Ilkogretim Online - Elementary Education Online, 2020; 19 (1): pp. 118-132
http://ilkogretim-online.org.tr
doi:10.17051/ilkonline.2020.644890

Middle school science teachers' understanding of nature of science: A q-method study[1/2]

Günkut Mesci, *Giresun Üniversitesi, Education Faculty,* Turkey, *gunkutmesci@gmail.com*
ORCID: 0000- 0003-0319-5993
William W. Cobern, *Western Michigan University, Mallinson Institute for Science Education,* U.S., *bill.cobern@wmich.edu* ORCID: 0000-0002-0219-203X

Abstract: Science education programs aim to develop scientific literacy. "Nature of Science" (NOS) has been recognized as an important part of scientific literacy, and science teachers are the crucial actors to achieve this goal. The purpose of this Q-method study is to describe how middle school science teachers understand NOS. The subjects for this study were six middle school in-service science teachers. Statements from the Nature of Science Scale (NOSS) were used for a Q-sort and then analyzed to determine teachers' subjective understanding of NOS. The analysis involved rotating the Q sorts using graphical and varimax rotations and then extracting the significant factors. According to analysis, the results indicate the teachers in this study believed that there is only one scientific method that all scientists should follow it. Also, they thought that the importance of team research and the purpose of scientific work to be for the betterment of human life.

Keywords: Nature of science, q method, in-service science teachers

Received: 30.01.2019	Accepted: 01.03.2019	Published: 15.01.2020

INTRODUCTION

Science education programs in many countries promote effective teaching and learning in science classrooms for the purpose of developing scientifically literate students, and Nature of Science (NOS) has been considered a part of scientific literacy in science education reforms (AAAS, 1993; MEB, 2018; NRC, 1996). Reform documents such as the Benchmarks for Science Literacy (AAAS, 1993), Next Generation Science Standards (NGSS, 2014), and the National Science Teachers Association position statement on NOS (2009) suggest that teachers of all grade levels need to help students develop an informed understanding of NOS as a component of developing scientific literacy. Science teachers are perhaps the most important factor to achieve this broad goal. Science education researchers have pointed out the importance of teachers' understanding of NOS and have assumed that there was a correspondence between teachers' views about science and the way in which they deal with related issues in class (e.g. Akerson, Abd-El-Khalick, & Lederman, 2000; Eichenger, Abell, & Dagher, 1997; McDonald, 2010; Osborne, Collins, Ratcliff, Millar, & Duschl, 2003; Schwartz & Lederman, 2002; Schwartz, Lederman, & Crawford, 2004).

The phrase "nature of science" can be difficult to define. Researchers have attempted to give a new meaning to NOS for a long time (e.g. Khun, 1962; Kimball, 1968; McComas, Clough, & Almazroa, 1998; Lederman, 2007). Although there is currently no consensus among science philosophers, science historians, scientists and science educators in a specific definition for NOS, it typically expresses the epistemology of science, as a way of knowing, the role of scientists and the values and beliefs specific to the development of scientific knowledge (Lederman, 2007). Also, NOS generally refers to the integration of philosophy, history, sociology and psychology of science to understand the basic values and assumptions in the development of scientific knowledge (Cobern & Loving, 2001; 2008; Lederman & Zeidler, 1987; McComas et. al., 1998). More specifically, people work on NOS to understand what science is, how it works, the epistemological and ontological bases of science, how scientists interact socially and culturally, and the mutual

[1] This paper has been produced from the master thesis titled "Secondary School Science Teachers' Understanding of The Nature of Science: A Study Using Q Methodology"
[2] This paper was presented at the 28th Annual Q Conference, Pittsburgh, PA

role between science and society (Clough, 2006). Current discussion among the science educators is about what aspects should be considered under the definition of NOS often includes concerns about lists (Allchin, 2011; Irzik & Nola, 2011; Lederman, 2007, Lederman & Lederman, 2014; McComas, 2008). Lederman & Lederman (2014) clearly states that the lists are a valuable tool that humans use to summarize key points or ideas. Contrary to the traditional empiricist view of science, the modern conceptions of NOS emphasize the tentative, historic, subjective, and holistic feature of scientific knowledge (Hodson, 1993).

There are various ways that NOS can be characterized. Relevant to the research reported in this paper is the work of Kimball (1968). Kimball (1968) developed a theoretical model, and he identified eight assertions characteristic of science. Kimball's assertions are as (a) the main driving force in science is the curiosity about the physical universe, (b) in the quest for knowledge, science is process oriented; it is a dynamic, ongoing activity rather than a static knowledge, (c) science aims at increasing consistency and simplicity as a simple and definitive method of mathematics and relations, (d) there is no one "scientific method" as often described in school science textbooks, but as many methods as there are practitioners, (e) science methods are better qualities than techniques, (f) an essential feature of science is to believe in the sensitivity of the physical universe to human ordering and understanding, (g) science has a unique openness, both in the field of mind and research, (h) tentativeness and uncertainty are all features of science. Nothing in science has been proved, and the recognition of this fact is a guide for the discipline to be taken into account. (Kimball, 1968; p. 111-112).

Although there are many studies of science teachers' views about NOS, a review of the published research literature on science teacher education showed that there is not enough studies dealing with middle school in-service science teachers' conceptions of NOS, and it is recommended that this literature needs to be enriched (Lederman, 2007; Lederman & Lederman, 2014). In addition, it has been emphasized many times that the introducing and application of new methodologies are important for science education studies (Wahbeh & Abd-El-Khalick, 2014). Hence, this Q methodology study addressed a gap in the science education research literature, and introduced a study of Q methodology in science education. This study attempts to answer what are the middle school science teachers' understandings of NOS as measured by the "Nature of Science Scale" (NOSS) (Kimball, 1968).

