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Exploring Nature of Science Understandings of Turkish Pre-service Science Teachers

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Abstract – Aiming at contributing to the literature and informing the program developers, this study presents research findings regarding the Turkish prospective science teachers' understanding of the nature of science. 168 prospective elementary and secondary science teachers participated in the study. The participants' views on the nature of science were assessed through a questionnaire. The results of the study confirmed those conducted in other countries. The findings indicated that prospective science teachers in Turkey, like their counterparts in the world, generally had uninformed views about the scientific enterprise.

Key words: nature of science, prospective science teachers, understandings

Introduction

The impact of science and technology on modern society has been so deep that the print and electronic media often announce the latest advancements in science and technology – human genome project, greenhouse effect, gene transplant, cloning, and artificial intelligence. Our familiarity of these esoteric terms is evidence for power of science and technology in shaping our lives and society. Therefore, the need to promote a society of scientifically literate citizens is regarded as urgent in many countries and is accepted as one of the main goals of science education (Jenkins, 1997). Achieving functional scientific literacy involves providing people with an understanding of science that they can use as they make decisions and engage in debate about scientific and technological issues outside formal education settings (Ryder, 2001). In this sense, educating for scientific literacy entails not only teaching science concepts and theories but also learning about the nature of these concepts and how they function with regard to other beliefs about the physical world (Eichinger, Abell, &

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Dagher, 1997). Therefore, the nature of science (NOS) has been the focus of attention in science education circles as a primary component of scientific literacy (Bell & Lederman, 2003; Meichtry, 1999; Tairab, 2001).

If we accept that schools, most importantly school science, play a significant role in the development of an adequate understanding of science, we need to turn our attention to the school science process and understand its complexity in order to improve it. In the last thirty years, discussions concerning a role for the NOS in school science have increased and few now argue with the proposition that school science experiences should include significant attention to how science works, including how knowledge is created and established (McComas, Clough, & Almozroa., 1998).

With this increasing attention, the development of teachers' conceptions of the NOS has also been a concern of science educators over the last thirty years (Lederman, Wade, & Bell., 1998). The reason why research has focused on teachers' conceptions appears to have a connection with two simple reasons. The first reason has been that a teacher's understanding of the NOS affects his/her students' conceptions, and the second one, which is related to the first, claims that teacher's behavior and the classroom environment are influenced by the teacher's conception of the NOS (Lederman, 1992). To this end, it can be argued that if teachers are to learn how to engage children in conceptual change instruction related to the NOS, they need to further develop their own understanding of the NOS in such a way as to enable them to plan the curriculum and choose appropriate teaching strategies in their classrooms (Bentley & Fleury, 1998).

The research conducted in this field and in science education in general has been dominantly from developed countries, mainly from the United States. Although many developing countries have utilized the results of this research base in reforming their education systems, these efforts usually fall short given the differences in educational, social, cultural and historical contexts in different countries (Leavitt, 1991). Our knowledge base about the science education practices and policies in the developing world is limited. Research results obtained from international studies and describing the aspects of different educational contexts can enhance the knowledge of what works best in different contexts and deepen our understanding of the educational contexts different countries (Guo, 2007). Thus, a larger international community may be able to use the research results to inform science education practices and policy-making. Such studies can also provide opportunities for educators and researchers from a given country to reflect on the goals, beliefs, and practices

that they take for granted (Guo, 2007). Towards this end, as a part of more comprehensive research program aiming to assess and improve Turkish science teachers' understanding of the NOS, this study attempts to fill this gap in the literature and presents the findings regarding the views of prospective primary and secondary science teachers on the NOS.

Context of the Study

Turkey has one of the biggest and youngest populations in Europe; therefore, education has been and continues to be of critical importance to the nation's social, political and economic development. Like many governments around the world, the Turkish government is aware of the importance of preparing its citizens for the challenges of the new century, and perceives the promotion of scientific literacy in society as an important goal of science education. However, science education, in particular, is still far from the desired level (Irez, 2006). Science education curriculum has been criticized on the basis that it is content based (Turkmen & Bonstetter, 1998) and gives less priority to student-centered activities (Cakici, 2001). Furthermore, Cakici (2001) argues that the Turkish national curriculum includes far too many topics and does not allow flexibility for teachers to select the content. The role of the teacher is to provide predetermined information in the light of the main aims of the curriculum (Cakici, 2001). This situation requires students to absorb a static body of scientific knowledge and also encourages rote learning rather than meaningful learning (Irez, 2006). Especially in the last two decades, science education in Turkey has been greatly influenced by entrance examinations at different educational levels. The most influential examination in a typical Turkish student's life is the university entrance examination. Although some alterations have been made recently, traditionally, the university entrance examination assesses the content knowledge of students in a variety of subjects such as physics, biology, chemistry, Turkish, and math. This has affected teaching and learning negatively in the nation's schools. Getting a high score in the university examination has required the mastering and memorizing of content by the students. Teaching has become a transmission of content knowledge and a successful and effective teacher is perceived as one whose students perform well in the exam (Cimer, 2004). Practical work, field trips, and social facets of schooling have been neglected (Cimer, 2004).

