Scholarum: Journal of Education
www.scholarum.dlsl.edu.ph
Vol. 2, No. 2, March 2023

Research Article

Senior High School Students' Extent of Agreement with the Components of Nature of Science (NOS) through Socio – Scientific Issues (SSI)

Joy Talens, Ph.D.
De La Salle Lipa
joy.talens@dlsl.edu.ph

ARTICLE INFO
Article History
Date Received: January 8, 2023
Date Accepted: March 3, 2022
Keywords
Nature of Science, Socio-scientific Issues, Extent of Agreement

ABSTRACT

This study explored the extent of agreement with the components of Nature of Science (NOS) among the purposively chosen 112 Senior High School (SHS) students enrolled in the Humanities and Social Science (HUMMS) and Accountancy, Business and Management (ABM) strands after analyzing socio-scientific issues (SSI). The embedded mixed method design was utilized in this study by administering a questionnaire. Weighted arithmetic mean and deductive approach were used to analyze quantitative and qualitative data. The SHS students agreed to a great extent with the following components of NOS after analyzing SSI: scientific investigations use a variety of methods; science is a human endeavor; science models, laws, mechanisms, and theories explain natural phenomena; scientific knowledge is open to revision considering new evidence; science is a way of knowing; scientific knowledge is based on empirical evidence; and science addresses questions about the natural and material world. However, they agreed to a moderate extent that scientific knowledge assumes order and consistency in the natural world. SHS Science teachers should incorporate in their lessons different activities that will enable SHS students to understand fully how scientific knowledge assumes order and consistency in the natural world.

INTRODUCTION

With the recent advancement in science and technology, citizens are expected to be equipped with knowledge, understanding, attitudes, values, and skills as scientifically, technologically, and environmentally literate individuals. In response, the Department of Education emphasized that the K to 12 Science curriculum should highlight learning competencies needed to train future citizens with all the rudiments required in the field of work. As graduates of this curriculum, they are also expected to demonstrate 21st-century skills.

For students to become scientifically literate, the nature of science (NOS) should be emphasized as a critical part of the science curriculum to enhance students' understanding of science concepts and enable them to make informed decisions on scientifically based personal and societal issues (National Science Teaching Association, 2023). Incorporating NOS in the science curriculum should be given the utmost importance in honing future citizens to adapt to the situations and solve problems or issues they face. However, this has been subject to arguments by many researchers (Zeynep et al., 2022). It is a common observation among different reform movements that understanding the NOS should be given priority (Duruk

Scholarum: Journal of Education
www.scholarum.dlsl.edu.ph
Vol. 2, No. 2, March 2023

et al., 2022). In addition, integrating NOS in the K to 12 classes should be enunciated (Koumara, 2022).

As a characteristic of scientific knowledge, the Nature of Science (NOS) refers to key principles and ideas of knowledge (Teacherlink, 2016). Aside from teaching scientific concepts, principles, theories, and laws, students should gauge the roles of science in improving the quality of life. Most of the solutions to the problems humans encounter in this period of rapid modernization and globalization can be remedied by applying scientific knowledge. However, the question is how to apply scientific concepts to solve problems confronting society. There are debates on suitable pedagogies and approaches to explore the NOS (Brock & Park, 2022). Prioritizing the acquisition of deep learning in science among students on NOS should be emphasized (Mork et al., 2022). Scientific literacy can be optimally developed by combining NOS with an inquiry approach (Widowati et al., 2017). Likewise, science education focuses on the interactions between science and society rather than the student's cognitive development (Chowdhury et al., 2020).

As part of the inquiry approach, using socio-scientific issues (SSIs) is one of the activities that can be used in science classes to enhance students' extent of agreement with the components of NOS. Situations that happen in everyday life are the contents of SSI, which are used in teaching different topics in science (Fani & Argaman, 2022). SSIs are scientifically studied and community-oriented issues which are complex, open-ended, and generally controversial. Analyzing these issues does not require definite and clear answers (Sadler, 2004; Aydın & Moçan, 2019; Ozbugutu, 2022). They involve social dilemmas because of changes and innovations in science and technology today (Ucak & Saka, 2022).

It should be noted that many industrialized countries use SSI in the classroom because this strategy enables students to understand that science is real and more humane and subjected to human errors (Reis & Galvo, 2011). Studies have shown that SSI contributes to developing decision-making skills on local and global issues, understanding NOS, and allowing learners to discuss controversial issues (Lee et al., 2013; Akbulut & Demir, 2020; Ucak & Saka, 2022). Thus, to strengthen students' views of NOS to make them scientifically literate, SSI, which is context-dependent, gives students a chance to discuss controversial issues confronting society (Khishfe, 2022).

Notably, studies conducted on NOS are limited to the following: science teachers' views of NOS (Zeynep et al., 2022; Al-Omari, 2022; Utami et al., 2022); development of a questionnaire to determine teachers' views on NOS (Takriti, 2022); NOS and teachers' professional development program (Koumara, 2022); graduate students' views of NOS (Duruk et al., 2022); NOS in science textbooks (Atakan & Akcay, 2022); improving students' conceptions of NOS (Khisfe, 2022). Meanwhile, studies conducted on SSI focused on the following:

- opinions of science teachers on teaching SSI (Ozbugutu, 2022; Fani & Armagan, 2022)
- evaluation of trends in theses on SSI (Yapicioglu & Atabey, 2020)
- effectiveness of science textbooks based on SSI (Kurnianingrum et al., 2022)

Scholarum: Journal of Education
www.scholarum.dlsl.edu.ph
Vol. 2, No. 2, March 2023

- effectiveness of SSI in teaching (Iranada & Rosdiana, 2022)

The above studies focused separately on NOS and SSI. Sadler et al. (2002) examined the interrelationships between three areas of science education: the NOS, SSI, and critical thinking. Callahan (2009) explored possible relationships between an SSI-based curriculum and three outcome variables: nature of science understanding, reflective judgment, and argumentation skill. The two studies were conducted several years ago. The only study related to the present study on exploring SHS students' level of agreement with the components of NOS through SSI was conducted by Bungingo et al. (2022), which investigated the status of Senior Secondary Physics students' views of NOS in Rwanda.