The understandings of science teachers about NOS have been revealed through studies conducted mostly with pre-service teachers (Abd-El-Khalick & Lederman, 2000). However, some researchers have investigated the in-service science teachers' views about NOS. For example, Gallagher (1991) examined 27 in-service secondary school science teachers throughout in-class observations and formal interviews, and he reported that 25 of them (93%) had "unsettled" views of NOS. King (1991) examined the views of thirteen beginning teachers by conducting a questionnaire and interviewing about NOS. At the end of the study, it was revealed that teachers had no knowledge about the history of science or philosophy of science. This lack of knowledge of NOS made it difficult for teachers to include them in lesson plans even though they thought it was important. Pomeroy (1993) examined the differences in NOS views of researcher scientists, secondary school science teachers and elementary school teachers. Interestingly, she found that the research scientists had a more traditional understanding of NOS compare to the secondary school science teachers and elementary school teachers' views of NOS. Aslan, Yalçın, and Taşar (2009) investigated 48 in-service science teachers' understandings of NOS by using the "Views on Science Technology and Society (VOSTS)" questionnaire. As a result of the analysis, it was found that science and technology teachers in Turkey have inadequate and wrong opinions about the definition of science, nature of observations, variability of scientific knowledge, proposition, theory and structure of laws.

Abd-El-Khalick and BouJaoude (1997) tried to assess the NOS aspects of 20 in-service secondary science teachers in Lebanon via using VOSTS items. They reported he larger majority of science teachers held naive and inconsistence understandings of some NOS aspects, including the importance and difference of observation/inferences, role of theories in a scientific investigation, and existence of a universal, step-wise scientific method. Haidar (1999) worked with pre-service and in-service teachers in the United Arab Emirates to understand their concepts of scientific method, scientific theories and laws and role of scientists. The participants' views were neither “traditional” nor “constructivist". According to Haidar's study, this result is based on the interaction between the participants' education and religious worldviews. Tairab (2001) similarly examined pre-service and in-service teachers' understandings of the characteristics of, and relationship between, science and technology; the aim of science; and the characteristics of scientific knowledge. Participants mostly believed that "technology is as the application of science” and "science is more as content than process-oriented". In another study that mentioned the inadequacy of studies with in-service teachers’ NOS views, Erdaş, Doğan, and Irez (2016) aimed at examining the subjects, samples, methods, and findings of the 134 studies conducted in Turkey between 1998 and 2012 through document analysis. The results indicated that students of all grade levels, pre-service, and in-service science teachers have not attained the desired understanding of NOS. The current study drew upon this background literature on NOS for a Q methodology study to identify the understanding of middle school science teachers’ views on NOS. This investigation was guided by the following research question: What are middle school science teachers’ understandings of NOS?

METHOD

This study is designed by using Q methodology. William Stephenson developed Q methodology, as a means of measuring subjectivity (McKeown & Thomas, 1988; Stephenson, 1955). Understanding or exploring subjectivity is its main reason for using a Q-methodology. Q allows the participants to present the expressions related to the subject, usually by sorting the statements. The selected statements are called the Q sample. These statements represent the communicative universe in which they are drawn.

Q methodology is a means of extracting subjective opinion. Despite its mathematical substructure, Q methodology's purpose is to reveal subjective structures, attitudes and perspectives from the standpoint of the person or persons being observed (Brown, 1996). For this reason, this research and Q methodology share the same purpose. In this study, participants sorted a Q sample that consisted of 29 statements based upon their views of NOS into the grid shown in Figure 1. Thus, the sorting process is subjective such that each item is judged relative to the others by the participant performing the sort. Since Q measures personal opinion regarding the statements related to a topic, validity is not a consideration (Brown, 1999). After the participants have completed the sorting process, the sorts are analyzed via factor analysis that uses correlation to group of people with similar views into factors. Thus, in Q, each factor represents a distinct perspective within the group. Although each sort is subjective, the factors determined in Q are based on concrete behavior and are typically reliable and replicable (Brown, 1980). The analyses in Q methodology include a number of tables. Among these tables is a representative Q sort for each factor. In addition, statements that represent consensus among the factors are also reported within the Q analyses (Brown, 1980; McKeown & Thomas, 1988).

-4	**-3**	**-2**	**-1**	**0**	**1**	**2**	**3**	**4**
28	27	19	20	10	2	1	8	15
	14	22	25	5	4	17	21	
		6	13	7	3	24		
			18	12	9			
			26	16	11			
				19				
				23				

FIGURE 1. *An example of a classification schema for the Q- sort technique for 29 statements*

Q approach was chosen to use in this study because it is a technique incorporating the benefits of both qualitative and quantitative research by giving rise to aspects of a subjective phenomenon that will emerge in a way that reflects the individual perspective of the data (Dennis and Goldberg, 1996). The Q method can provide the opportunity for researchers to compare the participants' understandings related to each statement within the instrument by sorting, and also help to reveal the ideas if there are any reasons under this sorting. Q ranking provides participants with an important control in deciding what is happening about a subject or phenomenon that is important to them. Participants use expressions to create their own version of their subjectivity, rather than relying entirely on the researcher's interpretation skills; therefore, meaning is only associated with a person who lists the expressions with respect to the classification point and classification (Simon, 2013). Considering the advantages of using the Q method and a new approach in science education research, it is assumed that this study might add an important value to the science education research approaches.

Participants

The subjects for this study were six middle school science teachers (two female and four male; average ages is 36). They were randomly recruited from public middle schools in Anatolia, Turkey. Several schools were randomly picked to visit, and the researcher talked to the school principals about the recruitment. After having gained the principal's permission at each school, the researcher talked to teachers who were interested to participate to study. For the teachers who agreed to sign the consent form, appointments were made for the interviews. All participants have at least ten years of teaching experience, and are currently teaching general science at the middle school level. All participants had graduated from different colleges, and are currently working on the different schools. They have all the same major that is general science teaching. In this study, although there are a small number of participants, the issue here is not the number of participants, but how they represent different perspectives (Akhtar-Danesh, Batunann, & Cordingley, 2008). In Q, the aim is to identify typical representations of different perspectives rather than finding the proportion of individuals with certain perspectives (Simon, 2013).

