

INSERVICE SCIENCE TEACHERS' VIEWS ABOUT THE NATURE OF SCIENCE

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ABSTRACT

The purpose of this study was to investigate the views of inservice science teachers on the nature of science (NOS) and scientific knowledge, which is a requisite for scientific literacy. Descriptive method is used in this study. The Views of the Nature of Science (VNOS) questionnaire, Form-C, developed by Abd-El-Khalick, Lederman, Bell, & Schwartz (2001) was utilized to collect qualitative data on science teachers' views about NOS. A total of thirty-two science teachers who work at several primary schools in Zonguldak, Turkey formed the sampling of this study. Analysis of responses to the open-ended questionnaire indicated that most of the inservice science teachers have alternative conceptions about NOS in terms of understanding of the empirical and tentative nature of science, and the role of creativity in science and the relationship between theories and laws. Moreover, participants failed to explain subjectivity of scientific knowledge and the distinction between observation and inference in the processes of science with aspects of the NOS. On the other hand, they had adequate understandings of the role for social and cultural factors in the construction of scientific knowledge.

Key Words: Nature of Science, Science Teaching, Teacher Education.

ÖZET

Bu çalışma bilimsel okuryazarlığın temeli olan bilimin doğası ve bilimsel bilgi hakkındaki fen bilgisi öğretmenlerinin görüşlerini belirlemek amacıyla yapılmıştır. Bu çalışmada betimsel yöntem kullanılmıştır. Araştırmada fen bilgisi öğretmenlerinin bilimin doğası hakkındaki bilgi düzeylerini belirlemek amacıyla Abd-El-Khalick, Lederman, Bell, & Schwartz, (2001) tarafından geliştirilen Bilimin Doğası Hakkındaki Görüşler Anketi kullanılmıştır. Çalışmanın örneklemini Zonguldak İli genelindeki

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ilköğretim okullarında görev yapan otuziki fen bilgisi öğretmeni oluşturmuştur. Araştırmada elde edilen verilerin analizinde fen bilgisi öğretmenlerinin bilimsel çalışmanın nasıl yapılacağı ve bilimin ne olduğu hakkında farklı görüşlere sahip olduğu tespit edilmiştir.

Anahtar Sözcükler: *Bilimin Doğası, Fen Bilgisi Eğitimi, Öğretmen Eğitimi.*

Inservice Science Teachers' Views about the Nature of Science

Many of the national and international reform documents stated that the goal of science education is to develop scientifically literate citizens with intellectual resources, values, attitudes and inquiry skills to promote development of man as a rational human being (American Association for the Advancement of Science, 1993; National Research Council, 1996; Bell et al., 2003). The achievement of scientific literacy for individuals is viewed also by many science educators as the educational solution to many economical, social, and environmental challenges of 21st century (Moss et al., 2001, Dogan, & Abd-El-Khalick, 2008).

The literature shows that scientifically literate individual possesses a wide variety of attributes, one of which is an adequate understanding of nature of science (NOS). Abd-El-Khalick and Lederman (2000) acknowledged that no consensus exist on NOS among philosophers of science, historians, and science educators. Such disagreement, however, should not be surprising or disconcerting given the multifaceted and complex NOS. Nevertheless, they used a general characterization to refer to NOS as a way of knowing, the epistemology of science, or the values and beliefs inherent in the development of scientific knowledge (Lederman, 1992). Scientific knowledge has several important aspects:

- Tentative: subject to change
- Empirically based: based on and/or derived from observations of the natural world
- Subjective: theory-laden
- Partly the product of human inference, imagination, and creativity
- Socially and culturally embedded
- Distinction between observations and inferences, and
- The functions of, and relationships between scientific theories and laws (Abd-El-Khalick et al., 1998; Akerson et al., 2000; Bell et al., 2000; Dickinson et al., 2000; Lederman, 1999; Meichtry, 1999, Palmer, 2009).

Opposed to these aspects of nature of knowledge, some people still have some misconceptions about scientific knowledge and inquiry. Table 1 shows the differences between traditional vs. constructivist views of scientific knowledge.