The researcher conducted this study to explore the SHS students' extent of agreement with the components of NOS through SSI in Physical Science. The indicators for NOS were based on the Next Generation Science Standards for the States By the States for High School (National Academies Press, 2013). This study considered the extent of the agreement since assessing the NOS can be based on views, perspectives, beliefs, conceptions, ideas, knowledge, and understanding (Brock & Park, 2022). Likewise, social concerns, dilemmas, and ethical rules in SSI should not be considered separately from science (Fani & Argaman, 2022). Moreover, developing NOS conceptions among learners is context-dependent (Kishfe, 2022). Furthermore, classroom activities can be designed to integrate NOS and teach this didactically or directly (Nouri et al., 2021; Nouri & McComas, 2019; Sweeney

Research Questions

This study explored the SHS students extent of agreement with NOS's components through the SSI analysis. Specifically, it sought answers to the following:

1. What is the extent of SHS students' agreement with the components of NOS after analyzing SSI?
2. Which among the eight components of NOS SHS students agreed to the greatest extent?
3. Which among the eight components of NOS SHS students agreed to the least extent?

Theoretical Background

This study is anchored on the NOS and the use of SSI in teaching. NOS involves occasionally taught but critical working science qualities (Indiana University, 2016). Likewise, NOS for high school, which is included in the Next Generation Science Standards for the States By the States (National Academies Press, 2013), consists of the following themes or components:

- Scientific investigations use a variety of methods.
- Scientific knowledge is based on empirical evidence.
- Scientific knowledge is open to revision considering new evidence.
- Scientific models, laws, mechanisms, and theories explain natural phenomena.
- Science is a way of knowing.

Scholarum: Journal of Education
www.scholarum.dlsl.edu.ph
Vol. 2, No. 2, March 2023

- Scientific knowledge assumes order and consistency in natural systems.
- Science is a human endeavor.
- Science addresses questions about the natural and material world.

On the other hand, Levinson's school and social issues model on the use of SSI (2008) emphasized that understanding science will equip future citizens to embrace and express their opinions on issues that can be debated publicly and possibly become directly involved in solving the issues or problems. Likewise, according to this model, individuals will be able to understand the methods by which science derives the evidence for the claims made by scientists; appreciate the strengths and limits of scientific evidence; make a sensible assessment of risk; and recognize the ethical and moral implications of the choices that science offers for action (Levinson, 2008). Moreover, SSI is grounded on the suppositions that whatever the students learn in science class can be applied in everyday life (Levinson, 2008).

Figure 1 shows that SSI was used in this study as a technique for teaching different topics in Physical Science among SHS students in the core subject, Physical Science, to solve real-life problems affecting society members. These problems can be solved by applying Science concepts, principles, theories, and/or laws to demonstrate their content and performance masteries. SHS students agreed to a very great extent with any or all the components of NOS for them to become scientifically, technologically, and environmentally literate citizens in the future, which is one of the objectives of the Science curriculum in the K to 12 Program of the Philippines.

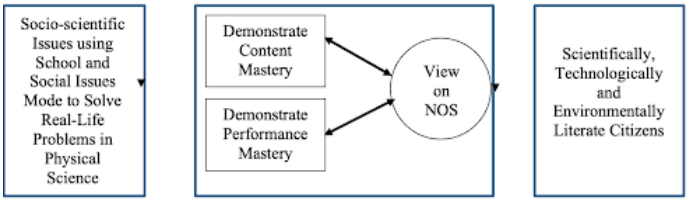

Figure 1: Theoretical Paradigm

MATERIALS AND METHODS

An embedded mixed-method research design was used to explore the participants' extent of agreement with the components of NOS among SHS students through SSI.

This study was conducted in the Senior High School of a private Catholic school in Lipa City, Batangas, Philippines, with the Grade 11 students enrolled in the K to 12 Program as participants.

The 112 Senior High School students enrolled in Physical Science during the First Semester of the School Year 2016 – 2017 participated in the study. They were purposively chosen based on their exposure to the use of SSI facilitated by the teacher-researcher. Likewise, these students completed their Junior High School under Accountancy, Business and Management (ABM) and Humanities and Social Sciences (HUMMS) in another school.

Research Instrument

A two-part questionnaire was the main instrument of this study. The first part of the questionnaire has 32 indicators in the form of a Likert scale which was based on the eight major themes or components of the Next Generation Science Standards for the States By

Scholarum: Journal of Education
www.scholarum.dlsl.edu.ph
Vol. 2, No. 2, March 2023

the States (National Academies Press, 2013) with the following scale:

6 – agreed to a very great extent
5 – agreed to a great extent
4 – agreed to a moderate extent
3 – agreed to some extent
2 – agreed to a limited extent
1 – did not agree at all

The continuum and interpretation below were also used to interpret the results:

5.16 – 6.00 – agreed to a very great extent
4.33 – 5.15 – agreed to a great extent
3.50 – 4.32 – agreed to a moderate extent
2.67 – 3.49 – agreed to some extent
1.84 – 2.66 – agreed to a limited extent
1.00 – 1.83 – did not agree at all

The second part of the questionnaire is an open-ended type to validate or verify the SHS students' answers in the first part of the instrument.

The questionnaire was based on the Next Generation Science Standards for States By States, which has eight themes or components to understand the Nature of Science (NOS). These standards emphasized that understanding the NOS depends on different groupings, and the indicators on each of the eight themes of NOS for the high school became the basis of this study.

Three Science Education professors from a teacher training institution validated the constructed questionnaire, and their suggestions and comments were incorporated in the revision of the instrument. Likewise, the instrument's reliability was established by conducting test-retest among 11 Second Year Bachelor of Elementary Education students who were not participants in this study. Using Cronbach Alpha to estimate the instrument's internal consistency, a reliability of 0.84 was obtained. This means that the constructed questionnaire has 84% consistency, which is reliable.

The SHS students, ages 16 to 18, were asked if they were willing to participate in this study, and all agreed. After giving their consent, an orientation was held, and it was emphasized that their involvement was voluntary. They were assured that their participation would be no risk in their participation in the study and would not entail payment. Likewise, it was made clear that the data collected would be used only for this study.

Statistical Treatment for Quantitative Analysis of Data

The frequency was used to determine the number of responses in each NOS indicator. The weighted arithmetic mean was used to measure each indicator's central tendency for each of the eight major components of NOS. The ranking was also used to determine which components the SHS students agreed upon to a certain extent.

Analysis of Qualitative Data

Since the themes were pre-selected based on the

Scholarum: Journal of Education
www.scholarum.dlsl.edu.ph
Vol. 2, No. 2, March 2023

eight major components of the NOS, the researcher used a deductive approach in analyzing qualitative data from the open-ended questionnaire.

The first step in the deductive approach is transcription, in which the researcher copied the respondents' answers in the open-ended questionnaire word for word. This is followed by familiarization with the students' answers, which the researcher read several times and printed in several copies to review the contents continuously. Then, the researcher identified each line that best fit the pre-selected codes, the eight major components of the NOS, to supplement or confirm the results of the quantitative analysis.

