European Journal of Education Studies
ISSN: 2501 - 1111
ISSN-L: 2501 - 1111
Available on-line at: www.oapub.org/edu

doi: 10.5281/zenodo.3365422

Volume 7 | Issue 6 | 2020

PRE-SERVICE TEACHERS' VIEW OF NATURE OF SCIENCE (NOS)

Philip Dorsah[i]
orcid.org/0000-0002-3314-2203
Department of Science,
Gambaga College of Education,
Ghana

Abstract:
The purpose of the study was to investigate pre-service teachers' view of nature of science (NOS). A descriptive survey design was used for the study. A convenience sampling technique was used to get the participants. Participants were made up of 231 level 100 pre-service teachers (119 males and 112 females) from five colleges of education in Ghana. All the colleges of education were under the same mentor university. Participants completed the view of nature of science questionnaire (NOSQ) through online learning platforms. Data was analyzed using descriptive and inferential statistics. The results revealed that in general pre-service have no adequate conceptions about nature of science. However, pre-service teachers have informed views of some aspects of nature of science. The results revealed that 56 (24.2%) of pre-service teachers have naïve view of NOS. The results also revealed that 89 (38.5%) of pre-service teachers have transitional view of NOS. The results also revealed that 86 (37.2%) of pre-service teachers have informed view of NOS. There was no significant difference in pre-service teachers view of NOS between males (M = 3.76, SD = .389) and females (M = 3.79, SD = .376), t (229) = -.707, p = .48. Therefore, we fail to reject the null hypothesis. One-way analysis of variance (ANOVA) showed no significant difference in pre-service teachers' view of NOS by programme options, [F (2,228) = .783, p = .458.]

Keywords: nature of science, scientific literacy, science education, teacher education, pre-service teachers

1. Introduction

1.1 Background

According to Cansız, Cansız, Tas, and Yerdelen (2017), Nature of science (NOS) has been a central topic in many international curriculum movements (e.g. American Association

[i] Correspondence: email pdorsah@gmail.com

for the Advancement of Science [AAAS], 1990, Bell, Matkins & Gansneder, 2011). Lederman (2007) posited that Nature of science (NOS) has received an increasing emphasis among researchers.

Research found that an understanding of the nature of science (NOS) is an important component of scientific literacy for all. Scientific literacy is a central goal for science education because it provides basic scientific understanding so that citizens can satisfactorily navigate through our technological world (Akerson & Buzzelli, 2007).

To be scientifically literate, it is not sufficient for students to have an understanding of only science content but also develop informed ideas about how scientists go about their work, along with the values they hold and assumptions they make while developing scientific knowledge, or NOS. Nature of science (NOS) refers to the epistemology of science, science as a way of knowing, or the values and beliefs inherent to the development of scientific knowledge (Lederman, 1992). According to Osborne (2007), cited in Findlay and Souter (2008), the primary goal of any science education should be to develop scientific literacy.

Ajaja (2012) proposed that science teachers must go beyond simply teaching science as a body of knowledge and that the focus should also be on developing scientific literacy. The role of science education in the socio-economic development of the societies and nations hardly needs any augments or discussions (Iqbal, Azam, & Rana, 2009). Iqbal et al (2009) added that students should be equipped with the ability to care and respond to the challenges and problems that develop in society, critical thinking, creative, problem solving and have a good understanding to apply the concept of science in problem solving. This ability can be achieved if students have scientific literacy.

Scientific literacy is a very important ability since it helps the individual to solve various problems due to rapid changes in the field of science and technology, both related to ethics, morals and global issues (Widowati, Widodo, Anjarsari, & Setuju, 2017).Nature of science (NOS) has been highlighted as critical component that prepare students as responsible citizens (Abd-El-Khalick, & Lederman, 2000; Halbrook & Rannikmae, 2007) and has become the central means to enhance the public's scientific literacy (Park et al., 2014). The strategic role of scientific knowledge in daily activities forced science educators to address the characteristic of scientific knowledge and the NOS issues through the school years (Karışan, & Cebesoy, 2018).

Teachers need to grasp at length about the Nature of Science content and be able to communicate this understanding effectively to students through various strategies or learning approaches (Widowati, Widodo, Anjarsari, & Setuju, 2017). It is widely agreed that understanding the nature of science (NOS) is an essential component of public engagement with science and scientific literacy (Millar, 2006).

DeBoer (2000) posit that Science is a particular way of looking at the natural world. Students should be introduced to this way of thinking and learn how to use it themselves since it is such an important means of generating knowledge of our world. Students should also be able to recognize when the methods of science are used correctly by others and when they are not. The validity of data, the nature of evidence, objectivity and bias, tentativeness and uncertainty, and assumptions of regularity and unity in the natural world are all important concepts for students to be aware of. At the same time, students need to recognize the limits of science and the power of other ways of thinking that are also functional in the world. There are emotional and spiritual aspects to our existence that fall outside the realm of science, and the line between these and the nature of scientific thought needs to be drawn so that students can more fully comprehend what science is and what it is not (DeBoer, 2000).

1.2 Problem Statement

Science forms an integral part of our everyday life and it is a universal truth that development of any nation scientifically and technologically is hinged on science. Science and Technology is the backbone of social, economic, political, and physical development of a country. Science is also concerned with the development of attitudes and therefore it is important for all citizens to be scientifically and technologically literate for sustainable development (National Council for Curriculum and Assessment [NaCCA], Ministry of Education [MOE], Ghana, 2019).Nature of science (NOS) forms part of the domains of scientific literacy and teachers' role in achieving scientific literacy as a country is very imperative.

Nature of science (NOS) refers to the assumptions, characteristics and methods of scientific inquiry (Rutledge, 2005). Lederman (1992) describes NOS as the "*epistemology and sociology of science, science as a way of knowing, of the values and beliefs inherent to scientific knowledge and its development.*" Understanding the nature of science is a key component of scientifically literate society according to the reform documents of the American Association for the Advancement of Science (AAAS) and the National Research Council (NRC) (Chiappetta & Koballa, 2010).

International curriculum reform organizations in science have called for sophisticated conceptions of NOS to be added as important learning outcomes in science education (National Science Teachers Association, 2003; American Association for the Advancement of Science [AAAS], 1990; Next Generation Science Standards, 2013).

Teachers' and pre-service teachers' NOS understandings are thought to have central role on students' NOS understandings (Akerson, Pongsanon, Rogers, Carter & Galindo, 2017; Khishfe, 2017). Research indicated that teachers understanding of NOS influence their students' NOS understandings (Yang, Han, Choi, Oh & Cho, 2005). The importance of teachers NOS conceptions calls for more investigations exploring and possibly enhancing individuals' NOS understandings (Abd-El-Khalick, 2003; Bell & Lederman, 2003).

Several attempts have been undertaken to enhance students and science teachers' NOS views. This is because science teachers have a significant influence on their students learning of nature of science (NOS). Science teachers need to have adequate knowledge about NOS to be able to include activities about NOS in his/her lessons. Science teachers must have a new and updated point of view about NOS if their students' views about NOS are to be improved (Sorensen Newton & McCarthy, 2012).