Instrument

Based on these eight assertions defined in earlier, Kimball (1968) developed a 29 Likert-item instrument, the Nature of Science Survey (NOSS). Its function was to provide a comprehensive explanation of NOS to measure differences in science. The development process is reported in his paper where he reported a split-half reliability of 0.72. The NOSS has been used several times in research related to students', teachers', and scientists' conceptions of nature of science. Anderson, Harty, & Samuel (1986) used the instrument with pre-service science teachers and reported and alpha internal consistency reliability coefficient of 0.74, while Cobern (1989) gave a reliability estimate of 0.71.

Although there are some current commonly used nature of science instruments, such as VNOS (Lederman et al., 2002), Kimball's NOSS is better suited for use with a Q analysis which is one of the most interests in this study. A Q analysis requires statements such as provided by Kimball's NOSS whereas the VNOS or other NOS instruments involves constructed responses and as such which are not compatible to a Q analysis. Kimball's eight assertions remain cogent today; however, the use of the Kimball NOSS does limit comparisons with findings from the more widely used NOS instruments. The analysis was carried out taking this point into consideration.

Four bilingual Turkish graduate students translated the English version of the instrument into Turkish independently. Then, they compared their translations and arrived at a consensus version with finding common terms in the instrument such as, the scientific method or the scientific investigation. In the second phase of the translation, two Turkish linguistic teachers reviewed the consensus version. After receiving their suggestions, some minor changes were made in the translation, and Turkish version of NOSS scale is finalized.

Data Collection Procedures

Data were collected from an Anatolian city in Turkey. This is an interview study where subjects were shown a set of statements which they ranked from most agree to least agree. While the subjects were ranking the statements, the researcher asked the subject to explain each rank. The ranks were recorded on paper and the interview conversation was audio recorded.

Each participant was interviewed separately. The Q set (composed of the 29 statements from the NOSS) was given to the respondent in the form of randomly numbered cards, each card containing one of the statements from the Q set. The respondent was instructed to rank the statements according to the participants' point of view regarding NOS. The ranking is done by placing the cards along a number line representing the Q distribution. In this study, Q sets contain 29 statements and employ a relatively flattened distribution with a range of -4 to +4 as shown in Figure 1.

Data Analysis

All Q sort data were entered into PCQ Method (Stricklin & Almeida, 2001), a program designed specifically for the analysis of Q sorts. The basic steps of the Q sorting procedure are as follows. A heterogeneous set of items (called a Q sample) is drawn from the concourse. A group of respondents (P set) was instructed to rank-order (Q sort) the Q sample along a standardized continuum according to a specified condition of instruction. Participants sorted statements according to their own likes and dislikes. The resulting Q sorts were submitted to correlation and factor analysis. Factors were extracted using the centroid method because it is the preferred factor extraction method for Q methodology (Brown, 1980; Stephenson, 1955). The maximum number of factors was allowed in order to investigate how many factors existed within the data. The audio recordings were transcribed and coded writing reflective coding which is called memoing. The interview data were used to help interpret the factors that result from the Q analysis.

FINDINGS

According to results of Q analysis, factors were extracted by using the centroid method. For this study, 6 sorts, 29 items, 9 piles, and 5 centroids are used to extract the maximum factors. By rotating the Q sorts within graphical and varimax rotations, the significant factors are elicited. The graphical rotation accounted for all 6 sorts on a single factor, which will be called the "Omnibus Factor". The other factors produced by the graphical rotation no sorts loading at statistically significant levels. A varimax rotation, however, resulted in 3 factors that accounted for 5 of 6 sorts. Two sorts (Ms. N and Ms. A) loaded on Factor A. Two sorts (Mr. I and Mr. U) loaded on Factor B. A single sort (Mr.N) loaded on Factor C.

The Omnibus Factor

The omnibus factor, accounted for all six subjects, is based on the subjects' strong agreement statements, and strong disagreement statements. The statements are given in, Tables 1 and 2.

Table 1. *Omnibus factor: Three most agreed to statements by all subjects*

NOSS item	Statement	Grid Position
15	Team research is more productive than individual research	+4
8	A fundamental principle of science is that discoveries and research should have some practical applications.	+3
21	The scientific method follows the five regular steps of defining the problem, gathering data, forming a hypothesis, testing it, and drawing conclusions from it.	+3

Table 2. *Omnibus factor: Three least agreed to statements by all subjects*

NOSS item	Statement	Grid Position
28	Scientific work requires a dedication that excludes many aspects of the lives of people in other fields of work	- 3
14	Investigation of the possibilities of creating life in the laboratory is an invasion of science into areas where it does not belong	-3
27	Scientific method is a myth which is usually read into the story after it has been completed	-4

All subjects strongly believed that team research is more productive than individual research. For example, Ms. N and Mr. N responded with the same Turkish proverb that is “two heads are better than one”. They had similar experiences, which make them think that group work is important for productivity and the creation of new ideas. They thought that in a classroom, whenever students work as a group or team, their ideas and examples automatically increase comparatively with students working alone. They also explained that students easily learn from their peers during team or group work.

> “If students within a group, they are asking more questions, more active, and more productive than individual working. Students usually generate new examples and ideas from their peers” (Mr. N Interview).

However, some subjects thought that group or team research might be inefficient if team members do not have good rapport with each other. They had some real examples from their daily jobs as middle school science teachers.

> “Group members must help other members of the group. They should cooperatively work with each other; otherwise, team research might cause negative effects such as, failure, losing self-confidence, and time consuming. Even if one member of group does not have good collaboration with other members of group, both individual and group efficiency may affect adversely” (Ms. A Interview)

The participants also agreed the scientific method follows the five regular steps of defining the problem, gathering data, forming a hypothesis, testing it, and drawing conclusions from it. Not surprisingly, the subjects strongly disagree that scientific method is a myth, which is usually read into the story after it has been completed. They believed that in order to do science reliably, validly, and efficiently, the all scientists should follow these five regular steps. They also agreed these steps are the best way to do science, and the scientific method also helps scientists to do science the shortest period of time.

> “If a scientist does not follow these processes of the scientific method, he or she cannot fix his mistakes when he or she makes a wrong.” (Mr. I Interview)

> “If you do not really care about the process and its implication, you cannot change, or improve your ideas. A scientific research has a process as well as product.” (Mr. I Interview)

However, two subjects thought that the steps are not necessary to follow in a strict order. According to them, scientists can discover something without following these steps in exact order.