Data Gathering Procedure

First, the researcher decided that the School and Social Issues Model for Teaching SSI (Levinson, 2008) would be used in this study. This model considers the following: (1) hierarchy; (2) source of knowledge; (3) view of knowledge; (4) controversy; (5) pedagogy; and (6) assessment.

After identifying the issues to be used, Scientific Method was discussed with the integration of SSI. Then, SHS students shared their arguments with the members of their group based on the given guide questions.

The researcher administered the two-part questionnaire. Part 1 is a Likert scale questionnaire based on NOS's eight major themes or components. Part 2 is an open-ended questionnaire to validate or verify the SHS students' responses in the first part of the questionnaire. This is helpful to understand further the respondents' extent of agreement with the components of the NOS through SSI.

RESULTS AND DISCUSSION

Table 1 shows one of the components of NOS, "Scientific investigations use a variety of methods," which was agreed to a great extent with a weighted average mean of 4.92. Among the five indicators, the respondents agreed to a very great extent that "Different methods, tools, and techniques were used for scientific investigations to revise and discover new knowledge," which is the first in rank. This result is confirmed by the responses of the SHS students in the open-ended questionnaire that after analyzing SSI, they agreed that they, too, "use different methods of investigations through observing things; analyzing data; predicting what may happen; conducting experiments using varied approaches; gathering data; and, following steps and methods and procedures as they try to solve problems confronting or affecting society such as the use of electronic jeepney, the building of hydroelectric powerplant and unexpected occurrence of a tornado." For McLelland (2016), a repeatable and systematic approach should be used in studying science. The responses also confirmed that science education looks at the interactions between science and society rather than focusing only on the students' cognitive development toward meaningful learning (Chowdhury et al., 2020).

On the other hand, SHS students agreed to a great extent that "Diverse methods were used in scientific investigations to obtain data" as least in rank for the first component of NOS. They admitted that "the

Scholarum: Journal of Education
www.scholarum.dlsl.edu.ph
Vol. 2, No. 2, March 2023

methods used in scientific investigations depend on the phenomena to be observed because not all methods fit all phenomena." They also recognized that it is "difficult to obtain data using various methods in investigating the issues." They also acknowledged that it is "difficult to obtain data using various methods in investigating the issues." Narquizan (2016) explained that there is no one scientific method by which all science is done. New methods of investigation may be introduced in the process of investigating things; thus, methods and tools of investigation continue to evolve. This can be attributed to the claim of SHS students that "new methods of investigation may be introduced in the process of investigating things; thus, methods and tools of investigations do not stop evolving." Indeed, varied methods are used in conducting scientific investigations, and it is possible that data cannot be obtained by using the same procedures (Smithsonian Learning Lab, 2016).

Table 1. Scientific Investigations Use a Variety of Methods

Indicator	WAM	Rank	Verbal Interpretation
1. Diverse methods were used in scientific investigations to obtain data.	4.47	5	Agreed to a Great Extent
2. Scientific knowledge is advanced through the use of new technologies.	5.08	3	Agreed to Great Extent
3. A common set of values described scientific inquiry.	5.14	2	Agreed to a Great Extent
4. Disciplinary domains were the bases for organizing the practices of science.	4.70	4	Agreed to a Great Extent
5. Different methods, tools and techniques were used for scientific investigations to revise and discover new knowledge.	5.22	1	Agreed to a Very Great Extent
TOTAL	**4.92**		**Agreed to a Great Extent**

Legend: 5.16 – 6.00 – Agreed to a Very Great Extent; 4.33 – 5:15 – Agreed to a Great Extent; 3.50 – 4.32 – Agreed to a Moderate Extent; 2.67 – 3.49 – Agreed to Some Extent; 1.84 – 2.66 – Agreed to a Limited Extent; and 1.00 – 1.83 – Did not agree at all

Table 2 shows one of the eight components of NOS: "Scientific knowledge is based on empirical evidence with a weighted average mean of 4.60 with a verbal description of agreed to a great extent. Among the five indicators, SHS students agreed to a great extent that "Science involves coordinating patterns of evidence with the existing theory," which is top in rank. SHS students support this, as evident in their responses in the open-ended questionnaire that through SSI, they realized that "the reasons why scientific evidence is needed are the following: (1) to prove something;(2) to serve as a basis of all knowledge, truth or fact; (3) to look for evidence; (4) to widen scientific knowledge; (5) to validate theory; (6) to achieve the purpose of investigation; (7) to attain new knowledge; and, (8) to evaluate outcomes." They acknowledged that: "laws and facts are based on accepted evidence," "theories and laws are supported by evidence," "the more evidence available, the more reliable scientific claims are," and "no facts are made without evidence." However, there were SHS students who believed that: "not all evidence is true," "not all evidence are facts," "not all scientists observe thoroughly," and "some scientists rely on what they see." Indeed, science demands and relies on empirical evidence (Narguizian, 2016) or information acquired by observation (Bradford, 2015). In solving the issues, SHS students believed that decisions through patterns of evidence and perspectives of the members of the society might be changed.

Table 2. Scientific Knowledge is Based on Empirical Evidence

Indicator	WAM	Rank	Verbal Interpretation
1. Empirical evidence is the basis of science knowledge.	4.59	3	Agreed to a Great Extent
2.To evaluate explanations about natural systems/phenomena, science disciplines share common evidence.	4.22	4	Agreed to a Moderate Extent
3. Science involves interrelated patterns of evidence	4.88	1	Agreed to a Great Extent
4. Evidence are reinforced by science arguments	4.72	2	Agreed to a Great Extent
TOTAL	**4.60**		**Agreed to a Great Extent**

Legend: 5.16 – 6.00 – Agreed to a Very Great Extent; 4.33 – 5:15 – Agreed to a Great Extent; 3.50 – 4.32 – Agreed to a Moderate Extent; 2.67 – 3.49 – Agreed to Some Extent; 1.84 – 2.66 – Agreed to a Limited Extent; and 1.00 – 1.83 – Did not agree at all

On the other hand, SHS students agreed to a moderate extent that "in evaluating explanations about natural systems/phenomena, Science disciplines share common evidence" as least in rank and the only indicator that was agreed to a moderate extent. They concurred that "evidence is the basis of scientific knowledge through the "use of a trial-and-error method,"

Scholarum: Journal of Education
www.scholarum.dlsl.edu.ph
Vol. 2, No. 2, March 2023

"conducting an investigation," "setting – up experiments," analyzing data," gathering evidence," and "observing things." They recognized that through SSI analysis, development of NOS among learners is context dependent (Khishfe, 2022). An example is whether the tornado that occurred in Manila was caused by climate change. In analyzing SSI, SHS students investigated the formation of a tornado in different parts of the country before concluding and suggesting a possible solution. They also analyzed tornado formation through recorded observations found in different electronic sources. Indeed, science demands and relies on evidence (Narguizian, 2016) or information acquired by observation (Bradford, 2015). It can also be surmised that in solving the issues mentioned above, the respondents believed that "decisions through patterns of evidence, perspectives of the members of the society may be changed."