According to Prachagool and Nuangchalerm (2019), teachers are key elements to help students understand nature of science. They added that if teachers have accurate concepts and understandings, they can help students to meet the goal of science education (Prachagool & Nuangchalerm, 2019).

Students' understanding of the Nature of Science (NOS) has become a global important educational objective. In order to achieve this educational goal, there is the need to have teachers with adequate NOS views who can be able to teach NOS in their instructions.

Abd-El-Khalick and Lederman (2000) emphasized that a necessary but insufficient condition for promoting such instructions in the classroom is that the teachers themselves must have informed views of NOS.

Some of the conceptual difficulties encountered by students are associated with those of their teachers. Therefore, it is essential that pre-service science teachers possess an appropriate understanding of NOS and effective pedagogical practices in order to help their students to learn these ideas properly (Cakmakci, 2012). If teachers themselves do not hold informed conceptions of NOS, then they cannot help their students develop a well-formed and sophisticated view of science and scientific knowledge. This study therefore aimed to determine pre-service teachers' view of nature of science (NOS).

1.3 Research questions

The study sought to answer the following research questions:

1) What is pre-service teachers' view of nature of science (NOS)?
2) Is there any significant difference between male and female pre-service teachers NOS views?
3) Is there any significant difference between Junior High, Upper grade and Early grade pre-service teachers NOS views?

2. Materials and methods

2.1 Design

A descriptive survey design was used for the study. Survey research provides a quantitative or numeric description of trends, attitudes, or opinions of a population by studying a sample of that population. It includes cross-sectional and longitudinal studies using questionnaires or structured interviews for data collection-with the intent of generalizing from a sample to a population (Fowler, 2009, Creswell, 2014).

Descriptive research does not fit neatly into the definition of either quantitative or qualitative research methodologies, but instead it can utilize elements of both, often within the same study. The term descriptive research refers to the type of research question, design, and data analysis that will be applied to a given topic. Descriptive statistics tell what is, while inferential statistics try to determine cause and effect (The Association for Educational Communications and Technology [AECT], 2001).

2.2 Participants

Convenience sampling was used to select participants for the study. Convenience sampling (also known as Haphazard Sampling or Accidental Sampling) is a type of nonprobability or non-random sampling where members of the target population that meet certain practical criteria, such as easy accessibility, geographical proximity, availability at a given time, or the willingness to participate are included for the purpose of the study (Dornyei, 2007).

The main objective of convenience sampling is to collect information from participants who are easily accessible to the researcher (Palinkas, Green, Wisdom and Hoagwood, 2013).

The sample consisted of thirty (231) level 100 pre-service teachers (119 males and 112 females). All the participants completed introduction to integrated science (I) course in their first semester. All the participants were also registered and taking the course introduction to integrated science II, and were all in their second semester. The study was conducted in the second semester. All participants agreed to participate and completed the questionnaires to measure their views of NOS. The participants completed the questionnaire online through online learning platforms (Google classroom and WhatsApp platforms).

2.3 Instrument

The instrument, pre-service teachers' view of nature of science questionnaire (NOSQ) was adapted and modified from two instruments. The beliefs about the nature of science (BANOS), developed by (Shaakumeni & Csapó, 2019) and the Students' Ideas about Nature of Science (SINOS) developed by Chen, Chang, Lieu, Kao, Huang and Lin (2013).

The original BANOS consisted of 16 items under five constructs namely empirical, socio-cultural, subjectivity, the scientific method and tentativeness. All the 16 items in the BANOS were maintained and five items from the SINOS were added: two items under tentativeness of science and three items under science for boys and girls. The NOSQ consisted of 21 items which were declarative statements describing particular dimensions or aspects of the nature of scientific knowledge. The aspects of nature of science in the NOSQ are shown in table 5 below:

Table 1: NOS aspects and number of items in the NOSQ scale

NOS aspect	Items	Number of Items
Empirical nature of science	1,2,3,4,5	5
Socio-cultural	6,7,8	3
Subjective nature of science	9,10,11	3
Scientific method	12,13,14	3
Tentative nature of science	15,16,17,18	4
Science for all	19,20,21	3
Total items		**21**

The instrument was a five-point Likert scale (Cohen et al., 2007), namely 1 = strongly disagree, 2 = disagree, 3 = not sure, 4 = agree, and 5 = strongly agree. The statements were all worded positively so that a high score indicates more informed nature of science view.

2.4 Validity of the instrument

a. Beliefs about Nature of Science Questionnaire (BANOS)

The original BANOS was based on dimensions of the nature of science as a theoretical framework. The BANOS was administered to 860 Grade 12 students in Namibia, using the paper-and-pencil method (Shaakumeni & Csapó, 2019).The reliability of the BANOS was α = 0.87. Exploratory factor analysis (EFA) revealed a five-factor structure, and the factor solution accounted for 67.73% of the total variance. The final instrument of the BANOS consisted of 16 items (Shaakumeni & Csapó, 2019).

Table 2: Reliabilities of items in the BANOS (from Shaakumeni & Csapó, 2019)

Subscales	Mean	SD	number of items	Cronbach's alpha
Subjectivity	9.9	3	5	0.72
Empirical	16.5	5.1	3	0.83
Socio-cultural	8.84	3	3	0.76
Scientific methods	10.6	2.8	3	0.72
Tentativeness	6.5	2.8	2	0.75
BANOS	52.2	11.6	16	0.87

b. Students' Ideas about Nature of Science (SINOS)

Students' Ideas about Nature of Science (SINOS) was developed by Chen et al (2013). The SINOS measured seven constructs namely; views on theory-ladenness, use of creativity and imagination, tentativeness of scientific knowledge, durability of scientific knowledge, coherence and objectivity in science, the science for girls stereotype, and the science for boys stereotype. SINOS was constructed based on the written responses of 431 sixth graders, elementary students' quotations related to NOS, and student interviews. SINOS demonstrates good quality as shown by its internal consistency, construct validity, and predictive validity. The Cronbach's alphas of the subscales ranged between 0.67 and 0.84. The overall alpha was 0.85. (Chen et al, 2013).

2.5 Data collection and Analysis

Data was collected online through students' online learning platforms (Google classroom and WhatsApp). The questionnaire was design using a Google forms. The consent of students was first sought to participate in the study through their course tutors of the five colleges of education. The tutors were then asked to place the questionnaire in the students' online platforms. The data collection process took one week. The data was then exported from Google sheet into excel format, cleaned and coded.