> “A scientist does not necessarily follow scientific method steps regularly. There are some historical discoveries which show that some inventions have been found without following these steps in an exact order.” (Mr. A Interview)

All subjects also thought that a fundamental principle of science is that discoveries and research should have some practical applications. With regard to this statement, it was observed that the subjects considered that "practical applications “refers to the experiments such as those carried out in school laboratory practices or in science laboratories. This item of NOSS was considered as the practical application of scientific knowledge in the original study. Since all subjects interpreted this item in the same way, we are reporting their interpretation of this item, which is that “practical application” means experimentation. The subjects strongly believe that science requires experimentation. They commonly believe that experimentation is fundamental to science with the possible exception of extending experimentation to humans. The participants cannot imagine a scientific discovery or research without experiments.

> “If some results or findings are not based on some practical applications or experiments, we cannot say that this is a scientific fact or truth” (Mr. A Interview)

> “A scientific research should be grounded practical applications or experiments. In this way, we can reach the truest knowledge by testing findings and results” (Mr. U Interview)

The subjects commonly disagreed that investigation of the possibilities of creating life in the laboratory is an invasion of science into areas where it does not belong. They believed that creating life in the laboratory is not an invasion because science should connect with and work cooperatively with other disciplinary fields.

> "Science surely affects everything. For example, let's think CERN (The European Organization for Nuclear Research), which is an international organization whose purpose is to operate the world's largest particle physics laboratory. I believe that after their investigations are completed, many different fields will be influenced, but surely, it will not be and invasion". (Ms. N Interview)

Finally, the subjects commonly disagree that scientific work requires a dedication that excludes many aspects of the lives of people in other fields of work. They believe that scientific research requires a dedication but scientists have their own private lives, which consist of their family, friends, and social life.

> "Scientific work should require a dedication, and scientists are different so far as other people, but they also have a life… They have families, friends and so on. They need to go outside, have fun, and live like other people." (Mr. I Interview)

According to the omnibus factor, all subjects thought that the scientific method has a crucial role in scientific research and they reject the idea that the scientific method is some kind of myth. They shared the opinion that scientific research must proceed by regular steps; however, the sequence of these steps may vary. They also believed that scientific research must be experimental; however, they believe that there are limits to what is acceptable as scientific research. All subjects also agreed that team research is much more productive than individual research. Finally, none of the subjects thought that science requires a dedication that excludes many aspects of the lives of people in other fields of work.

Factor A: Ms. N and Ms. A

Ms. N and Ms. A both loaded at a significant level on Factor A which is characterized by agreement and disagreement statements, which are provided in Tables 3 and 4. As it happened, these two subjects were only female participants in this study. Factor A and Omnibus Factor share the bottom three least agreed to statements and one of the most agreed to statement. However, two most agreed to statements of Factor A differ from the most agreed statements of the Omnibus Factor.

Table 3. *Factor A: Three most agreed to statements by Ms. N and Ms. A*

NOSS item	Statement	Grid Position
24	Scientific research should be given credit for producing such things as modern refrigerators, television, and home air-conditioning	+4
2	Classification schemes are imposed upon nature by the scientist: they are not inherent in the materials classified	+3
15	Team research is more productive than individual research	+3

Table 4. *Factor A: Three least agreed to statements by Ms. N and Ms. A*

NOSS item	Statement	Grid Position
27	Scientific method is a myth which is usually read into the story after it has been completed	-3
14	Investigation of the possibilities of creating life in the laboratory is an invasion of science into areas where it does not belong	-3
28	Scientific work requires a dedication that excludes many aspects of the lives of people in other fields of work	-4

These two subjects agreed that scientific research should be given credit for producing such things as modern refrigerators, television, and home air-conditioning. Although this statement is not in top three agree statement of the Omnibus Factor, Ms. N and Ms. A strongly believed that scientists should be encouraged to produce new technologies, which make life easier. Their examples of technology all relate to home life, which suggest their interest in the improvement of everyday life through technology. They also thought that scientific research is needed for the production of new machines and technologies. Ms. N had a doubt about huge trade marketing.

> "As a general, scientific research should be done for producing new machines. However, technology and science might be abused by big companies in order to earn much more money and power." (Ms. N Interview)

> "If a new machine is come up, as a woman, I want to buy it." (Ms. N Interview)

As in the Omnibus Factor, Ms. N and Ms. A disagree that the scientific method is a myth. They believed that the methods of science are as important as the products of science.

> "Without knowing what happened during a scientific research, it is impossible to develop and help science and future scientific research. Scientists must consider the methods of science. They should deeply examine what had been done during this process. I think this is the best possible way to push forward science." (Ms. N Interview)

> "If a scientist found a result or produce something new, other scientists ask him/her how did you found or produce it. What kind of method did you follow? And why this method is the best way for this research? A scientist must answer these kinds of questions after his/her research has been done." (Ms. N Interview)

Ms. N and Ms. A also agreed that the scientist imposes classification schemes upon nature. As distinct from the Omnibus Factor, they thought that scientists have generated classification schemes over thousands of years. Both participants gave the Periodic Table as an example. They think scientists put the elements together by considering their features and availability in the nature. Ms. A gave the example of classification of living creatures, which were developed by observing the characteristics of organism in nature.

As with the subjects characterized by the Omnibus Factor, these two subjects commonly disagreed that scientific work requires a dedication that excludes many aspects of the lives of people in other fields of work. They believed that scientific work requires a dedication but it does not necessarily excludes many aspects of the lives of people in other fields of work. These two participants thought that scientists are human beings and they have friends, families, and life like other people. They also pointed out that scientists should connect with other people's life and works.