SHS students also agreed that "not all evidence is true." This confirmed the statement of Bradford (2016) that scientist is human and prone to error. Scientists have their own beliefs and experiences; they have a prior understanding of a certain topic; they have varied cultural backgrounds and training, as well as expectations and biases that may affect the results of the experiments (Science Learning Hub, The University of Waikato, 2016). Indeed, science education looks at the interactions between science and society rather than focusing only on the student's cognitive development toward meaningful learning (Chowdhury et al., 2020).

Table 3. Scientific Knowledge is Open to Revision in the Light of New Evidence

Indicator	WAM	Rank	Verbal Interpretation
1. Scientific explanations can be probabilistic.	4.56	3	Agreed to a Great Extent
2. Most scientific knowledge is subject to change based on new and/or reinterpretation of existing evidence	4.75	2	Agreed to a Great Extent
3. Scientific argumentation is used to clarify the relationships between ideas and evidence that may result in revision of an explanation	4.80	1	Agreed to a Great Extent
TOTAL	**4.70**		**Agreed to a Great Extent**

Legend: 5.16 – 6.00 – Agreed to a Very Great Extent; 4.33 – 5:15 – Agreed to a Great Extent; 3.50 – 4.32 – Agreed to a Moderate Extent; 2.67 – 3.49 – Agreed to Some Extent; 1.84 – 2.66 – Agreed to a Limited Extent; and 1.00 – 1.83 – Did not agree at all

Table 3 shows one of the components of NOS, "Scientific knowledge is open to revision in the light of new evidence," with a weighted average mean of 4.70 with a verbal description of agreed to a great extent. Although all the indicators are interpreted as Agreed to a great extent, "Scientific argumentation is used to clarify the relationships between ideas and evidence that may result in the revision of an explanation" is the first in rank. This is supported by the responses of the SHS students in the open-ended questionnaire that "even ideas have been presented as well as pieces of evidence and relationships have been established between them, time will come that they will be revised through time if there is new evidence found." They also recognized that "even scientific knowledge is supported by a wealth of data from repeated trials, it is not considered the final word." There are reasons why scientists continuously conduct experiments and challenge assumptions, findings, and results of previous studies (Teacherlink.org, 2016). Likewise, NOS is evidence-based, methodical, and founded on the origin of knowledge and its history (Lederman, 2007; McComas, 2019; Nouri & McComas, 2019; Osborne et al., 2003; Badmus & Jita, 2022).

On the other hand, SHS students agreed to a great extent that "Scientific explanations can be probabilistic" as the least in rank. This is evident in their re-

Scholarum: Journal of Education
www.scholarum.dlsl.edu.ph
Vol. 2, No. 2, March 2023

sponses: "by nature, human beings want to: satisfy their curiosity, explore the earth, and interpret things differently." They admitted that "man's personal beliefs also affect what human wants to revise his or her understanding of Science concepts if new evidence is found." According to the respondents: "all things evolve through times; nothing is permanent in this world; everything is temporary; and theories can be revised anytime." Likewise, "it is important to look into man's beliefs about science that it is: a never-ending process of learning; a never-ending search for knowledge; continuously growing; full of patterns and these patterns are most of the times unpredictable; and will always provide additional evidence or new ideas." They also explained that "revision in the light of new evidence can: improve knowledge, change perspective, and lead to continuous development or advancement." The Science Learning Hub, The Waikato University (2016) confirms the pronouncements. In decision-making, it is important to consider the relevant scientific knowledge, its reliability, origin, and limitations. It should also be remembered that science can be tested, verified, and questioned (Lederman, 2007; Osborne et al., 2003; Badmus & Jita, 2022).

Table 4. Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena

Indicator	WAM	Rank	Verbal Interpretation
1. Explanations in science are provided by theories and laws	4.22	5	Agreed to a Moderate Extent
2. A scientific theory is substantiated explanation of some aspect of the natural world before it is accepted. Likewise, theory is generally modified considering this new evidence when new evidence is discovered	4.84	2	Agreed to a Great Extent
3. The following are the tools in developing scientific theory: models, laws, mechanisms, and explanations	4.87	1	Agreed to a Great Extent
4. Laws are descriptions of the relationships among observable phenomena	4.72	3	Agreed to a Great Extent
5. Hypotheses are often used by scientist to develop and test theories and explanations	4.54	4	Agreed to a Great Extent
TOTAL	**4.64**		**Agreed to a Great Extent**

Legend: 5.16 – 6.00 – Agreed to a Very Great Extent; 4.33 – 5:15 – Agreed to a Great Extent; 3.50 – 4.32 – Agreed to a Moderate Extent; 2.67 – 3.49 – Agreed to Some Extent; 1.84 – 2.66 – Agreed to a Limited Extent; and 1.00 – 1.83 – Did not agree at all

Table 4 shows one of the eight major components of NOS, which is "models, laws, mechanisms and theories explain natural phenomena" with a weighted average mean of 4.64. and verbal description of agreed to a great extent. Among the five indicators under the fourth component which they agreed to a great extent is "The following are tools in the developing scientific theory: models, mechanisms and explanations" This is the first in rank among all the indicators. SHS students admitted in the open-ended questionnaire that "the following are the purposes of explaining natural phenomena through science models, laws, and mechanisms: to become realistic; to explain phenomena; and, to tackle history which are based on observations, experimentations and predictions". They added that "these models, laws and mechanisms originated from: the environment; natural phenomena; experiences; real life situations; natural disasters; man – made disasters; perceived by the senses; and patterns of previous event or happening". According to National Academy of Sciences (2016), through observations and ideas, models, laws, mechanisms, and theories originated that add to new or additional knowledge.