Data was analyzed using IBM SPSS 21. Pre-service teachers' view of NOS was computed by summing up individual students' response to each item and dividing by the total number of items (21). This gave the view of nature of science score for each student. Descriptive statistics such as mean and standard deviation were computed for the view of NOS score. The mean scores, frequencies and percentages of each item were also computed. Pre-services teachers View of NOS was put into three categories based on their view of NOS score. The categories are naïve view of NOS (1-3.5), transitional view of NOS (3.6-3.9) and informed view of NOS (4-5). The view of NOS scores ranges and categories are shown in table 4 below:

Table 3: View of NOS score range and categories

View of NOS score range	NOS view
1-3.5	Naïve
3.6-3.9	Transitional
4-5	Informed

Independent samples t-test was performed to determine if any difference exist in views of NOS between males and female pre-service teachers. ANOVA was also used to determine if any significant difference exist in view of NOS by programme.

3. Literature review

3.1 Nature of Science (NOS)

Although there is no singular definition for NOS, it has been described as, "*the epistemology of science, science as a way of knowing, or the values and beliefs inherent to scientific knowledge and its development*" (Lederman, 2007, p. 833) as cited in Wong, Firestone, Ronduen & Bang, 2016).

It is also, "*the intersection of issues addressed by the philosophy, history, sociology, and psychology of science as they apply to and potentially impact science teaching and learning*" (McComas, Clough, & Almazroa, 1998, p. 5). Nature of science (NOS) is critical for teachers and learners of science since it authentically describes what science is, how it happens, and how scientific knowledge develops (AAAS, 1993; NSTA, 2000).

The nature of science (NOS) according to Gess-Newsome (2002) is the epistemological foundations of science, which include its empirical basis, tentativeness, subjectivity, creativity, unification, and its cultural and social embedded characteristics. The nature of science encapsulates the characteristics of science that make people understand scientific endeavours with less acquisition of cumbersome scientific knowledge. Scientists and science educators have emphasized the absence of a consensus among researchers and scientists on the meaning of the nature of science. They opined that the situation is so because the nature of science is multifaceted, ever-changing and convoluted. Like scientific knowledge, conceptions of the nature of science are ever dynamic and have witnessed different transformations throughout the development of science and scientific processes. Moreover, despite continuing disagreements about a particular definition of the nature of science, at a certain level of generality and within a set period, there is a shared perspective about the nature of science.

Although there is not one single definition of NOS, philosophers, historians, and science educators agree on common aspects of NOS (Erumit, Fouad & Akerson, 2019). These aspects include:

1) Scientific knowledge is tentative (subject to change in light of new evidence),
2) Scientific knowledge is empirically based (comes from observations of natural world),

3) Scientific knowledge is subjective (is theory-laden and influenced by personal experiences/biases, etc.),
4) There is no one way of doing science (the scientific method),
5) Scientific knowledge involves human inference, creativity, and imagination,
6) scientific knowledge is socially and culturally embedded (scientific knowledge is influenced from the cultures in which it is generated),
7) There is a distinction between observations and inferences (observations are based on five senses; however, inferences are not accessible to our five senses- inferences are explanations based on observations),
8) Theories and laws are different types of scientific knowledge; one does not become another and there is no hierarchy between them (Lederman, 2007, p. 833-834; Abd-El-Khalick and Lederman, 2000b; Lederman, Abd-El-Khalick, Bell, & Schwartz, 2002; Ayvacı, & zbek, 2019).

Chen et al included two additional constructs in their students' ideas of nature of science (SINOS) scale. These constructs are both about gender stereotypes and can be grouped as a category called, science for all. Both boys and girls can contribute to and participate in science (Chen, Chang, Lieu, Kao, Huang, & Lin, 2013). The constructs are science for girls and science for boys.

Nature of science involves understanding what science is and what role it plays; who scientists are and what roles they play; the nature of scientific evidence, observations, facts, rules, laws, and the scientific method; and how science is done (Taşar, 2003).

The American Association for the Advancement of Science (AAAS) [1990] have offered substantive issues relevant to the nature of science by dividing into 3 components include the scientific worldview, scientific inquiry, and scientific enterprise (Prachagool & Nuangchalerm, 2019).

Studies show that teachers possess naive understanding of NOS and often hold alternative conceptions about most of the NOS aspects (Buaraphan, 2009; Lederman, 1992). Research on the views of pre-service teachers show that the greater majority of them have several naive NOS views, which are inconsistent with contemporary interpretations of the NOS (Lederman, 2007).

3.2 Nature of Science (NOS) instruction

NOS instruction is vital for students' understanding of science. Students must have a firm understanding of what science is and what science is not, in order to be able to successfully assume a stance and scientifically support their position (Chiappetta & Koballa, 2010).

In order to increase knowledge of NOS, students and teachers must be exposed to explicit instruction of NOS either as an isolated concept or integrated into other scientific subject matter (Abd-El-Khalick, 2001; Khishfe & Abd-El-Khalick, 2002). Khishfe and Lederman (2007) found that regardless of whether the NOS instructional material was integrated or isolated, the gains were not significantly different. The key is the explicit instruction.

Various approaches have been taken to help students develop their NOS views. These approaches include historical, implicit, and explicit and reflective. The historical approach uses history of science for enhancing students' NOS views. The implicit approach employs inquiry- based hands-on science activities to enhance students' NOS views without explicitly discussing NOS. The explicit and reflective approach aims to explicitly refer to NOS aspects and reflect on these aspects in science lessons. In the explicit and reflective approach, students are introduced to NOS aspects in science activities and they cognitively reflect on the NOS aspects that they have used/experienced (Khishfe& Abd-El-Khalick, 2002). In the explicit and reflective approach, NOS activities might be either integrated in science content (contextualized) or separate NOS activities might be used to teach NOS aspects before integrating them in science content (decontextualized) (Akerson et al., 2013). This explicit instruction involves the planning and purposeful teaching of NOS concepts rather than expecting conceptions to occur as a byproduct of teaching strategies (Aikenhead, 1988 as cited by Lederman, 1999; Goeke, 2009).

There is emerging evidence that an explicit and reflective approach to the teaching of NOS is more effective than implicit approaches regarding students' conceptions of NOS (Lederman, 2006). Akerson, et al., (2006), found that pre-service elementary teachers' views of NOS were improved after a one semester science methods course that incorporated explicit NOS instruction.

Lederman, Lederman, and Antink, (2013), emphasize that we should no longer assume that students will come to understand NOS or scientific inquiry as a by-product of doing science-based or inquiry activities. Lederman et al (2013) added that NOS and scientific inquiry should be thought of as a "cognitive" rather than as an "affective" instructional outcomes. If students are expected to develop more adequate conceptions of NOS and scientific inquiry, then, as any cognitive objective, this outcome should be planned for, explicitly taught, and assessed. In regard to being explicit, literature states teachers must plan in advance to design lessons so students may be directly attended to NOS themes or topics (Herman, 2010).The second component of effective NOS instruction requires teachers facilitate their students to reflect on NOS ideas that have been explicitly identified. This involves effective pedagogical practices such as asking engaging questions, requiring journaling, student discussion, or other activities that force students to deeply wrestle with identified NOS themes. By requiring students to reflect on NOS issues in this manner they are better able to make connections between their classroom activities and the way science works (Clough, 2006).