There is an ongoing interest in helping teachers and students develop scientific views consistent with the contemporary conception of NOS among researchers and science educators. Many studies use different methods and instruments for assessing teachers' and students' conceptions; nevertheless they all report results which indicate teachers' and students' conceptions are not consistent with modern scientific practices. Additionally, a growing body of research indicates that the relationship between teachers' conceptions and their classroom practices is far from being direct or simple. Similar results are examined in research focused on the translation of teachers' conceptions of the NOS into classroom practice. In general, these studies have indicated that the relationship between teachers' beliefs about NOS and their classroom practice is more complex than originally imagined (Abd-El-Khalick et al., 1998; Lederman, 1999; Abd-El-Khalick & Lederman, 2000; Bell et al., 2000).

Although a large research tradition has developed around the conceptions of NOS in other countries, less has been done in Turkey. For instance, Yalvac and Crawford (2001) explored the Turkish graduate and undergraduate science education students' conception of NOS using an adapted form of the Nature of Science Questionnaire (NSQ). Findings of their study suggested that the majority of the participants hold views of nature of science aligned with logical positivism. Similarly, Macaroglu, Tasar, and Cataloglu (1998) assessed the preservice science teachers' beliefs about the nature of science using The Beliefs about Science and School Science Questionnaire (BASSSQ) and found that Turkish preservice science teachers believe in the objectivity of scientific knowledge and yet believe that it is subject to change.

Turkish education system has been an ongoing reform effort named National Educational Development Project since 1998. The objective of this effort is to improve the quality of teacher education at the primary and secondary school level. This project mainly focuses on the science teacher education program in terms of emphasizing on the field experience, scientific literacy, and the pedagogical content knowledge. Since, 2006-2007 teacher education programs required to teach History of Science and Nature of Science Course as part of their curriculum program.

Table 1: Comparison of traditional and constructivist views of nature of science

Traditional Nature of Science	Constructivist Nature of Science
<ul style="list-style-type: none"> – scientific knowledge is definite, correct or unchangeable – universal truth 	<ul style="list-style-type: none"> – scientific knowledge is tentative (subject to change) – a view of truth according to individual. – scientific knowledge is never absolute or certain
<ul style="list-style-type: none"> – using concrete data – searching to prove or to truth 	<ul style="list-style-type: none"> – empirically-based – role of evidence
<ul style="list-style-type: none"> – single scientific method – science starts with neutral observations 	<ul style="list-style-type: none"> – scientific knowledge is theory-laden. – observations always motivated and guided by theories.
<ul style="list-style-type: none"> – imagination and creativity are needed in scientific investigations during the planning and design stages 	<ul style="list-style-type: none"> – imagination and creativity are used in all stages of data collection (planning and design, data collection, after data collection) – involves the invention of explanation – generating scientific knowledge involves human endeavor.
<ul style="list-style-type: none"> – science is universal – scientific knowledge must perform the norms of culture that held by scientific community 	<ul style="list-style-type: none"> – socially and culturally embedded – science is a human enterprise – scientists' methods depend on their prior knowledge
<ul style="list-style-type: none"> – observations are neutral that cannot be affected by bias (personal beliefs) – inferences are statement about phenomena that are not directly accessible by senses 	<ul style="list-style-type: none"> – observations are affected by personal beliefs. – inferences drove scientific constructs
<ul style="list-style-type: none"> – scientific laws are absolute and certain. It cannot change because they are proven facts – theories are unproven – theories are alternative beliefs – hierarchical relationship that theories becomes laws with the accumulation of evidence 	<ul style="list-style-type: none"> – scientific laws states what is observed – theories states the how and why – no hierarchical relationship

Source: Akerson et al., 2000; Bell et al., 2000; Buss, et al., 2002; Dickinson et al., 2000; Lederman & O'Malley, 1990; Lederman, 1999; Meichtry, 1999; Morrison, Raab & Ingram, 2009.

The Importance of Study

This research is important for several reasons. First, the results can inform inservice science teachers' initial views about the NOS and the scientific knowledge. Second, the results may provide information what views of the NOS that inservice science teachers are presenting to their students.

Purpose

The purpose of this study was to reveal the views of inservice science teachers on the NOS and scientific knowledge, which is a requisite for scientific literacy. The question guiding this study was:

- What are inservice science teachers' views of NOS and scientific knowledge?