On the other hand, "Theories and laws provide explanations in science" got the least in rank and was the only component that was agreed upon to a moderate extent. The SHS responses support this: "theories are not facts; theories are not precise; not everything can be explained by science; there is a need for details; and not all things in nature are the same." This is evident when they were asked to solve problems confronting or affecting society, such as using electronic jeepneys, building hydroelectric powerplants, and unexpected occurrences of a tornado, which are media enhanced and affect people's lives. SHS students explained that "gaining knowledge of NOS is a great advantage in

Scholarum: Journal of Education
www.scholarum.dlsl.edu.ph
Vol. 2, No. 2, March 2023

finding solutions to the problems by being aware that ordinary people understand the decisions on those issues if models, mechanisms, and explanations can be provided to them." For them, "models, mechanisms, and explanations are provided to make scientific concepts become realistic; to explain phenomena and to tackle history." Thus, to develop informed decisions and judgments, students should learn to assess, evaluate, and critique data presented by media, reports, and advertisements as consumers of different products and services (Science Learning Hub, The University of Waikato, 2016).

Table 5. Science is a Way of Knowing

Indicator	WAM	Rank	Verbal Interpretation
1. Science is both a body of knowledge and process being used to extend this knowledge.	4.72	2	Viewed to a Great Extent
2. Science is a unique way of knowing	4.65	3	Viewed to a Great Extent
3. Science distinguishes from other ways of knowing through use of empirical standards, logical arguments, and skeptical review.	4.89	1	Viewed to a Great Extent
4. Science knowledge is history and includes refinement of, and changes to, theories, ideas, and beliefs over time.	4.23	4	Viewed to a Moderate Extent
TOTAL	4.62		Viewed to a Great Extent

Legend: 5.16 – 6.00 – Agreed to a Very Great Extent; 4.33 – 5:15 – Agreed to a Great Extent; 3.50 – 4.32 – Agreed to a Moderate Extent; 2.67 – 3.49 – Agreed to Some Extent; 1.84 – 2.66 – Agreed to a Limited Extent; and 1.00 – 1.83 – Did not agree at all

Table 5 shows one of the eight major components of NOS, "Science is a way of knowing," with a weighted average mean of 4.62 verbal description of agreed to a great extent. Among the four indicators, students viewed, to a great extent, "Science distinguishes from other ways of knowing through the use of empirical standards, logical arguments, and skeptical review," which is the first in rank. This is evident in how the SHS students describe science as: "a process of experimenting and discovering new things; explains phenomena on how things work; and it involves the search for reasons." Likewise, they agreed that "Science: can prove anything; is everywhere and anywhere; can explain everything; is right; can identify patterns in nature; and can reveal underlying problems." Therefore, it can be said that science is a product of people's efforts to find answers to many questions, as evident when they were asked to analyze SSI. NOS is founded on the origin of knowledge and its history (Lederman, 2007; McComas, 2019; Nouri & McComas, 2019; Osborne et al., 2003; Badmus & Jita, 2022).

On the other hand, the only indicator the SHS students agreed to a moderate extent is "Science knowledge is history and includes refinement of, and changes to, theories, ideas, and beliefs over time" as least in rank. SHS students responded that Science could not answer all questions. They also stated that Science is history because, according to them, there were instances presented in analyzing SSI, particularly on the issue of electronic jeepneys that no matter how they marketed the new vehicle as a solution to the problem of air pollution in the city, people are not used to it. They will still consider the local jeepney manufacturing industry even though there is no provision for reducing air pollutant emissions. Likewise, students need to understand NOS to use Science in their daily lives. They should learn to assess, evaluate, and critique data from media, reports, and advertisements as consumers of different products and services (Science Learning Hub, The University of Waikato, 2016).

Table 6. Scientific Knowledge Assumes an Order and Consistency in Natural Systems

Indicator	WAM	Rank	Verbal Interpretation
1. Scientific knowledge assumes that natural laws operate in the past, today and in the future	4.53	1	Agreed to a Great Extent
2. Science explains that the universe is a vast single system in which basic laws are consistent	3.86	2	Agreed to a Moderate Extent
TOTAL	**4.20**		**Agreed to a Moderate Extent**

Legend: 5.16 – 6.00 – Agreed to a Very Great Extent; 4.33 – 5:15 – Agreed to a Great Extent; 3.50 – 4.32 – Agreed to a Moderate Extent; 2.67 – 3.49 – Agreed to Some Extent; 1.84 – 2.66 – Agreed to a Limited Extent; and 1.00 – 1.83 – Did not agree at all

Table 6 shows one of the eight major NOS components, "Scientific knowledge assumes an order and consistency in natural systems," with a weighted av-

Scholarum: Journal of Education
www.scholarum.dlsl.edu.ph
Vol. 2, No. 2, March 2023

erage mean of 4.20 and a verbal description of agreed to a moderate extent. Students agreed to a great extent between the two indicators that "Scientific knowledge is based on the assumption that natural laws operate in the past, today, and in the future." They agreed that after analyzing and solving SSI that "Science: is everything; includes all aspects of the world; is part of everyday life; explains different phenomena; explains understanding about the world; is based on tested facts; involves questioning the beginning of everything; and evaluates explanation." They added that "Science laws are products of observation; prediction; explanation; evidence; proofs; investigations; theories; laws; natural phenomena; and patterns of occurrence." They concur that "there is a reason for everything; science knows it all; everything has scientific basis or bases; and science is systematic." Likewise, scientific knowledge is not absolute, as this involves tentative explanations based on experiments and observations (Nouri et al., 2021; Nouri & McComas, 2019; Badmus & Jita, 2022).

On the other hand, SHS students agreed to a moderate extent that "Science explains that the universe is a single vast system in which basic laws are consistent." They have doubts that "the universe is a single vast system in which basic laws are consistent." This is supported by their explanation that: "the world evolves; nature and humans change; profound changes occur in the universe; Scientific knowledge is not consistent; and Scientific knowledge lacks evidence". Thus, students need to understand science's nature to use it daily. They should develop informed decisions and judgments by learning to assess, evaluate, and critique data presented by media, reports, and advertisements as consumers of different products and services (Science Learning Hub, The University of Waikato, 2016).

Table 7 shows one of the eight major components of NOS, "Science is a human endeavor," with a weighted average mean of 4.83 and verbal description of agreed to a great extent. Among the five indicators, students agreed to a great extent "that Advances in technology are influenced by the progress of science," which is first in rank. SHS students responded that after analyzing SSI, they claimed and proved that: "since the start of civilization, humans already searched for knowledge to make life easier; "since ancient times, people were studying Science"; "humans make every product of technology; proven by humans"; "human exploration"; based on human observations of natural phenomena"; and "based on human experiences." These statements proved that the concept of SSI was developed as a bridge between science and its interactions within society (Sadler, 2004; Chowdhury et al., 2020).