According to Kim, Ko, Lederman, and Lederman (2005), NOS-specific pedagogical approaches can be categorized into either implicit or explicit and reflective. The implicit approach proposes that by engaging learners in inquiry-based activities, or exposing learners to episodes of history of science, they will also come to understand NOS. With respect to an inquiry-based approach, it is assumed that learners may be able to understand epistemological meanings behind "doing science" (Sandoval & Morrison, 2003).

The historical approach suggests the incorporation of history of science in science teaching is essential in order for learners to enhance their understandings of NOS. History of science has been viewed as having a significant role in learning NOS (Kim, Ko, Lederman, & Lederman, 2005).The approach assumes that learners will discern aspects of NOS embedded in historical episodes (Abd-El-Khalick, & Lederman, 2000). Research using implicit approach indicates that it is unlikely that learners can learn what teachers do not intentionally teach by simply engaging in inquiry-based activities or historical episodes.

3.3 Scientific literacy

Scientific literacy is the capacity to use scientific knowledge, to identify questions and to draw evidence-based conclusions in order to understand and help make decisions about the natural world and the changes made to it through human activity (Coll & Taylor, 2009). Coll and Taylor posit that scientific literacy has three dimensions;

First, scientific concepts, which are needed to understand certain phenomena of the natural world and the changes made to it through human activity. The main content of the assessment is selected from within three broad areas of application: science in life and health; science of the earth and the environment and science in technology.

Second, scientific processes, which are centered on the ability to acquire, interpret and act upon evidence.

Third, scientific situations, selected mainly from people's everyday lives rather than from the practice of science in a school classroom or laboratory, or the work of professional scientists.

Norris and Philips (2003) contend that the term scientific literacy has been used to include various components from the following:

1) Knowledge of the substantive content of science and the ability to distinguish from non-science;
2) Understanding science and its applications;
3) Knowledge of what counts as science;
4) Independence in learning science;
5) Ability to think scientifically;
6) Ability to use scientific knowledge in problem solving;
7) Knowledge needed for intelligent participation in science-based issues;
8) Understanding the nature of science, including its relationship with culture;
9) Appreciation of and comfort with science, including its wonder and curiosity;
10) Knowledge of the risks and benefits of science; and
11) Ability to think critically about science and to deal with scientific expertise.

Table 4: Most prevalent views of the NOS in international policy documents (from McComas et al., 1998, p. 6 cited in Suzuri-Hernandez, 2010)

1.	Scientific knowledge, while durable, has a tentative character.
2.	Scientific knowledge relies heavily, but not entirely, on observation, experimental evidence, rational arguments, and skepticism.
3.	There is no one way to do science (therefore, there is no universal step-by-step scientific method)
4.	Science is an attempt to explain natural phenomena.
5.	Laws and theories serve different roles in science; therefore, students should note that theories do not become laws even with additional evidence.
6.	People from all cultures contribute to science.
7.	New knowledge must be reported clearly and openly.
8.	Scientists require accurate record keeping, peer review and replicability.
9.	Observations are theory-laden.
10	Scientists are creative.
11.	The history of science reveals both an evolutionary and revolutionary character.
12.	Science is part of social and cultural traditions Science and technology impact each other.
13.	Scientific ideas are affected by their social and historical milieu.

3.4 Myths about nature of science (NOS)

McComas (1998) identified the following widely-held myths about nature of science (NOS).

Table 5: Widely-held myths about nature of science (NOS) (from McComas, 1998)

1.	Hypotheses become theories that in turn become laws.
2.	Scientific laws and other such ideas are absolute.
3.	A hypothesis is an educated guess.
4.	A general and universal scientific method exists.
5.	Evidence accumulated carefully will result in sure knowledge.
6.	Science and its methods provide absolute proof.
7.	Science is procedural more that creative.
8.	Science and its methods can answer all questions.
9.	Scientists are particularly objective.
10	Experiments are the principal route to scientific knowledge.
11.	Scientific conclusions are reviewed for accuracy.
12.	Acceptance of new scientific knowledge is straightforward.
13.	Science models represent reality.
14.	Science and technology are identical.
15.	Science is a solitary pursuit.

4. Results

4.1 Background characteristics of participants

The participants were level 100 pre-service teachers pursuing a four-year Bachelor of Education programme from five colleges of education. Table 6 summarizes their demographic characteristics. Males were 119 (51.5%) and females were 112 (48.5%). The ages of participants ranged between 18 and 40. Majority of the participants (140) aged between 18-23 representing 60.6%. eighty-seven of the aged between 24-30 representing 37.7% and four participants aged between 31-40 representing 1.7%.

The participants offered different options under the Bachelor of Education programme. The options are Junior High School programme, Upper grade programme and Early grade programme. The junior high school option consisted of 74 pre-service teachers representing 32%. The upper grade consisted of 109 pre-service teachers representing 47.2? and the Early grade consisted of 48 pre-service teachers representing 20.8%.

Table 6: Background variables of participants (N=231)

Category	n	(%)
Gender		
Male	119	51.5
Female	112	48.5
Total	**231**	**100**
Age		
18-23	140	60.6
24-30	87	37.7
31-40	4	1.70
Total	**231**	**100**
Programme		
Junior High School	74	32.0
Upper Grade	109	47.2
Early Grade	48	20.8
Total	**231**	**100**

4.2 Research question 1: What is pre-service teachers' view of nature of science (NOS)?

This question sought to find out pre-service teachers view of nature of science. Item analysis was performed on the 21 items of the NOS scale. Participants' responses to each item were summed and the means computed. Table 7 summarizes the descriptive statistics of responses to the items and table 8 shows the frequencies and percentages of responses. Table 9 presents NOS score ranges, NOS views and percentages by categories.

Table 7: Descriptive Statistics of NOS items (N = 231)

Item	Statement	N	M	SD
12	There is no single step-by-step method that all scientists in the world use.	231	2.80	1.34
5	Models such as atoms and species are products of human imagination.	231	3.00	1.26
7	The value of the culture determines how science is practiced.	231	3.20	1.19
6	Science is influenced by cultures.	231	3.23	1.23
18	Scientific knowledge is built on the knowledge of our predecessors, but might be wrong, and might be replaced.	231	3.59	1.01
10	Scientists' background and beliefs influence their work.	231	3.62	1.10
11	Scientists use their creativity to analyze data.	231	3.68	1.11
2	Experiments support rather than prove scientific claims.	231	3.73	1.13
4	Experiments are not the only source of scientific evidence.	231	3.74	1.09
3	Scientific theories are conclusions about observable phenomena.	231	3.83	1.01
14	Scientific laws are descriptions of the relationship among	231	3.87	0.85

	observable phenomena.			
15	Some scientific ideas today were different in the past.	231	3.92	0.99
8	Science is influenced by economic factors such as research funding.	231	3.94	0.91
1	Scientists can use human senses to make scientific claims.	231	3.94	0.91
9	Scientists can look at the same evidence or set of data and come up with different conclusions.	231	4.03	0.99
21	Girls have same capabilities for doing scientific research as well as boys.	231	4.03	1.05
16	Scientific ideas can change due advances in technology.	231	4.19	0.97
17	Scientific knowledge changes because people continue to change their views about the world and come up with new ideas.	231	4.19	0.82
20	Girls have talents for doing scientific research as well as boys.	231	4.24	0.86
13	Scientists use different procedures to study the natural world.	231	4.25	0.85
19	Girls are fit to be scientists as well as boys.	231	4.30	0.92

From Table 7, the results revealed that pre-service teachers view of NOS mean scores were higher for some items and low for other items. The mean scores for items 9, 13, 16, 17, 19, 20 and 21 ranged between 4.03 and 4.30. The mean scores for items 1,2,3,4,5,6,7,8,10,11,14,15 and 18 ranged between 3.00 and 3.94. The mean score for item 12 is 2.80 which is the lowest.

