2020). Analysis of Religious Characters and Logical Thinking Skills After Using Solar System Teaching Material Integrated with Islamic Science. *Journal of Innovation in Educational and Cultural Research, 1*(2), 69-76.

Fouad, K. E., Master, M. H., & Akerson, V. L. (2015). Using history of science to teach nature of science to elementary students. *Science & Education*, *24*(9), 1103-1140.

Gathong, S. & Chamrat, S. (2019). The implementation of science, technology and society environment (STSE)-based learning for developing preservice general science teachers' understanding of the nature of science by empirical evidence. *Jurnal Pendidikan IPA Indonesia*, *8*(3), 345-360.

Garcı´a-Carmona, A. & Dı´az, J. A. A. (2016). Learning about the nature of science using newspaper articles with scientific content: a study in initial primary teacher education. *Science & Education*, 25, 523-546.

Karakas, M. (2017). Turkish students' views on nature of science. European Journal of Education Studies, *3*(10), 176-183.

Kim, S. Y., & Hamdan Alghamdi, A. K. (2020). Saudi Arabian secondary students' views of the nature of science within Islamic context. *International Journal of Science Education*, *42*(13), 2266-2283.

Lederman, N. G. (2007). Nature of science: Past, present, and future. In S. K. Abell & N. G. Lederman (Eds.), *Handbook of research on science education* (pp. 831–879). Lawrence Erlbaum.

Lederman, N. G., Abdul-El-Khalick, F., Bell, R. L., & Schwartz, R. S. (2002). View of nature of science questionnaire: toward valid and meaningful assessment of learner's conceptions of nature of science. *Journal of Research in Science & Teaching*, *39*(6), 497-521.

Lederman, N. G. & Lederman, G. S. (2019). Teaching and learning nature of scientific knowledge: Is it Déjà vu all over again. *Disciplinary and Interdisciplinary Science Education Research*, *1*(6), 1-9.

Liang, L., Chen, S., Xiam, C., Kaya, O.N., Adams, A.D., Monica, M., & Ebenezer, J. (2008). Assessing preservice teachers' views on the nature of scientific knowledge: a dual-response instrument. *Asia-Pacific on Science Learning and Teaching*, *9*(1), 1-20.

Lillahkul, N., & Supanakul, P. (2018). Way of life of Muslim people in Thailand's southern provinces, and health promoting lifestyle. *The Southern College Network Journal of Nursing and Public Health*, *5*(2), 302-312.

Lin, H. S., & Chen, C. C. (2002). Promoting pre-service chemistry teachers, understanding about the nature of science through history, *Journal of Research in Science Teaching, 39*(9), 773-792.

Mansour, N. (2010). Science teachers' interpretations of Islamic culture related to science education versus the Islamic epistemology and ontology of science. *Cultural Studies of Science Education*, 5, 127-140.

McDonald, C. V., & Abd-El-Khalick, F. (2017). Representations of nature of science in school science textbooks. In C. V. McDonald & F. Abd-El-Khalick (Eds.), *Representations of nature of science in school science textbooks: A global perspective* (pp. 1–19). London: Routledge.

Meyer, X., & Crawford, A. B. (2011). Teaching science as a cultural way of knowing: merging authentic inquiry, nature of science, and multicultural strategies. *Cultural Studies in Science Education*, 6, 525-547.

Michel, H. & Newmann, I. (2017). Nature of Science and science content learning the relation between students' nature of science understanding and their learning about the concept of energy. *Science & Education*, *25*(9), 951-975.

Ministry of Education. (2008). The Basic Education Core Curriculum B.E. 2551 (A.D.2008). Retrieved December 17, 2020, from http:// www.act.ac.th/document/1741.pdf.

NGSS. (2013). *Next generation science standards: for states, by states*. Washington, DC: National Academies Press.

Nelson, C. E., Scharmann, L. C., Beard, J., & Flammer, L. I. (2019). The nature of science as a foundation for fostering a better understanding of evolution. *Curriculum and Education*, *12*(6), 2-16.