This situation, inevitably, has affected the profile of science education as well. Arguably, it has led many students and science teachers to associate the study of science subjects at school with memorization of the vocabulary of science, with little emphasis on understanding underlying scientific processes. Many students appeared to do well in the

exam, yet without showing motivation for or demonstrating an understanding of science. Few would argue against the fact that this memorization of the content of science has also led these students to associate science with a set of "truths" (Tobin & McRobbie, 1997).

In the light of present research, we have very little idea of the level of understanding of how science teachers in Turkey, who are primarily responsible from educating scientifically literate citizens, view science and its nature. This is important as Turkey has been in a process of reforming her educational system at all levels in order to educate global citizens equipped with 21st Century skills. Such an attempt would necessarily require research evidence about the strengths and shortcomings of the current practices.

Methodology

With the recognition of the need for the NOS within the school science curriculum, the assessment of teachers' understanding of the NOS has been a focal point for science education research over the years. A wide range of probes and instruments employing qualitative and/or quantitative approaches have been developed and used in different studies. We used both methodologies in different stages of our research program aiming to assess and improve Turkish science teachers' understanding of the NOS. For the purposes of this study, the first part of the 'Beliefs about Science and School Science Questionnaire' (BASSSQ) which aims to reveal teachers' views on scientific inquiry was chosen. One of the main reasons for choosing the BASSSQ was that the structure and the orientation of the questionnaire was comparatively suitable to assess whether Turkish science teachers' ideas were consistent with those stated by the new secondary science (physics, chemistry, biology) curriculum. The BASSSQ assesses the views regarding the NOS ranging on a continuum from an objectivist to a constructivist view (Aldridge, Taylor, & Chen, 1997). The objectivist image of science defends the application of inductive methods and argues that a true scientist uses value-neutral experimental observation which yields incontestable facts about nature (Aldridge, Taylor, & Chen, 1997). The constructivist (or post-modern) view of science, on the other hand, argues that scientific inquiry is shaped 'ineluctably' by human values, scientific observation is theory laden (Kuhn, 1970), and that there is no single correct scientific method (Lakatos, 1970).

The full questionnaire was designed to measure two dimensions of teachers' beliefs: (1) beliefs concerning the teacher's view of the NOS, and (2) beliefs concerning the teacher's view of the nature of school science (Aldridge, Taylor, & Chen, 1997). Thus, the questionnaire comprises two parts: the teacher's view of science and the teacher's view of

school science. As the purpose of this study is to present the Turkish secondary science teachers' views on the NOS, only the findings about the first part of the questionnaire will be presented here.

There are 20 items in this part of the questionnaire and responses to the items are recorded on a five-point Likert-type frequency response scale. In scoring, each item response is allocated 1, 2, 3, 4, or 5 points for each of the response categories. Items aligned with an objectivist view are scored in reverse and, during statistical analysis, are adjusted accordingly. A scale mean score is calculated by dividing the total scale score by the number of respondents and the number of scale items. Thus, the scale mean scores range between 1 (Almost Never) and 5 (Almost Always). A higher score indicates more constructivist view of the NOS and a lower score represents more objectivist view.

The questionnaire was translated into Turkish by one of the authors. Then a panel of three experts compared and revised the translated version of BASSSQ and concluded that the Turkish version of BASSSQ correctly reflected the original version. In order to establish the reliability of the instrument, initial form was piloted with 122 pre-service science teachers. As a result, to have a sound internal consistency, elimination of four items (items 4, 7, 11, and 14) deemed to be suitable. Such elimination was not considered problematic as similar strategy was suggested by the developers of the questionnaire (Chen, Taylor, & Aldrigde, 1997). In order to make the analysis more relevant to our purposes and give more detailed accounts of Turkish secondary science teachers' views of the NOS, remaining questions were divided into four sub-scales according to contextual relevance as subjectivity in science (questions 1, 2, 3, 5, 6 and 10), the nature of scientific method (questions 8 and 9), the tentative nature of scientific knowledge (questions 12, 16 and 17), and the relationship between science and society (questions 13, 15, 18, 19 and 20). Finally, the Cronbach alpha coefficients of the subscales were found as 0.81 for the nature of scientific method, 0.72 for the tentative nature of scientific knowledge, 0.69 for the relationship between science and society, and 0.64 for subjectivity in science subscales.