Table 8: Frequencies and percentages of responses of view of NOS items (N = 231)

	Strongly disagree		Disagree		Neutral		Agree		Strongly agree		Total	Total
Item	n	(%)	n	(%)	n	(%)	n	(%)	n	(%)	(n)	(%)
1	6	(2.6)	15	(6.5)	21	(9.1)	133	(57.6)	56	(24.2)	231	100
2	13	(5.6)	30	(13)	21	(9.1)	110	(47.6)	57	(24.7)	231	100
3	9	(3.9)	22	(9.5)	21	(9.1)	127	(55)	52	(22.5)	231	100
4	11	(4.8)	32	(13.9)	13	(5.6)	125	(54.)	50	(21.6)	231	100
5	26	(11.3)	74	(32)	36	(15.6)	63	(27.3)	32	(13.9)	231	100
6	22	(9.5)	58	(25.1)	29	(12.6)	90	(39)	32	(13.9)	231	100
7	18	(7.8)	64	(27.7)	31	(13.4)	90	(39)	28	(12.1)	231	100
8	4	(1.7)	20	(8.7)	21	(9.1)	128	(55.4)	58	(25.1)	231	100
9	9	(3.9)	13	(5.6)	17	(7.4)	114	(49.4)	78	(33.8)	231	100
10	7	(3)	43	(18.6)	30	(13)	101	(43.7)	50	(21.6)	231	100
11	14	(6.1)	29	(12.6)	21	(9.1)	120	(51.9)	47	(20.3)	231	100
12	48	(20.8)	68	(29.4)	20	(8.7)	72	(31.2)	23	(10)	231	100
13	5	(2.2)	6	(2.6)	15	(6.5)	105	(45.5)	100	(43.3)	231	100
14	2	(0.9)	16	(6.9)	41	(17.7)	123	(53.2)	49	(21.2)	231	100
15	6	(2.6)	24	(10.4)	17	(7.4)	120	(51.9)	64	(27.7)	231	100
16	8	(3.5)	11	(4.8)	9	(3.9)	103	(44.6)	100	(43.3)	231	100
17	2	(0.9)	9	(3.9)	22	(9.5)	107	(46.3)	91	(39.4)	231	100
18	10	(4.3)	26	(11.3)	48	(20.8)	112	(48.5)	35	(15.2)	231	100
19	5	(2.2)	9	(3.9)	17	(7.4)	80	(34.6)	120	(51.9)	231	100
20	1	(0.4)	14	(6.1)	16	(6.9)	97	(42)	103	(44.6)	231	100
21	5	(2.2)	27	(11.7)	14	(6.1)	94	(40.7)	91	(39.4)	231	100

Table 9: View of NOS score range and categories

View of NOS score range	NOS view	Items	n	%
1-3.5	Naïve	5,6,7,12,18	56	24.2
3.6-3.9	Transitional	1,2,3,4,8,10,11,14,15	89	38.5
4-5	Informed	9,13,16,17,19,20,21	86	37.2
Total			**231**	**100**

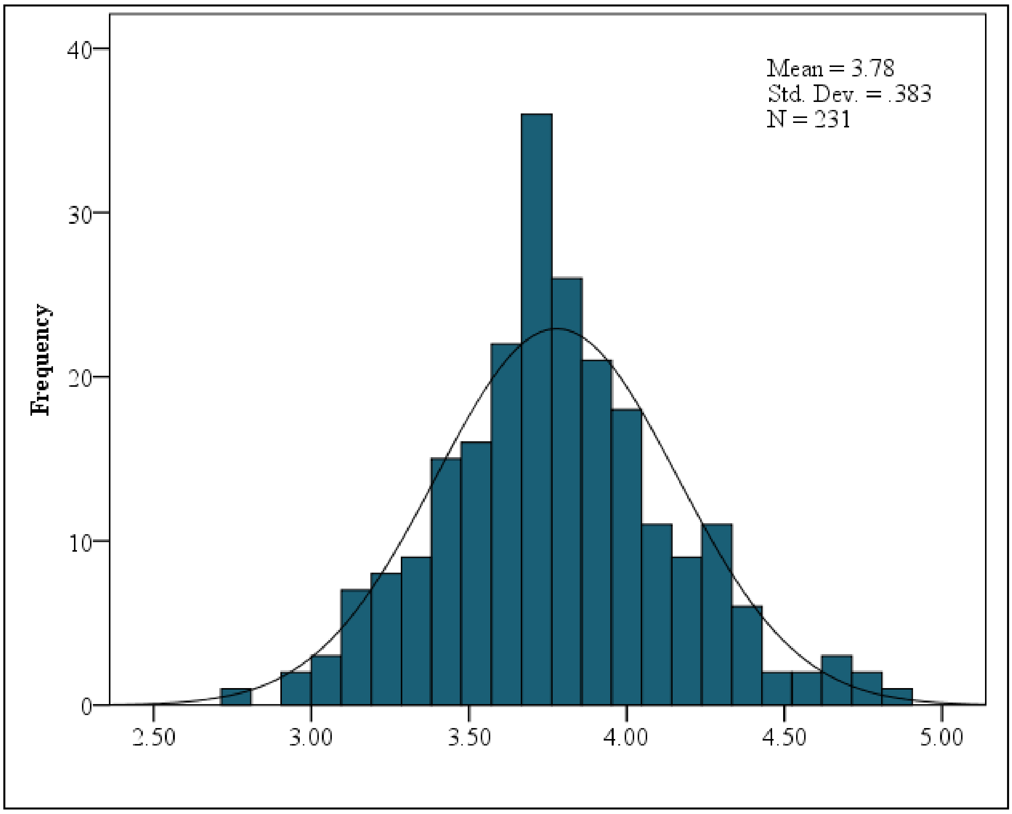

Figure 1: Distribution of NOS scores

From Table 9, the results revealed that 56 (24.2%) of pre-service teachers have naïve view of NOS. From the views of NOS categories, pre-service teachers have naïve view of NOS on items 5,6,7,12 and 18.

The items include: Models such as atoms and species are products of human imagination (item 5, empirical), Science is influenced by cultures (item 6, socio-cultural), The values of the culture determine how science is practiced (item 7, socio-cultural), There is no single step-by-step method that all scientists in the world follow (item 12, scientific method), Scientific knowledge is built on the knowledge of our predecessors, but it might be wrong and might be replaced (item 18, tentative).