> "When a scientific work is doing, this scientist must get help from other scientists who are in other fields of work because a scientific research requires to work of many scientists who have different subject of fields such as chemistry, biology, statistic, and language." (Ms. A Interview)

> "Einstein put his mind to his own scientific works, but he also worked with other scientists cooperatively. He usually gives a lot of importance to many aspects of the lives of people in other fields of work. His dedication includes other people and their scientific works." (Ms. N Interview)

According to Factor A, Ms. N and Ms. A thought that scientific research should be given credit for producing such things as modern refrigerators, television, and home air-conditioning. However, Ms. N and Ms. A did not have strong agreement on the Omnibus Factor. As in the Omnibus Factor, these two subjects shared the opinion that a team research is more productive than individual research. Ms. N and Ms. A differed from the subjects that loaded on the Omnibus Factor in that they did not believe so strongly that the scientific method characterizes how science is done. They also believed that the scientists impose classification schemes upon nature; however, they rejected the idea that the scientific method is a kind of myth. Neither subject thought that science requires a dedication that excludes many aspects of the lives of people in other fields of work. Finally, they rejected the idea that investigation of the creating life in the laboratory is an invasion of science into areas where it does not belong.

Factor B: Mr. I and Mr. U

Mr. I and Mr. U loaded at a significant level on Factor B, which is characterized by agreement, and disagreement statements, which are provided in Table 5 and 6. Factor B and Omnibus Factor share two of the least agreed to statements and one of the most agreed to statements. However, two most agreed to statements and one least agreed to statement of Factor B differ from the most agreed and least agreed to statements of the Omnibus Factor.

Table 5. *Factor B: Three most agreed to statements by Mr. I and Mr. U*

NOSS item	Statement	Grid Position
21	The scientific method follows the five regular steps of defining the problem, gathering data, forming a hypothesis, testing it, and drawing conclusions from it	+4
1	The most important scientific ideas have been the result of a systematic process of logical thought	+3
17	Scientific investigations follow definite approved procedures	+3

Table 6. *Factor B: Three least agreed to statements by Mr. I and Mr. U*

NOSS item	Statement	Grid Position
27	Scientific method is a myth which is usually read into the story after it has been completed	- 3
14	Investigation of the possibilities of creating life in the laboratory is an invasion of science into areas where it does not belong	-3
6	The scientific investigation of human behavior is useless because it is subject to unconscious bias of the investigator	-4

Mr. U expressed some disadvantages on the scientific method, even though he is a methodology person. He believed that, there might be other ways instead of an exact method for all scientific research,

> "The scientific method might restrict freedom of scientists. Also, some scientific investigations do not fit in these exact steps of the scientific method. Some scientists might have different styles, and they are generally marginal people so they sometimes do not need to follow an exact method, but commonly the steps of the scientific method are practicable for most scientific research." (Mr. U Interview)

As in the Omnibus Factor, Mr. I and Mr. U believed that the scientific method is not a myth. They thought that it is an actively situated in every process of a scientific research, and it is a part of the process, which is referenced after many years it has been completed.

> "If you work through a scientific research or live this period of time, and present a result of reality, it cannot be said that this process (the scientific method) is a myth." (Mr. I Interview)

In parallel to this, they agreed that the most important scientific ideas have been the result of a systematic process of logical thought. Differently from the Omnibus Factor, these two subjects believed that the result of a systematic process of logical thought (they frequently referred to the scientific method) generates the most important ideas.

> "A scientific research must include cause and effect relation. If you have a cause and effect relation, and if you find this relationship via a systematic process, you must achieve an important scientific idea." (Mr. U Interview)

As with the subjects characterized by the Omnibus Factor, Mr. I and Mr. U also rejected that the scientific investigation of human behavior is useless because it is subject to unconscious bias of the investigator. They strictly rejected the first sentence of this statement that the scientific investigation of human behavior is useless even some scientific investigation of human behavior might include unconscious bias of the investigator. They generally believed that scientists are very objective when they do science, but some scientific research like about human behavior, includes biases of researchers. However, it should not be said that this kind of investigations are useless.

> "Although this kind of investigation is even a little subject to the investigator's biases, we cannot say that these are useless. The investigation of human behavior is very useful, because we can understand human's inheritance and their relationships with other creatures via the scientific investigation of human behavior". (Mr. I Interview)

> "I believe that the scientist can not include his or her biases within an investigation about human behavior because objectivity is one of the most important characteristics of to be a scientist. Scientists should be objective". (Mr. U Interview)

According to Factor B, Mr. I and Mr. U believed that scientific investigations must follow definite procedures, which are called the scientific method. As one might expect of persons strongly holding to a strict view of the scientific method, they rejected the idea that the scientific method is a myth, as in the Omnibus Factor. They believed that the most important scientific ideas have been the result of a systematic process of logical thought. As distinct from the Omnibus Factor, they rejected the idea that the scientific investigation of human behavior is useless because it is subject to unconscious bias of the investigator, but they reject the idea that creating life in the laboratory would be acceptable. In other words, they see the scientific method as a clear set of steps that can be applied objectively, but there are limits to the acceptability of scientific research.

Factor C: Mr. N

Mr. N only loaded at a significant level on Factor C, which is characterized by agreement with, and disagreement statements, which are provided in Table 7 and 8. Factor C and Omnibus Factor shared two most agreed to statements and one least agreed to statements. However, two least agreed statements and one most agreed statement of Factor C differ from the Omnibus Factor.

Table 7. *Factor C: Three most agreed to statements by Mr. N*

NOSS item	Statement	Grid Position
15	Team research is more productive than individual research	+4
4	The primary objective of the working scientist is to improve human welfare	+3
8	A fundamental principle of science is that discoveries and research should have some practical applications	+3

Table 8. *Factor C: Three least agreed to statements by Mr. N*

NOSS item	Statement	Grid Position
22	One of the distinguishing traits of science is that it recognizes its own limitations	- 3
19	The essential test of a scientific theory is its ability to correctly predict future events	-3
27	Scientific method is a myth which is usually read into the story after it has been completed	-4

Mr. N strongly believed that the primary objective in science is to improve human welfare. He thought that science must be conducted to improve human beings welfare even this idea is not completely true in reality. He stated that science should be completely done for human beings, and also believed that team research enables scientists to improve human welfare.