Niyomwong, N. (2015)**.** *Improving teaching and learning process in science and technology for society and living (STSL) course to develop the understanding of nature of science: A Participatory Action Research*. (Doctoral dissertation, Kasertsart University).

Nur, E. M., & Fitnat, K. (2015). Explicit-reflective teaching nature of science as embedded within the science topic: Interactive historical vignettes technique. *Journal of Education and Training Studies*, *3*(6), 40-49.

Olusegun, S. B. (2015). Constructivism learning theory: a paradigm for teaching and learning. *IOSR Journal of Research & Method in Education*, *5*(6), 66-70.

Reid-Smith, J. A. (2013). *Historical short stories as nature of science instruction in secondary science classrooms: science teachers, implementation and students, reactions*. (Doctoral dissertation, The Iowa State University).

Safkolam, R., Khumwong, P., Pruekpramool, C., & Hajisamoh, A. (2017). Science teachers, understanding and teaching of nature of science in Islamic private schools in Yala Province. *Al-Hikmah*, *7*(14), 127-139.

Sangsa-ard, R., Thathong, K. & Chapoo, S. (2014). Examining grade 9 students, conceptions of the nature of science. *Procedia- Social and Behavioral Sciences*, *116*, 382-388.

Saree, M., Jorajit, S., & Nawsuwan, K. (2018). School' strategic management towards being a world-class standard school of Islamic private school schools in three southern border provinces of Thailand. *Princes of Narathiwas University Journal of Humanities and Social Sciences*, *6*(2), 89-102.

Schreier, M. (2012). *Qualitative content analysis in practice*. London: Sage.

Stinner, A., Klassen, S., & Mcmillan, B. A. (2003). The renewal of case studies in science education. *Science & Education*, *12*(7), 617-643.

Sutherland, D., & Dennick, R. (2002). Exploring culture, language and perception of the nature of science. *International Journal of Science Education, 24*(1), 25–36.

Tabel, K., Billingsley, B., Riga, F., & Newdick, H. (2011). To what extent do pupils perceive science to be inconsistent with religious faith? An exploratory of 13-14 years- old English pupils. *Science Education International*, *22(2),* 99-118.

Tolvanen, S., Jansson, J., Vesterinen, V. M., & Aksela, M. (2014). How to use historical approach to teach nature of science in chemistry education. *Science & Education*, *23*(8), 1605-1636.

Thiangchanthathip, K. (2016). *The development of HIER learning model for enhancing scientific conceptions, and the nature of science understanding of 10th grade students*. (Doctoral dissertation, Srinakharinwirot University).

Vongmontha, A. (2012). Developing the potential for educational management in Islamic private schools in three southern border Provinces. *Songklanakarin Journal of Social Science & Humanities*, *19*(1), 255-280.

Wan, Z. H., Wong, S. L., & Zhan, Y. (2013). When nature of science meets Marxism: aspects of nature of science taught by Chinese science teacher educators to prospective science teachers. *Science & Education*, *22*(5), 1115-1140.

Wicaksono, A. G., Minarti B. I., & Roshayanti, F. (2018). Analysis of students' science motivation and nature of science comprehension in middle school. *Indonesian Journal of Biology Education*, *4*(1), 35-42.

Williams, C. T., & Rudge, D. W. (2016). Emphasizing the history of genetics in an explicit and reflective approach to teaching the nature of science: a pilot study. *Science & Education*, 25, 407-427.

Winslow, M. W., Staver, J. R., & Scharmann, L. C. (2011). Evolution and personal religious belief: Christian university biology-related majors' search for reconciliation. *Journal of Research in Science Teaching*, *48*(9), 1026-1049.

Wolfenburger, B., & Canella, C. (2015) Cooperative learning about nature of science with a case from the history of science. *International Journal of Environmental & Science Education*, *10*(6), 865-889.