The results also revealed that 89 (38.5%) of pre-service teachers have transitional view of NOS. Pre-service teachers have transitional view of NOS on the following items: Scientists can use human senses to make scientific claims (observations) [item 1, empirical], Experiments support rather than prove scientific claims (item 2, empirical), Scientific theories are conclusions about observable phenomena (item 3, empirical), Experiments are not the only source of scientific evidence (item 4, empirical), Science is influenced by economic factors such as research funding (item 8, socio-cultural), Scientists' backgrounds and beliefs influence their work (item 10, subjective), Scientists use their creativity to analyze data (item 11, subjective), Scientific laws are descriptions of the relationship among observable phenomena (item 14, scientific method) and Some scientific ideas today were different in the past (item 15, tentative).

The results also revealed that 86 (37.2%) of pre-service teachers have informed view of NOS. Pre-service teachers have informed view of NOS on the following items:

Scientists can look at the same evidence or set of data and come up with different conclusions (item 9, subjective), Scientists use different procedures to study the natural world (item 13, scientific method), Scientific ideas can change due to advances in technology (item 16, tentative), Scientific knowledge changes because people continue to change their view about the world and come up with new ideas (item 17, tentative), Girls are fit to be scientists as well as boys (item 19, science for all), Girls have talents for doing scientific research as well as boys (item 20, science for all) and Girls have same capabilities for doing scientific research as well as boys (item 21, science for all).

4.3 Descriptive statistics of aspects of view of NOS

It was revealed (see table 10) that socio-cultural influence of science recorded the lowest mean score (M = 3.45, SD = .786), followed by the scientific method (M = 3.64, SD = .624). Empirical nature of science recorded a mean score of 3.65, SD = .547. The third highest is the subjective nature of science (M = 3.78, SD = .737). The second highest aspect is tentative nature of science (M = 3.97, SD = .643). The aspect with the highest mean score is science for all (M = 4.19, SD = .782).

Table 10: Descriptive statistics view of NOS aspects in the (NOSQ) instrument

	N	Min	Max	M	Std. Dev
Empirical NOS	231	2	5	3.65	.547
Socio-cultural	231	1	5	3.45	.786
Subjective NOS	231	1	5	3.78	.737
Scientific method	231	2	5	3.64	.624
Tentative NOS	231	1	5	3.97	.643
Science for all	231	2	5	4.19	.782
Valid N	231				

4.4 Research question 2: Is there any significant difference between male and female pre-service teachers' view of NOS?

This question sought to find out if there is any difference in pre-service teachers' view of NOS between males and females pre-service teachers. To answer this question, Independent samples t-test was performed assuming equal variance. The result is presented in table 11. The results revealed that there was no significant difference in pre-service teachers view of NOS between males (*M* = 3.76, *SD* = .389) and females (*M* = 3.79, *SD* = .376), t (229) = -.707, *p* = .48. Therefore, we fail to reject the null hypothesis.

Table 11: Independent samples t-test of view of NOS scores by gender

Gender	N	M	SD	t	p
Male	119	3.76	0.389	-0.707	0.48*
Female	112	3.79	0.376		

*not significant, p > .05.

4.5 Research question 3: Is there any significant difference between Junior High, Upper grade and early grade pre-service teachers view of NOS?

This question sought to determine if there is any significant difference in pre-service teachers' view of NOS by programme options. To answer this question one-way ANOVA was performed. Table 12 shows the results of the ANOVA. The results showed that there was no significant difference in pre-service teachers' view of NOS by course options, [F (2,228) = .783, *p* = .458.]

Table 12: ANOVA of view of NOS scores by programme

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.230	2	.115	.783	.458*
Within Groups	33.448	228	.147		
Total	33.677	230			

*not significant, p > .05

Table 13: Descriptive statistics of pre-service teachers' view of nature of science based on programme

	N	M	SD	Std. Error
Junior High School	74	3.73	.410	.047
Upper grade	109	3.79	.369	.035
Early Grade	48	3.80	.369	.053
Total	231	3.77	.382	.025

4.6 Discussion

In general, pre-service teachers held some misconceptions about the nature of science (NOS). The results revealed that 24.2% of pre-service teachers have naïve views about NOS and 38.5% held transitional views about NOS. Some few pre-service teachers (37.2%) held informed view of NOS. it can be concluded that 62.7% of pre-service teachers held inaccurate conceptions of nature of science (NOS).

On specific nature of science aspects, it was revealed that socio-cultural influence of science recorded the lowest mean score (M = 3.45, SD = .786), followed by the scientific method (M = 3.64, SD = .624). Empirical nature of science recorded a mean score of 3.65, SD = .547. The third highest is the subjective nature of science (M = 3.78, SD = .737). The second highest aspect is tentative nature of science (M = 3.97, SD = .643). The aspect with the highest mean score is science for all (M = 4.19, SD = .782).

The results are consistent with other studies. For example, Akerson and Buzzelli (2007) found that all pre-service teachers except one held inadequate views of the empirical NOS, by recognizing the need for data collection to support scientific claims. Regarding the tentative NOS, Akerson and Buzzelli (2007) found reported that no pre-service teacher held informed views, those at the dualism position tended to respond in ways indicating they believed that scientists themselves do not change their minds. Jones (2010) reported that Over one-third of pre-service teachers' responses were classified as informed (36.8%) making the social and cultural aspect of NOS second only to the empirical aspect with regards to the number of participants with an informed understanding.

The majority of responses were scored as uninformed (55.3%) regarding differentiating between and properly describing a scientific law and scientific theory. Nearly 50% of participant responses would be indicative of an informed understanding of the empirical.

Karışan and Cebesoy, (2018) found that pre-service science teachers held informed views with respect to most of NOS aspects including empirical, subjective, tentative, creative, inferential, and sociocultural aspects.

On the relationship between theory and law, they found that although there were some informed views on this aspect (33%), most of the pre-service teachers (40%) posited naïve views about theory and law. Four of the pre-service teachers (27%) had transitional views about theory and law. Thirty-three (33%) showed naïve understanding of subjective NOS, 20% showed transitional views, and the remaining 47% showed informed views. They also found that 27% of pre-service teachers held naïve views about NOS, 13% held transitional view and 60% held informed view (Karışan & Cebesoy, 2018). On socio-cultural influence, 33% showed the transitional understanding of social-cultural aspects of NOS, while 67% showed informed views.

The study found that there was no significant difference in view of NOS between males and females pre-service teachers. This is consistent with other studies for example Adedoyin, and Bello, (2017), found that there was no significant difference in the number of correct conceptions about the nature of science held by male and female undergraduate pre-service teachers.