> "Science should be done to improve human beings' welfare, but in reality, science might be abused by some scientists and governments. Let's look at atomic bomb… it was used as a combat vehicle.., but it would be used for human welfare like generating energy…" (Mr. N Interview)

> "In order to improve human welfare as a main goal of doing science, scientists should work as a team because working as a team is more productive and effective than working individually." (Mr. N Interview)

Mr. N also agreed that the fundamental principle of science is that discoveries and research should have some practical applications. As with the subjects characterized by the Omnibus Factor, he firstly thought about science at school. According to him, scientific discoveries should be based on practical applications.

> "If you think about a real science classroom, we are doing some experimentation, and achieving some results. If these results can be connected some practical applications such as

generating new materials like electroscope, thermos, and telegraph, students only understand that they are learning and doing science." (Mr. N Interview)

As distinct from the Omnibus Factor, Mr. N disagreed that the one of the distinguishing traits of science is that it recognizes its own limitations. He believed that science has been changing and developing day by day, there is no limitation in science.

"When people's curiosity continues, science cannot recognize its own limitation because there is no limitation in science." (Mr. N Interview)

"Lets' look at the Copernicus time. He argued that the Earth is not flat, it is spherically, but the people did not believe him, and tried to kill him… they thought that science cannot continue, everything was found, and that was all… But, we have seen that science has continuing. There is no limitation in science. Thus science cannot recognize its own limitation." (Mr. N Interview)

He also rejected the idea that the essential test of a scientific theory is its ability to correctly predict future events. He believed that the most important thing is that a scientific theory must allow scientists to generate new theories and discoveries, not to correctly predict future events

"I do not think that a scientific theory necessarily predicts future events correctly… I mean it is not necessary because if a theory makes scientists to discover something or produce new theories, this is the essential test of a scientific theory, not correctly predicting future events." (Mr. N Interview)

According to Factor C, Mr. N thought that team research is more productive than individual research as in the Omnibus Factor. He argued that scientists produce new discoveries and inventions for human beings' welfare by working as a team. Also, he believed that the most important principle of a scientist's works is to improve human welfare. In this sense, he thought that an essential principle of science is that discoveries and researches should be based on some practical implications. As distinct from the Omnibus Factor, Mr. N rejected the idea that science recognizes its own limitations, and he argued that the essential test of a scientific theory is not related to its ability to correctly predict future events. Lastly, like other subjects, he believed that the scientific method is very important, and it is not a myth.

DISCUSSION AND CONCLUSION

This paper has presented an unusual research methodology that promotes the scientific study of subjectivity. This study corroborates other recent research on Turkish teachers' views about nature of science, which is that Turkish science teachers do not have an adequate understanding of the nature of science (Aslan et al., 2009; Bilgic, 1985; Erdaş et al., 2016; Erdoan, 2004; Sahin, Deniz, & Gorgen, 2006).

As the parallel of the results had been found in Aslan et al., (2009); Abd-El-Khalick and BouJaoude, (1997); Irez, (2006); Sahin et al., (2006), in this study, all six participants strongly hold the idea that the scientific method is the most important thing in scientific research. They believed that there is a universal scientific method, and it has several steps, which must be followed in an exact order. Also, participants of this study hold naïve ideas about the purpose of science and technology. They commonly argued that science with technology in perceiving human welfare as a primary objective for scientists and development of new machines for mankind as the main purpose of science. In other words, participants confuse the purpose of science with purpose of technology. Participants also believed that scientific knowledge and scientists are often objective, and all scientific research is useful, but interestingly participants thought that scientists are also human beings, and they should have life like other people who are in other fields of work. However, these findings are interesting even though not aligned with all the NOS aspects.

As distinct from the recent research about the Turkish teachers' beliefs about the NOS (Erdaş et al., 2006; Irez, 2006; Macaroglu, Tapar, & Caparoglu, 1998), participants of this study believed that there is no limit in science. This perspective showed that participants in this study had informed views about science is tentative. It is an open- ended effort. They often believed that science needs creativity as well as teamwork.

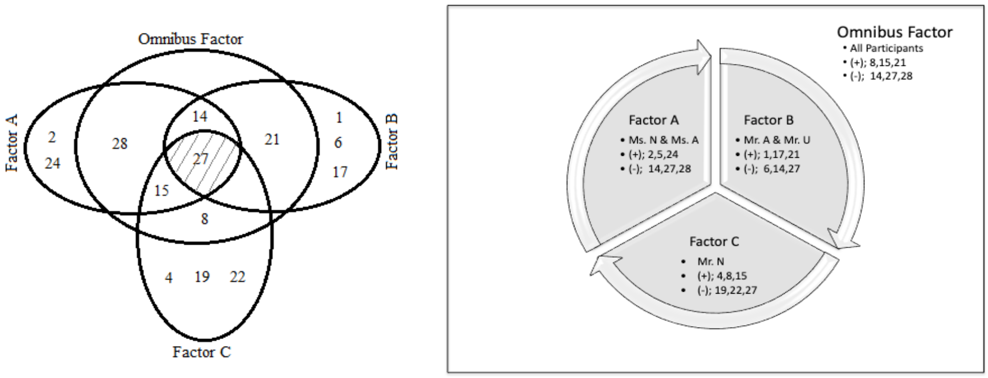

FIGURE 2. *Relationship between the factors, participants, and NOSS statements*

As shown in Figure 2, all participants significantly loaded on one factor. The Omnibus Factor characterized by procedural and utilitarian views of science. Subsequent rotations led to three sub-factors within the Omnibus Factor (Figure 2).

According to the Omnibus Factor, all subjects thought that science in productive, practical, and procedural terms, rather than creativity and curiosity. All subjects believe that team research or group working is more productive than individual research. They also highly believed that the scientific method is the most important element in scientific research and it has regular steps, which should be followed in an exact order, and scientific research must be based on some practical applications.

Ms. N and Ms. A loaded in a factor, which is generally characterized by utilitarian rather than creativity and curiosity. They strongly believed that scientific research must be based on technology and practical applications. As distinct from the Omnibus Factor and other sub-factors, these two subjects thought that scientific research must be given credit to produce such things like modern refrigerators, air condition and so on. As a common statement loaded on all factors, they also argued that the scientific method is not myth, and scientific research needs team works.