Table 7. Science is a Human Endeavor

Indicator	WAM	Rank	Verbal Interpretation
1. Human endeavor, imagination and creativity resulted to scientific knowledge	4.89	2	Agreed to a Great Extent
2. The advancement in science are contributed by individuals and teams from many nations and cultures.	4.81	3.5	Agreed to a Great Extent
3. Scientists' backgrounds, theoretical commitments and fields of endeavor influence the nature of their findings	4.81	3.5	Agreed to a Great Extent
4. Advances in technology is influenced by progress of science	5.05	1	Agreed to a Great Extent
5. Science and engineering are influenced by society and society is influenced by science and engineering	4.62	5	Agreed to a Great Extent
TOTAL	**4.83**		**Agreed to a Great Extent**

Legend: 5.16 – 6.00 – Agreed to a Very Great Extent; 4.33 – 5:15 – Agreed to a Great Extent; 3.50 – 4.32 – Agreed to a Moderate Extent; 2.67 – 3.49 – Agreed to Some Extent; 1.84 – 2.66 – Agreed to a Limited Extent; and 1.00 – 1.83 – Did not agree at all

On the other hand, students also agreed to a great extent that "Science and engineering are influenced by society, and society is influenced by science and engineering" as least in rank. After analyzing and solving problems in SSI, they responded that "hu-

Scholarum: Journal of Education
www.scholarum.dlsl.edu.ph
Vol. 2, No. 2, March 2023

mans by nature are described as; are curious; are willing to learn; have inquisitive minds; need to pursue something; have the capacity to think; have the ability to come up with ideas; and can create knowledge." Indiana University (2016) emphasized that science is a social process involving people working collaboratively, sharing their works' results and findings at conferences, and publishing them in peer-reviewed journals. Each scientist has his or her own biases. In addition, NOS is a sociocultural and creative activity of scientists (Lederman, 2007; McComas, 2019; Nouri & McComas, 2019; Osborne et al., 2003; Badmus & Jita, 2022).

Table 8. Science Addresses Questions About the Natural and Material World

Indicator	WAM	Rank	Verbal Interpretation
1. Science cannot answer all questions	4.21	3	Agreed to a Moderate Extent
2. Science and technology may raise ethical issues	4.15	4	Agreed to a Moderate Extent
3. Science knowledge indicates what can happen in natural systems	4.60	2	Agreed to a Great Extent
4. Many decisions are not made using science alone, but on social and cultural contexts to resolve issues	4.77	1	Agreed to a Great Extent
TOTAL	**4.43**		**Agreed to a Great Extent**

Legend: 5.16 – 6.00 – Agreed to a Very Great Extent; 4.33 – 5:15 – Agreed to a Great Extent; 3.50 – 4.32 – Agreed to a Moderate Extent; 2.67 – 3.49 – Agreed to Some Extent; 1.84 – 2.66 – Agreed to a Limited Extent; and 1.00 – 1.83 – Did not agree at all

Table 8 shows one of the eight major components of NOS, "Science addresses questions about the natural and material world," with a weighted average mean of 4.43 and verbal description of agreed to a great extent. Among its four indicators, students agreed to a great extent that "Many decisions are not made using science alone, but on social and cultural contexts to resolve issues," which is first in rank. They agreed that: "the world is full of questions that need explanations; questioning is a product of curiosity; and questioning will never end." Combining descriptions and beliefs of SHS students will result in gaining new information; discovering that there is more to learn about this world; gaining different perspectives; and understanding the world. Likewise, NOS is sociocultural (Lederman, 2007; McComas, 2019; Nouri & McComas, 2019; Osborne et al., 2003; Badmus & Jita, 2022). Cultural influence has a place in NOS – the society in which science would be practiced must impact the direction of research (Nouri et al., 2021; Sweeney & McComas, 2022; Badmus & Jita, 2022).

On the other hand, students agreed to a moderate extent that "Science and technology may raise ethical issues" as the least in rank. They agreed that "science alone is not enough to satisfy the needs of the people." An example is the protest in constructing a hydroelectric power plant in Mindoro. People protested the construction of this renewable energy source because it affects the livelihood of those who depend on agriculture. On the other hand, the plant's construction aims to provide additional sources of clean energy to meet the country's demands for development and globalization. According to the students, no matter how noble the intention of constructing the power plant is, people will still question it because the primary concern is the satisfaction of their basic needs. Indeed, in this case, social and cultural aspects should provide answers to these queries. This confirms the claim of Narquizan (2016) on the historical, cultural, and social influences on science. However, ethical questions will always be raised in resolving these SSIs, particularly questions on ethical and moral issues. They confirmed that "science is part of everyday life that explains different phenomena; that is why questioning will never end." Through science, "questions about natural and material world abounds that resulted to gaining new information; discovering that there are more to learn about this world; gaining different perspectives; and

Scholarum: Journal of Education
www.scholarum.dlsl.edu.ph
Vol. 2, No. 2, March 2023

and understanding the world." For humans to understand what is happening in day-to-day life, understanding the Nature of Science (NOS) is vital.

Table 9. Summary of Results

Major theme of the NOS	WAM	Rank	Verbal Interpretation
1. Scientific investigations use a variety of methods	4.92	1	Agreed to a Great Extent
2. Scientific knowledge is based on empirical evidence	4.60	6	Agreed to a Great Extent
3. Scientific knowledge is open to revision considering new evidence	4.70	4	Agreed to a Great Extent
4. Science models, laws, mechanisms, and theories explain natural phenomena	4.72	3	Agreed to a Great Extent
5. Science is a way of knowing	4.62	5	Agreed to a Great Extent
6. Scientific knowledge assumes an order and consistency in the natural world	4.20	8	Agreed to a Moderate Extent
7. Science is a human endeavor	4.83	2	Agreed to a Great Extent
8. Science addresses questions about natural and material world	4.43	7	Agreed to a Great Extent
Total	**4.63**		**Agreed to a Great Extent**

Legend: 5.16 – 6.00 – Agreed to a Very Great Extent; 4.33 – 5:15 – Agreed to a Great Extent; 3.50 – 4.32 – Agreed to a Moderate Extent; 2.67 – 3.49 – Agreed to Some Extent; 1.84 – 2.66 – Agreed to a Limited Extent; and 1.00 – 1.83 – Did not agree at all

Table 9 shows that SHS students agreed to a great extent with all the components of the NOS, with a weighted average mean of 4.63. They ranked them as follows: Scientific investigations use a variety of methods; Science is a human endeavor; Science models, laws, mechanisms, and theories explain natural phenomena; Scientific knowledge is open to revision considering new evidence; Science is a way of knowing; Scientific knowledge is based on empirical evidence; Science addresses questions about natural and material world; and Scientific knowledge assumes order and consistency in the natural world.