A chi-square analysis was conducted to compare the number of misconceptions about the nature of science held by male and female undergraduate pre-service biology teachers. There was no significant difference in the number of misconceptions about the nature of science held by undergraduate pre-service biology teachers. They also reported that undergraduate pre-service biology teachers held both correct conceptions and misconceptions about the nature of science. The finding suggests that undergraduate pre-service biology teachers held more misconceptions about the nature of science than correct conceptions. The gender difference in the conception of undergraduate pre-service biology teachers was found to be statistically insignificant.

5. Conclusion

From the findings pre-service teachers hold inadequate or naïve views of NOS, it is essential that NOS instruction be undertaken to improve their views of NOS such that they can provide appropriate instruction to their own future students. For example, Akerson and Buzzelli (2007) suggested explicit lessons about the tentative NOS couched in scientific inquiry that are then connected with a reflective discussion regarding multiple views and interpretation of the data may enable pre-service teachers to develop informed views. Pre-service teachers could engage in an activity that required them to build a circuit using a battery, bulb, and wire, for instance. The pre-service teachers should find several different ways to solve this problem (Akerson and Buzzelli, 2007).

Sharing the views of Wong, Firestone, Ronduen, and Bang, (2016), Science teachers need to understand NOS because it is a critical component of scientific literacy. If teachers themselves do not hold sophisticated conceptions of NOS, then they cannot help their students develop an informed and sophisticated view of science and scientific knowledge (Wong *et al,* 2016). Science teachers must hold accurate conceptions of NOS in order to cultivate students' conceptions of NOS and foster scientific literacy (Wong, Firestone, Ronduen, & Bang, 2016).

References

Abd-El-Khalick, F. (2001). Embedding nature of science instruction in pre-service elementary science courses: Abandoning scientism, but. ...Journal of Science Teacher Education, 12, 215–233.

Abd-El-Khalick, F. (2005). Developing deeper understandings of nature of science: The impact of a philosophy of science course on pre-service science teachers' views and instructional planning. International Journal of Science Education, 27(1), 15-42.

Abd-El-Khalick, F., & Laderman, N. G. (2008). Improving science teachers' conceptions of the nature of science: A critical review of literature. International Journal of Science Education, 22(7), 665-701.

Abd-El-Khalick, F., & Lederman, N. G. (2000a). Improving science teachers' conceptions of the nature of science: A critical review of the literature. International Journal of Science Education, 22(7), 665-701.

Abd-El-Khalick, F., Lederman, N. G., Bell, R. L., & Schwartz, R. S. (2001). Views of Nature of Science Questionnaire (VNOS): Toward Valid and Meaningful Assessment of Learners' Conceptions of Nature of Science. *Proceedings of the Annual Meeting of the Association for the Education of Teachers in Science (Costa Mesa, CA, January 18-21, 2001).*

Adedoyin, A. O., & Bello, G. (2017). Conceptions of The Nature of Science Held by Undergraduate Pre-Service Biology Teachers in South-West Nigeria. *Malaysian Online Journal of Educational Sciences, 5*(1).

Ajaja, P. O. (2012). Senior Secondary School Science Teachers in Delta and Edo States Conceptualization about the Nature of Science. *International Education Studies, 5*(3). doi:10.5539/ies.v5n3p67

Akerson, V. L., & Buzzelli, C. A. (2007). Relationships of Preservice Early Childhood Teachers' Cultural Values, Ethical and Cognitive Developmental Levels, and Views of Nature of Science. *Journal of Elementary Science Education, 19*(1), 15-24.

Akerson, V. L., & Volrich, M. (2006). Teaching nature of science explicitly in a first-grade internship setting. Journal of Research in Science Teaching, 43, 377-374

Akerson, V. L., Abd-El-Khalick, F., & Lederman, N. G. (2000). Influence of a reflective explicit activity-based approach on elementary teachers' conceptions of nature of science. Journal of Research in Science Teaching, 37(4), 295-317.

Akerson, V. L., Pongsanon, K., Rogers, M. A. P., Carter, I., & Galindo, E. (2017). Exploring the use of lesson study to develop elementary pre-service teachers' pedagogical content knowledge for teaching nature of science. International Journal of Science and Mathematics Education, 15(2), 293-312.

Akerson, V., Morrison, J., & McDuffie, A. (2006). One course is not enough: Pre-service elementary teachers; retention of improved views of nature of Teaching science, Journal of Research in Science 43(2), 194-213.

American Association for the Advancement of Science (AAAS). (1993). Benchmarks for science literacy. New York: Oxford University Press.

American Association for the Advancement of Science [AAAS]. (1990). Science for all Americans. New York: Oxford University Press.

Ayvacı, H. Ş., & zbek, D. O. (2019). The Effect of Documentary Films on Preservice Science Teachers' Views of Nature of Science. *J.Sci.Learn, 2*(3), 97-107. doi:10.17509/jsl.v2i3.17998.

Bell, R., Matkins, J.& Gansneder, B. (2011). Impacts of Contextual and Explicit Instruction on Preservice Elementary Teachers' Understandings of the Nature of Science. Journal of Research in Science Teaching. 48. 414 - 436. 10.1002/tea.20402.

Cakmakci, G. (2012). Promoting Pre-service Teachers' Ideas about Nature of Science through Educational Research Apprenticeship. *Australian Journal of Teacher Education*, *37*(2).

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

Chen, S., Chang, W.-H., Lieu, S.-C., Kao, H.-L., Huang, M.-T., & Lin, S.-F. (2013). Development of an Empirically Based Questionnaire to Investigate Young Students' Ideas About Nature of Science. *Journal of Research in Science Teaching, 50*(4), 408-430. doi:10.1002/tea.21079.

Chiappetta, E. L., & Koballa, T. R. (2010). Science instruction in the middle and secondary schools. Boston, MA: Allyn and Bacon.

Clough, M.P. (2006). Learners' responses to the demands of conceptual change: Considerations for effective nature of science instruction. Science Education, 15, 463-494.

Coll, R. K., & Taylor, N. (Eds.). (2009). *Special Issue on Scientific Literacy* (Vol. 4): International Journal of Environmental & Science Education.

Creswell, J. W. (2014). Research Design: Qualitative, Quantitative and Mixed Methods Approaches (4th ed.). London: Sage Publications Ltd.

DeBoer, G. E. (2000). Scientific Literacy: Another Look at Its Historical and Contemporary Meanings and Its Relationship to Science Education Reform. *Journal of Research in Science Teaching, 37*(6), 582-601.

Dornyei, Z. (2007). Research methods in applied linguistics. New York: Oxford University Press. 336 pages.

Erumit, B. A., Fouad, K. E., & Akerson, V. L. (2019). How Do Learner-Directed Scientific Investigations Influence Students' Questioning and Their Nature of Science Conceptions? *International Journal of Education in Mathematics, Science and Technology (IJEMST), 7*(1), 20-31. doi:10.18404/ijemst.509246.

Findlay, M., & Souter, N. (2008). Student teachers views on the nature of science: do they change during a one year pre-service programme? Paper presented at the British Educational Research Association Annual Conference, Heriot-Watt University, Edinburgh.