Mr. I and Mr. U loaded in a factor, which is highly characterized by believing that scientists follow a strict scientific method rather than use creativity and subjectivity. These two subjects strongly agreed that all scientific research is related to the scientific method. They argued that the scientific method has a crucial role in scientific research. Thus, they believed that the scientific method is not a myth, and the most important scientific ideas have been result of a systematic process of logical thought, which are to define the problem, gather data, form a hypothesis, test it, and draw conclusions from it. As distinct, Mr. I and Mr. U believed that scientists are usually objective, and investigation of the human behavior is not useless because it is not subject to unconscious bias of the investigator.

Mr. N loaded in a factor, which is characterized by productivity and practical applications rather than theoretical aspects. He believed that the scientific method is not a myth; it is a real and the most important process in scientific research. As distinct from the other two sub-factors, Mr. N thought that science must be based on some practical applications. He believed that the fundamental principle of science is to improve human welfare. He also thought that the most important thing is that a scientific theory must allow scientists to generate new theories and discoveries rather than testing of a scientific theory whether it is a good theory or bad theory. In addition, he believed that there is no limit in science; everything might be done with science, it is all about creativity.

IMPLICATIONS

As emphasized in the current literature, knowing nature of science and being able to integrate it effectively into the teaching is very important for educating science literate individuals (Lederman, 2007; McComas et al., 1998). Thus, teacher preparation programs for in-service teachers need to prepare teachers for improving their understandings of nature of science. Although all of the proposed and accepted NOS aspects in the current literature have not been investigated in this study, it is important to reveal the understandings of the in-service science teachers on the other NOS themes in future studies. This study indicates that these Turkish middle school science teachers have limited views of how scientists go about their work. Additional research is warranted to explore how these teachers understand other aspects of NOS such as socio-cultural aspects of NOS, or distinctions between and functions of scientific theories and laws.

The findings of this study would be useful for the National Education Departments in designing a quality-training program for science teachers. Also, science education programs could benefit from the conclusion of the study in future planning to improve pre-service science teacher programs and courses.

Since this study is mainly limited to middle school science teachers in an Anatolian city (central region), and also it is a small size participant study, similar studies should be conducted to measure science teachers' views and understanding of the nature of science in the rest of the country by using high level of participation. Also, further studies should be taken into consideration to study the NOS conceptions of elementary teachers, high school science teachers, prospective science teachers, science educators, and students in all levels.

Due to the fact that the Q methodology is a very new in science education and it has not been applied very often on this area, it is important to use this methodology in order to increase its prevalence in science education and to apply it on other research subjects and to evaluate its results. As a mix method, Q method allows researchers to investigate participants' subjectivity both as a group and an individually. Researchers may have a chance to compare the statements, which participants rank them according to their own beliefs rather than just saying "agree", or "disagree", and the reasons for their selection with the supported interviews. Robbins and Kreuger (2000) suggested that Q is a useful method because of its adaptability. With regard to education, it may be beneficial to use the teachers and their students to study and compare subjectivity and attitudes in the acquisition of education. Q can be used to describe the feeling of finding attitudes, perceptions and values effectively. This method is also useful in allowing the generating of a theory rather than testing hypotheses for researchers, rather than reducing it to various ideas, taking into account all human beings, allowing new ideas to be developed, thus allowing the human experience to be captured.

REFERENCES

Abd-El-Khalick, F., & BouJaoude, S. (1997). An exploratory study of the knowledge base for science teaching. *Journal of Research in Science Teaching*, *34*, 673–699.

Abd-El-Khalick, F., & Lederman, N. G. (2000). The influence of history of science courses on students' views of nature of science. *Journal of Research in Science Teaching*, *37* (10), 1057-1095

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

Akhtar-Danesh, N., Batunann, A., & Cordingley, L. (2008). Q-methodology in nursing research: a promising method for the study of subjectivity. *Western Journal of Nursing Research.* 30, 6, 759-773.

Allchin, D. (2011). Evaluating knowledge of the nature of (whole) science. *Science Education, 95*(3), 518-542

American Association for the Advancement of Science (AAAS) (1993). *Benchmarks for science literacy: A Project 2061 report*. New York: Oxford University Press.

Anderson, H. O., Harty, H., & Samuel, K. V. (1986). Nature of science, 1969 and 1984: Perspective of pre-service secondary science teachers. *School Science and Mathematics*, *86* (1), 43- 50.

Aslan, O , Yalçın, N , Taşar, M . (2009). Fen ve Teknoloji Öğretmenlerinin Bilimin Doğası Hakkındaki Görüşleri. *Ahi Evran Üniversitesi Kırşehir Eğitim Fakültesi Dergisi,* 10 (3), 1-8. Retrieved from http://dergipark.gov.tr/aeukefd/issue/1416/16984

Bilgic,, M. (1985). *The effectiveness of inquiry oriented laboratory on students' understanding of the nature of scientific knowledge at university level.* Unpublished master's thesis, Middle East Technical University, Ankara, Turkey.

Brown, S. R. (1980). *Political subjectivity: Applications of Q methodology in political science*. Yale University Press, New Haven.

Brown, S. R. (1996). Q Methodology and qualitative research. *Qualitative Health Research*. *6* (4), 561–567.

Brown, S. R. (1999). *Subjective behavior analysis*. Unpublished manuscript. Read at a panel on "The objective analysis of subjective behavior: William Stephenson's Q methodology," annual convention of the Association for Behavior Analysis, Chicago.

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

Cobern, W. W. (1989). A comparative analysis of NOSS profiles on Nigerian and American pre-service, secondary science teachers. *Journal of Research in Science Teaching, 26* (6) 533-541.

Cobern, W. W., & Loving, C. C. (2001). Defining 'science' in a multicultural world: Implications science education. Science Education, 85(1), 50-67.

Cobern, W. W., & Loving, C. C. (2008). An essay for educators: Epistemological realism really is common sense. Science & Education, 17(4), 425-447.