METHODS

Sample

The sample included thirty-two science teachers of whom twenty female (62%) and twelve male (38%). Data were collected from eight different schools representing both urban and rural locales in Zonguldak, Turkey. Teachers who participated in the study varied in qualifications and experiences. Qualifications of teachers ranged from Bachelors Degree with Teaching Diploma to Bachelors Degree in science-related fields. Teaching experiences of teachers ranged from two to twenty-four years with an average of nine.

Data Collection

The qualitative data collection method was utilized to investigate science teachers' views about NOS and scientific knowledge. Qualitative data for the study was derived from the administration of the Views of Nature of Science (VNOS) questionnaire-Form C developed by Abd-El-Khalick, Lederman, Bell, & Schwartz (2001). A participant information inventory was also used to obtain additional information about teachers considering gender, age, qualifications and science experience.

Instrument

The Views of Nature of Science Questionnaire-Form C, (VNOS-C; Abd-El-Khalick, Lederman, Bell, & Schwartz, 2001) was selected to provide information on inservice science teacher views of NOS. VNOS-C was

developed to investigate science teachers' views about NOS and to assess their own ability to incorporate NOS while teaching. The instrument mainly consists of ten open-ended questions. The questionnaire was translated into Turkish by one of the authors. Then it was independently retranslated into English by the other author, who is also native speakers of Turkish. Finally, the original VNOS-C and the retranslated VNOS-C versions were compared by a science education expert and it was concluded that the Turkish version of VNOS-C was correctly reflecting the original version.

Data Analysis

Predetermined coding categories were developed from a search of the literature on teaching and learning NOS. Other coding categories emerged during the data analysis. Before starting the coding, all questionnaires transcripts were carefully analyzed. One of the interesting finding was a difference in the way of some participants mentioned about their beliefs regarding with scientific knowledge. As one of the participants explains "development of scientific knowledge requires empirical evidence, data, and observation", the other explains that "organization of scientific knowledge affected by the norms of the culture". In looking at these differences coding categories were refined. Also the data were analyzed quantitatively to give more explicit information about the results.

RESULTS

Analysis of responses to the open-ended questionnaire indicated that most of the inservice science teachers have alternative conceptions about NOS in terms of understanding of the empirical and tentative nature of science, and the role of creativity in science and the relationship between theories and laws. Moreover, participants failed to explain subjectivity of scientific knowledge and the distinction between observation and inference in the processes of science with aspects of the NOS. On the other hand, they had adequate understandings of the role for social and cultural factors in the construction of scientific knowledge.

Science Teachers' Understanding of the Nature of Science Concepts

Tentativeness of Scientific Knowledge

Most of the participants hold inadequate views of the tentativeness of scientific knowledge. Mostly they believe that scientific laws are proven to be true and cannot be changed. Two of them (6%) noted that scientific theories do change. However, these participants think that theory change only because of new discoveries or new evidence, thus excluding the role of reinterpreting existing data or new ideas in causing theory change. Examples include:

"I do believe that most scientific knowledge requires experiments so that theories can be turned into facts".

"I believe for a theory to become fact it has to be verified first through experimentation and only then it can become a fact, which then cannot change."

The Scientific Knowledge is Empirically Based

Participants held inaccurate ideas of the empirical nature of science. Even though they noted that science is different from other disciplines because of the role of evidence, however, they did not mention about observations of natural phenomena as a characteristic factor that science unlike other disciplines. An example includes; *"Science is different from other disciplines because other non-science disciplines are human derived while science is evidence derived."* A sixty-three percent (63%) of teachers agreed that scientific knowledge is cumulative and increases with increasing observation.

Since all the participants had a traditional way of learning experience in Turkey, they mostly have naïve understanding of scientific method. A ninety-four percent (94 %) of teachers indicated that the use of the scientific method is necessary to discover and validate knowledge.