Fowler, F. J. (2009). *Applied Social Research Methods: Survey research methods (4th ed.)*. Thousand Oaks, CA: SAGE Publications, Inc. doi: 10.4135/9781452230184

Gess-Newsome, J. (2002). The use and impact of explicit instruction about the nature of science and science inquiry in an elementary science methods course. Science and Education, 11(15), 55–67.

Goeke, J. L. (2009). What is explicit instruction? Explicit Instruction: A Framework for Meaningful Direct Teaching (pp. 1-14). Upper Saddle River, NJ: Pearson Education.

Herman, B. C. (2010). Teaching the nature of science: Practices and associated factors. Graduate Theses and Dissertations. doi: https://lib.dr.iastate.edu/etd/11431

Iqbal, H. M., Azam, S., & Rana, R.A. (2009). Secondary school science teachers' views about the nature of science. Bulletin of Education and Research, 31(2); 29-44

Jones, W. I. (2010). Examining Preservice Science Teacher Understanding of Nature of Science: Discriminating Variables on the Aspects of Nature of Science. Faculty Dissertations, 38. http://digitalcommons.cedarville.edu/faculty_dissertations

Karışan, D., & Cebesoy, Ü. B. (2018). Exploration of Preservice Science Teachers' Nature of Science Understandings. Pamukkale Üniversitesi Eğitim Fakültesi Dergisi (PAU Journal of Education), 44, 161-177 doi:10.9779/PUJE870

Khishfe, R. (2017). Consistency of nature of science views across scientific and socio-scientific contexts. International Journal of Science Education, 39(4), 403-432.

Khishfe, R., & Abd-El_Khalick, F. (2002). Influence of explicit and reflective versus implicit inquiry-oriented instruction on sixth graders' views of nature of science. Journal of Research in Science Teaching, 39, 551-578.

Kim, B. S., Ko, E. K., Lederman, N. G., & Lederman, J. S. (2005). A Developmental Continuum of Pedagogical Content Knowledge for Nature of Science Instruction. Paper presented at the Annual Meeting of the National Association for Research in Science Teaching, Dallas, Texas.

Lederman, N. G, Abd-El-Khalick, F, Bell, R. L., &Schwartz, R. S. (2002). Views of nature of science questionnaire (VNOS): Towards valid and meaningful assessment of learners' conceptions of nature of science. Journal of Research in Science Teaching, 39, 497-521

Lederman, N. G. (1992). Students' and teachers' conceptions of the nature of science: A review of the research. Journal of Research in Science Teaching, 29(4), 331-359.

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). London: Lawrence Erlbaum Associates.

Lederman, N. G., Lederman, J. S., & Antink, A. (2013). Nature of Science and Scientific Inquiry as Contexts for the Learning of Science and Achievement of Scientific Literacy. *International Journal of Education in Mathematics, Science and Technology (IJEMST), 1*(3), 138-147.

McComas, W. F., Clough, M. P., & Almazroa, H. (1998). A review of the role and character of the nature of science in science education. In W. F. McComas (Ed.). The Nature of Science in Science Education: Rationales and Strategies. Kluwer Academic Publishers. (pp. 3-39).

Millar, R. (2006). Twenty first century science: Insights from the design and implementation of a scientific literacy approach in school science. International Journal of Science Education, 28(13), 1499-1521.

MOE. (2019). Science Curriculum for Primary Schools. National Council for Curriculum and Assessment (NaCCA), Ministry of Education, Ghana.

National Science Teachers Association. (2000). NSTA position statement: The nature of science. Washington, DC: Author.

National Teaching Council [NTC]. (2017). National teachers' standards (NTS) for Ghana Guidelines. *Published by the Ministry of Education (Ghana), under Creative Commons Attribution-ShareAlike*.:Available online at www.t-tel.org/hub.html

NGSS, Lead States (2013). Next generation science standards: For states, by states (Vol. 1 and 2). Washington, DC: The National Academies Press.

Norris S. P., & Phillips, L. M. (2003). How literacy in its fundamental sense is central to scientific literacy. Science Education, 87, 224-240.

Osborne, J. (2007). Science Education for the Twenty First Century. Eurasia Journal of Mathematics, Science & Technology Education, 3(3), 173-184.

Palinkas, L. A., Horwitz, S. M., Green, C. A., Wisdom, J. P., Duan, N., & Hoagwood, K. (2013). Purposeful sampling for qualitative data collection and analysis in mixed method implementation research. *Administration and policy in mental health and mental health services research*, *42*(5), 533-544. http://dx.doi.org/10.1007/s10488-013-0528-y

Prachagool, V., & Nuangchalerm, P. (2019). Investigating understanding the nature of science. *International Journal of Evaluation and Research in Education (IJERE), 8*(4), 719-725. doi:10.11591/ijere.v8i4.20282

Sadler, T., Chambers, F., & Zeidler, D. (2004). Student conceptualizations of the nature of science in response to a socioscientific issue. International Journal of Science Education, 26, 387-409.

Sandoval, W. A., & Morrison, K. (2003). High school students' ideas about theories and theory change after a biological inquiry unit. Journal of Research in Science Teaching, 40(4), 369-392.

Shaakumeni, S. N., & Csapó, B. (2019). Exploring the Factorial Validity of the Beliefs about Nature of Science Questionnaire. *Science Education International, 30*(1), 38-44.

Sorensen, P., Newton, L., & McCarthy, S. (2012). Developing a science teacher education course that supports student teachers' thinking and teaching about the nature of science. Research in Science & Technological Education, 30(1), 29-47.

Taşar, M. F. (2003). Teaching history and the nature of science in science teacher education programs. Pamukkale University Journal of Education, 1(13), 30-42.

The handbook of research for Educational Communications and Technology [AECT]. (2001). The Association for Educational Communications and Technology. Retrieved from http://members.aect.org/edtech/ed1/41/41-01.html on 23/05/2020

Widowati, A., E. Widodo, P. Anjarsari, & Setuju (2017). The Development of Scientific Literacy through Nature of Science (NoS) within Inquiry Based Learning Approach. *International Conference on Science and Applied Science, IOP Conf. Series: Journal of Physics: Conf. Series 909*. doi:10.1088/1742-6596/909/1/012067

Wong, S. S., Firestone, J. B., Ronduen, L. G., & Bang, E. (2016). Middle School Science and Mathematics Teachers' Conceptions of the Nature of Science: A One-Year Study on the Effects of Explicit and Reflective Online Instruction. *International Journal of Research in Education and Science (IJRES), 2*(2), 469-482.

Yang, I. H., Han, K. G., Choi, H. D., Oh, C. H., & Cho, H. J. (2005). Investigation of the Relationships between Beginning Elementary Teachers' Beliefs about the Nature of Science, and Science Teaching and Learning Context. *Journal of Korean Elementary Science Education*, *24*(4), 399-416.

Zeidler, D., Walker, K., Ackett, W., & Simmons, M. (2002). Tangled up views: Beliefs in the nature of science and responses to socioscientific dilemmas. Science Education, 86, 343-367.