Among the eight components of NOS, SHS students agreed to a great extent that scientific investigations use various methods, which they considered first in rank. They are aware that scientists use different methods of investigation through observing things, analyzing data, predicting what may happen, conducting experiments, using varied approaches, gathering data, and following steps, methods, and procedures. On the other hand, they agreed to a moderate extent that scientific knowledge assumes order and consistency in the natural world, which is the least in rank. SHS students agreed that world evolves; nature and humans change; profound changes occur in the universe; scientific knowledge is inconsistent; and scientific knowledge lacks evidence. The previous statements are why SHS students agreed to a moderate extent that scientific knowledge assumes order and consistency in the natural world. Thus, there is a need to emphasize in science classes the least agreed component of NOS using SSI to train students to come up with solutions and decisions based on scientific evidence as they demonstrate their content and performance masteries. Khisfee (2022) emphasized that the student's perceptions of what NOS is all about are context-dependent. These results contradict Bugingo et al. (2022) findings that many students strongly hold naïve views about all the targeted NOS aspects.

Discussion

It is important to consider that the main purpose of science education is not only on the student's cognitive development, but it should also emphasize that the interactions between science and society will result in meaningful learning (Chowdhury et al., 2020). Thus, combining NOS within the inquiry approach is imperative to optimize science learning (Widowati et al., 2017). Using SSI in science class is one way for students to understand NOS, an important component of science literacy.

This paper explored the SHS students' extent of agreement with the components of NOS through SSI in Physical Science class. After analyzing SSI, it was found that SHS students agreed to a great extent with the following eight major components of NOS

ranked as follows: Scientific investigations use a variety of methods; Science is a human endeavor; Science models, laws, mechanisms, and theories explain natural phenomena; Scientific knowledge is open to revision in light of new evidence; Science is a way of knowing; Scientific knowledge is based on empirical evidence; Science addresses questions about natural and material world; and, Scientific knowledge assumes order and consistency in the natural world.

The above results and findings align with the context of the Next Generation Science Standards (National Academies Press, 2013), from which the eight major themes of the NOS were based. According to these standards, High School students or graduates of High School Diplomas must meet all eight themes. It was found that SHS students agreed to a great extent that scientists use different methods of investigation through observing things, analyzing data, predicting what may happen, conducting experiments, using varied approaches, gathering data, and following steps, methods, and procedures. These may be done to find reasonable answers, find discoveries, prove something, find clues, validate theories, look for more information, enhance skills, know possibilities, search for evidence of proofs, revise or accept theories and be able to know what is right or wrong. As applied to the analysis of SSI, SHS students agreed that the methods and tools should be used and done first, even by ordinary citizens, before making any decisions for the common good.

In requiring students to analyze SSI, they were able to have a glimpse of NOS without directly teaching them about its eight major themes. SSI, which is context-dependent, gives them a chance to discuss controversial issues confronting members of society (Khishfe, 2022). They manifested decision-making skills on local and global issues and understood NOS (Akbulut & Demir, 2020; Ucak & Saka, 2022).

CONCLUSION AND RECOMMENDATIONS

Conclusion

After analyzing Socio Scientific Issues (SSI), SHS students agreed to a great extent with the following components of the Nature Of Science (NOS):

- Scientific investigations use a variety of methods.
- Science is a human endeavor.
- Science models, laws, mechanisms, and theories explain natural phenomena.
- Scientific knowledge is open to revision considering new evidence.
- Science is a way of knowing.
- Scientific knowledge is based on empirical evidence.
- Science addresses questions about the natural and material world.

However, SHS students agreed to a moderate extent that Scientific knowledge assumes order and consistency in the natural world.

Recommendations

Based on the results and findings of this study, SHS Science teachers should incorporate in their lessons different activities that will enable SHS students to

understand how scientific knowledge assumes order and consistency in the natural world.

REFERENCES

Akbulut, H.I. & Demir, O. (2020). Science Teachers' Views of Socio Scientific Issues. International Journal of Progressive Education, 16(1), 237-256. doi: 10.29329/ijpe.2020.228.17

Al-Omari, A.S. (2022). Science Teachers' Perceptions on the Nature of Science: Towards a Better Understanding of Science and its Reality. DOI: 10.31559/LCJS2022.11.6.1

Atakan, M. and Akcay, B. (2022). Representation of Changes about Nature of Science in Turkish Middle School Science Textbooks. Science and Education, DOI: 10.1007/s11191-022-00403-6

Aydın, E. & Kılıç Mocan, D. (2019). Socio-scientific issues in Turkey from past to present: A Document analysis, Anatolian Journal of Teacher, 3(2), 184-197, DOI: 10.35346/aod.638332.

Badmus, O and Jita, L. (2022). Didactic handout on Nature of Science: toward effective teaching of Physical Science curriculum. Science Education International, 33 (3) DOI: 10.33828/sei.v33.i3.6

Bradford, A. (2015). Empirical evidence: a definition. Retrieved: from: www.livescience.com.

Brock, R. and Park, W. (2022). Vol.:(0123456789) Science & Education. Retrieved from: https://doi.org/10.1007/s11191-022-00368-6

Bugingo, J. B., Yadav, L.L. and Mashood, K.K. (2022). Rwandan senior secondary Physics students' views on NOS. International Journal of Learning, Teaching and Educational Research 2 (11), 426-442, December 2022https://doi.org/10.26803/ijlter.21.11.24

Callahan, B.E. (2009). Enhancing the nature of science understanding, reflec tive judgment, and argumentation through socio-scientific issues. Retrieved from: https://www.researchgate.net/publica tion/241371396_Enhancing_nature_of_science_understanding_re flective_judgment_and_argumentation_through_socioscientific_is-sues

Chowhuwdry, Holbrook, J. and Ranikmae, M. (2020). Socio-scientific Issues within Science Education and their Role in Promoting the Desired Citizenry. Science Education International 31(2), 203-208 https://doi.org/10.33828/sei.v31.i2.10

Duruk, U., Kocabuk, A., & Cavus, E. (2022). Students' nature of science understandings: A phenomenological study. Education Quarterly Reviews, 5 (2), pp. 738-755. Available from: https://www.researchgate.net/publication/366237455_Students%27_Nature_of_Science_Understandings_A_Phenomenological_Study [accessed Jan 06 2023].