All of the teacher have alternative conceptions about how scientific process takes place. They indicated that the scientific method is a step-by-step process. One of the teachers mentioned that *"Theories are like as a step to reach the real truth."* Additionally, a thirty-eight percent (38 %) of teachers believed the hierarchical relationship of scientific method that a hypothesis, if tested empirically, becomes a theory eventually become scientific laws, which is alternative conception about the development of scientific theories. One example is *"A theory is based on the assumption of results and it can change - one it has been experimented on and verified as a fact then the theory changes to a scientific law."*

The Effect of Human Creativity and Imagination on the Nature of Scientific Knowledge

All of the teachers described importance of creativity in different level of construction of scientific knowledge. For example, while 38 % of teachers believe that imagination and creativity only used during the planning and the design, 56 % of teachers believes that imagination and creativity affective role on whole process. An example includes: *“They need imagination and creativity in all stages but they used creativity during in design stage than other stages. After data collection, if the data doesn’t fit with what they plan and design, then they needs imagination and creativity to explain it and design another investigation to prove their explanation.”*

The Socially and Culturally Embeddedness of Scientific Knowledge

The effect of social and cultural factors on scientific knowledge was explored in question 9. Twenty-five participants pointed out that society has an influence on science and scientific knowledge. An example is: *“Science is universal but is affected by culture also...”*

Only seven participants believe “universal science” that science cannot be affected by the culture and social factors. They failed to recognize that scientists’ training and background as well as their beliefs influence their work. Examples follow:

“Scientific knowledge does not affect from social and a cultural value...science is universal.”

“Science is universal. It does not affect from socio-cultural, politics and economic factors”

The Functions of and Relationships between Scientific Theories and Laws

Participants’ views about scientific theories and laws were assessed by items 4 and 5. Most of the teachers’ believe that theories and laws are same kind of knowledge and they are only separated based on level of certainty. One teacher stated that, “theories become laws over time when enough evidence is collected.” One participant indicated that: *“Theory is not change but it will be improved based on new information and technological development.”* Teachers held both novice view and expert view about scientific laws. A ninety-seven percent (97 %) of teachers hold novice views are related to the role of previous theories on observation, discovering new theories and development of theories. A seventy-five percent (75 %) of teachers agreed with novice view that scientific

laws can not change. These teachers have alternative conception of hierarchical relationship between theory and law. One teacher stated that: *"Theory can change, it is not proven yet to be true...law is 100% proven."* A six percent (6 %) of teachers agreed with the expert view that scientist invest scientific laws. These teachers have adequate understanding of hierarchical relationship between law and theories. One teacher explained that: *"There are no differences in terms of their changeable (theory &law)."* A nineteen percent of teachers did not demonstrate views about nature of scientific theories, and scientific laws.

Moreover, the subjective (theory-laden) nature of scientific knowledge; differences between observation and inferences were not evident in the case of all participants answers to any open-ended questions on the questionnaire.

DISCUSSION

The results of this study suggested that although understanding NOS could be thought of as a necessary condition, it nevertheless was not sufficient. The study showed that teachers had several alternative conceptions regarding understanding of the nature of science and scientific knowledge. These alternative conceptions are:

- Hierarchical relationship between hypothesis, theories, and laws,
- Laws are absolute truth,
- Science is universal, and
- There is one scientific method

The study also showed that inservice science teachers' views were mostly held traditional (novice) views about scientific knowledge, scientific theories, scientific method and scientific laws. The explanation for the existence of the novice views could be attributed to educational system of Turkey.

Helping teachers to internalize the instructional importance of NOS may help avoid the lack of attention to NOS evidenced in teachers' instructional decisions. A teacher cannot be expected to teach what he or she does not understand. Therefore, teacher preparation programs should be based on improving science teachers' conceptions of NOS with the anticipation that improved students' conceptions would necessarily follow. More professional development activities should focus on teachers' understandings of NOS and ways to translate these understandings into classroom practice. The findings presented in this study can be helpful for teacher educators in revision their programs result in enhancing future science teachers' views on understanding of NOS. Therefore studies about science teachers' views on NOS should

continue until to develop scientific views consistent with the contemporary conceptions of NOS.

LIMITATION OF THE STUDY

Study conclusions cannot necessarily be generalized because of the small sample size. However, this study, with some corroboration from other similar studies, can offer an indicator of conceptions held by a wider population of teachers.

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