Dennis, K. E. & Goldberg, A. P. (1996). Weight control self-efficacy types and transitions affect weight- loss outcomes in obese women. *Addictive Behaviors.21,* 1, 103-116

Eichenger, D. C., Abell, S. K., & Dagher, Z. R. (1997). Developing a graduate level science education course on the nature of science. *Science & Education, 6*, 417–429.

Erdaş, E., Doğan, N., & İrez, S. (2016). Bilimin Doğasıyla İlgili 1998-2012 Yılları Arasında Türkiye'de Yapılan Çalışmaların Değerlendirmesi. *Kastamonu Eğitim Dergisi,* 24 (1), 17-36. Retrieved from http://dergipark.gov.tr/kefdergi/issue/22606/241610

Erdoan, R. (2004). *Investigation of the pre-service science teachers' views on nature of science.* Unpublished master's thesis, Middle East Technical University, Ankara, Turkey.

Gallagher, J. J. (1991). Prospective and practicing secondary school science teachers' knowledge and beliefs about the philosophy of science. *Science Education*, *75*, 121-133.

Hadson, D. (1993). In search of a rationale for multicultural science education. *Science Education*, *77*, 685-711.

Haidar, A. H. (1999). Emirates pre-service and in-service teachers" views about the nature of science. *International Journal of Science Education, 21*, 807-822.

Irez, S. (2006). Are we prepared? An Assessment of pre-service science teacher educators" beliefs about nature of science. *Science Education, 90*, 1113-1143.

Irzik, G., & Nola, R. (2011). A family resemblance approach to the nature of science for science education. *Science & Education, 20* (7–8), 591–607.

Kuhn, T. S. (1962). *The structure of scientific revolutions*. Chicago: University of Chicago Press.

Kimball, M. E. (1968). Understanding the nature of science: A comparison of scientists and science teachers. *Journal of Research in Science Teaching*, *5*, 110- 120.

King, B. B. (1991. Beginning teachers" knowledge of and attitudes toward history and philosophy of science. *Science Education, 75* (1), 135- 141.

Lederman, N. G. (2007). Nature of science: Past, present, and future. In Abell, S. & Lederman, N. (Eds.) *Handbook of Research on Science Education*. Mahwah, New Jersey: Lawrence Erlbaum Associates, Publishers

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

Lederman, N. G., & Lederman, J. S. (2014). Research on teaching and learning of nature of science. In Lederman N. G., & Abel S. K. (Eds.) *Handbook of research in science education.* 711 third Ave., New York, NY 10017: Routledge, Taylor and Francis.

Lederman, N. G., & Zeidler, D. L. (1987). Science teachers' conceptions of the nature of science: Do they really influence teacher behavior? *Science Education*, *71*, 721–734.

Macaroglu, E., Tapar, M. F., & Cataloglu, E. (1998). "Turkish pre-service elementary school teachers' beliefs about the nature of science". *Paper presented at the annual meeting of the National Association for Research in Science Teaching, San Diego, CA.*

McComas, W. F. (2008). Seeking historical examples to illustrate key aspects of the nature of science. *Science & Education, 17* (2-3), 249-263

McComas, W. F., Clough, M. P., & Almazroa, H. (1998). 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* (pp. 3-39). Kluwer Academic Publishers, Dordrecht, the Netherlands.

McDonald, C. V. (2010). The influence of explicit nature of science and argumentation instruction on preservice primary teachers' views of nature of science. *Journal of Research in Science Teaching, 47*(9), 1137–1164.
McKeown, B., & Thomas, D. (1988). *Q methodology*. Sage Publications, Newbury Park, Calif
MEB. (2018). *Fen bilimleri dersi öğretim programı.* Ankara. (Online) it is retrieved from http://mufredat.meb.gov.tr in 15 September, 2018.
National Research Council. (1996). *National science education standards*. Washington, DC: National Academy of Sciences.
National Science Teachers Association. (2009). *NSTA position statement: Scientific inquiry. (Online)* it is retrieved from http://www.nsta.org/about/positions/inquiry.aspx in May 2013.
Next Generation Science Standarts (NGSS), (2014). (Online) it is retrieved from http://www.nextgenscience.org/sites/ngss/files.15.13.pdf in June 2016
Osborne, J., Collins, S., Ratcliff e, M., Millar, R., & Duschl, R. (2003). What "ideas-about science" should be taught in school? A Delphi study of the expert community. *Journal of Research in Science Teaching, 40*, 692-720.
Pomeroy, D. (1993). Implications of teachers' beliefs about the nature of science: Comparison of the beliefs of scientists, secondary science teachers, and elementary teachers. *Science Education, 77*, 261–278.
Robbins, P. & Kreuger, R. (2000). Beyond bias? The promise and limits of Q method in human geography. *The Professional Geographer,* 52,4, 636-648.
Sahin, N., Deniz, S., & Gorgen, I. (2006). Student teachers' attitudes concerning understanding the nature of science in Turkey. *International Education Journal, 7*, 51–55.
Simons, J. (2013). An introduction to Q methodology. *Nurse Researcher* 20, 3, 28-32
Schwartz, R. S., & Lederman, N. G. (2002). "It's the nature of the beast": The influence of knowledge and intentions on learning and teaching nature of science. *Journal of Research in Science Teaching, 39(3), 205–236.*
Schwartz, R. S., Lederman, N. G., & Crawford, B. A. (2004). Developing views of nature of science in an authentic context: an explicit approach to bridging the gap between nature of science and scientific inquiry. *Science Education, 88*(4), *610–646*.
Stricklin, M., & Almeida, J. (2001). *PCQ: Analysis software for Q-technique* [Computer software]. (rev. ed.) PCQ Software, Portland OR, U.S.
Stephenson, W. (1955). *The study of behavior: Q-technique and its methodology*. University of Chicago Press, Chicago.
Tairab, H. (2001). How do pre-service and in-service science teachers view the nature of science and technology? *Research in Science and Technological Education, 19*, 235–250.
Wahbeh, N., & Abd-El-Khalick, F. (2014). Revisiting the translation of nature of science understandings into instructional practice: Teachers' nature of science pedagogical context knowledge. *International Journal of Science Education, 36*(3), 425-466.