Fani, H. and Argaman, F. O. (2022). Science teachers' opinions on socio-scientific issues. Contemporary Educational Research Journal, 12 (3), 184 – 196.

Indiana University (2016). What is the nature of science? Retrieved: from: http://www.indiana.edu/~ensiweb/nos.html.

Iranada, A.G. and Rosdiana, L. (2022). Effectiveness of socio-scientific issues with mind mapping strategy on students learning outcomes on heat topic. J. Pijar MIPA, 17 (5), DOI: 10.29303/jpm.v17i5.3708

Khishfe, R. (2022). Improving students' conceptions of nature of science: A review of the literature. Science & Education DOI: 10.1007/s11191-022-00390-8

Koumara, A. (2022). History of pressure implemented in a Nature of Science Professional Development Program for science teachers Available from: https://www.researchgate.net/publication/365190375_History_of_Pressure_Implemented_in_a_Nature_of_Science_Professional_Development_Program_for_Science_Teachers

Kurnianingrum , A.M., Hariyadi, S. and Asyiah, I.N. (2022). Effectiveness of science textbooks on socio-scientific issues in global warming materials to improve learning outcomes. International Journal of Advanced Research 10(11):580-583 DOI: 10.21474/IJAR01/15701

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). Mahwah, NJ: Lawrence Erlbaum Associates.

Levinson, R. (2007). Towards a pedagogical framework for the teaching of controversial socio – scientific issues to secondary schools in the age range 14 – 19. Retrieved: from: http://eprints.ioe.ac.uk/47/.

Levinson, R. (2008). Promoting the role of the personal narrative in teaching controversial socio-scientific issues. Science and Education, 17, 855-871.

McComas, W.F. (2019). Principal elements of the nature of science: Informing science teaching while dispelling the myths. In: McComas, W.F. (Ed.), Nature of Science in Science Instruction. Berlin: Springer Academic.pp. 35-66

McLelland, C. V. (2016). The nature of science and the scientific method. Retrieved from: http://www.geosociety.org/educate/NatureScience.pdf.

Mork, S. M., Haug, B. S., Sorborg, O., Ruben, S. P., and Erduran, S. Humanising the nature of science: an analysis of the science curriculum in Norway. Retrieved from: https://www.researchgate.net/publication/361459906_Humanising_the_nature_of_science_an_analysis_of_the_science_curriculum_in_Norway.

National Science Teaching Association. (2023). Nature of science. Retrieved from: https://www.nsta.org/nstas-official-positions/nature-science

Narquizian, P. (2016). Exploring the nature of Science in the next generation science standards: understanding the Science of nature through the nature of Science. Retrieved from: http://www. Calstatela.edu/faculty/pnargui/.

National Academies Press. (2013). Understanding the scientific enterprise: the nature of science in the next generation Science standards. Retrieved: September 10, 2016, from: www.nextgenscience.org/sites/default.files.

Nouri, N., & McComas, W.F. (2019). History of science (HOS) as a vehicle to communicate aspects of nature of science (NOS): Multiple case of HOS instructors' perspectives regarding NOS. Research in Science Education, 51(1), 289-305.

Nouri, N., Saberi, M., McComas, W.F., & Mohammadi, M. (2021) Proposed teacher competencies to support effective nature of science instruction: A meta-synthesis of the literature. Journal of Science Teacher Education,32(6), 601-624

Osborne, J., Collins, S., Ratcliffe, M., Millar, R., & Duschl, R. (2003). What ideas-about-science should be taught in school science? A Delphi study of the expert community. Journal of Research in Science Teaching,40(7), 692-720

Ozbugutu, E. (2022). Opinions of science teachers who are graduate students on teaching socio scientific issues. Available from: https://www.researchgate.net/publication/363847090_Opinions_of_Science_Teachers_who_are_Graduate_Students_on_Teaching_Socio_Scien-

tific_Issues

Reis, P and Galvao, C. (2007). Teaching controversial socio – scientific issues in biology and geology classes: a case study. Retrieved from: www.academic.research.microsoft.com.

Sadler, T.D., Chambers, F.W. and Zeidler, D.L. (2002). Student conceptualizations of the nature of science in response to a socio-scientific issue. International Journal of Science Education, 26 (4), 387 – 409

Sadler, T .D. (2009). Contemporary trends and issues in science education#39: socio – scientific issues in the classroom; teaching, learning and research. Retrieved from: http://www.powells.com/biblio?show=HARDCOVER:NEW:978940007:150.50

Science Learning Hub, The University of Waikato (2016). The nature of science. Retrieved from: http://sciencelearn.org.nz/Nature-of-Science.

Smithsonian Learning Lab. (2016). Scientific investigations use a variety of methods. Retrieved from: https://www.learninglab.si.edu>standards>view.

Sweeney, S.J., & McComas, W.F. (2022). Early elementary (K-4) teachers' perception of the developmental appropriateness, importance, and potential for classroom inclusion of key nature of science aspects. Journal of Research in Science Teaching, 2022, 1-31

Takriti, R.A., Erduran, S., Tairab, H. and Alamirah, I.N. (2022). Translation and validation of a questionnaire for measuring teachers' views on nature of science. Research in Science and Technological Education, DOI: 10.1080/02635143.2022.2138846

Teacherlink. (2016). The butterfly project: the nature of science. Retrieved from: www.teacherlink.org/content/science/class_examples/Bflypages/nos.htm

Ucak, E. and Saka, C. (2022). The effect of using web 2.0 tools in the teaching of socio-scientific issues on pre-service science teachers. International Journal of Curriculum and Instruction, 14(3), 2679- 2710

Utami, I.S., Rochintaniawati, D., Risdiana, D. and Suwarma, I.R. (2022). Understanding the nature of science (NOS) of in-service science teachers: instructional practices and their implications on renewable energy. Journal Penelitian & Pengembangan Pendidikan Fisika 8(2):315-324 DOI: 10.21009/1.08213

Widowati, A. Widodo, E. Anjarsari, P. and Setuju. (2017). The development of scientific literacy through nature of science (NoS) within inquiry-based learning approach. International Conference on Science and Applied Science 2017. doi :10.1088/1742-6596/909/1/012067

Yapicioglu, A.E. & Atabey, N. (2020). Evaluation of trends in theses on socio-scientific issues: the case of Turkey. International Journal of Progressive Education, 16(4), 115-134. doi: 10.29329/ijpe.2020.268.8

Zeynep, M.D., Sungur, S. and Cakiroglu, J. (2022). Science teachers' views on the nature of science and its integration into instruction. Science & Education. Retrieved from: https://doi.org/10.1007/s11191-022-00409-0