Results

Table 1 presents the mean values and standard deviations of prospective science teachers' views about subjectivity in science, scientific method, the tentative nature of scientific knowledge, and the relationship between science and society. While the participants presented relatively good understanding of the tentative nature of scientific knowledge (M=3,58) and the role of subjectivity in science (M=3,39), their views of scientific method (M=2,01) and

the relationship between science and society (M=2,72) were mostly objectivist. While there are not significant differences between the mean scores of the groups of prospective teachers regarding the majority of the scales, the physics teachers group reflected significantly objectivist views regarding the scale scientific method (M=1,76).

Table 1 Mean Values and Standard Deviations of Prospective Science Teachers' Views about Science

Scales	Physics n=41		Chemistry n=23		Biology n=27		Science n=77		Total N=168	
	M	SD	M	SD	M	SD	M	SD	M	SD
Tentativeness	3,50	0,69	3,38	0,85	3,65	0,66	3,65	0,72	3,58	0,72
Science&Society	2,58	0,57	2,43	0,89	2,46	0,78	2,97	0,66	2,72	0,73
Subjectivity	3,45	0,48	3,49	0,49	3,37	0,60	3,35	0,48	3,39	0,50
Scientific Method	1,76	0,49	2,07	0,68	2,06	0,79	2,12	0,69	2,01	0,67

Figure 1 presents the detailed analysis of the mean values for the questions related to the nature of scientific method. The mean values for the questions 8 and 9 were identical (M=2,01). The subjects tended to believe that scientific investigations start with observations of nature and scientific investigations follow the scientific method.

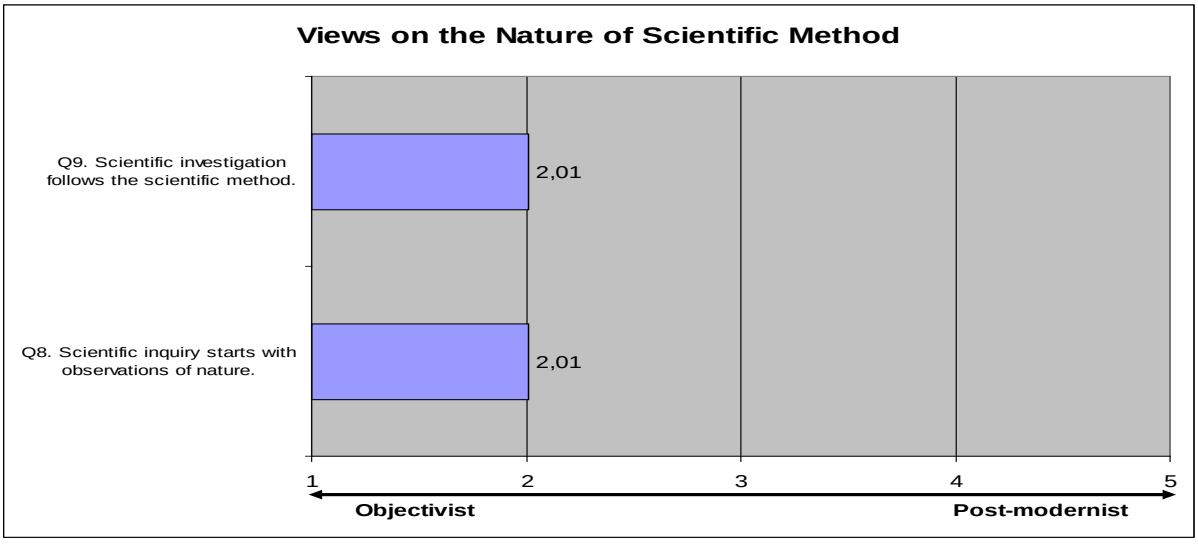

Figure 1 Mean Response Values for the Nature of Scientific Method.

Figure 2 presents the detailed analysis of the mean values for the questions related to the relationship between science and society. Mean values for the questions 13, 18, 19 and 20 were relatively low indicating the participants' general belief in independence of science from social and cultural aspects. However the participants' mean values were slightly higher for the question 15 (M=3,25), indicating their belief that the evaluation of scientific knowledge varies with changes in situations.

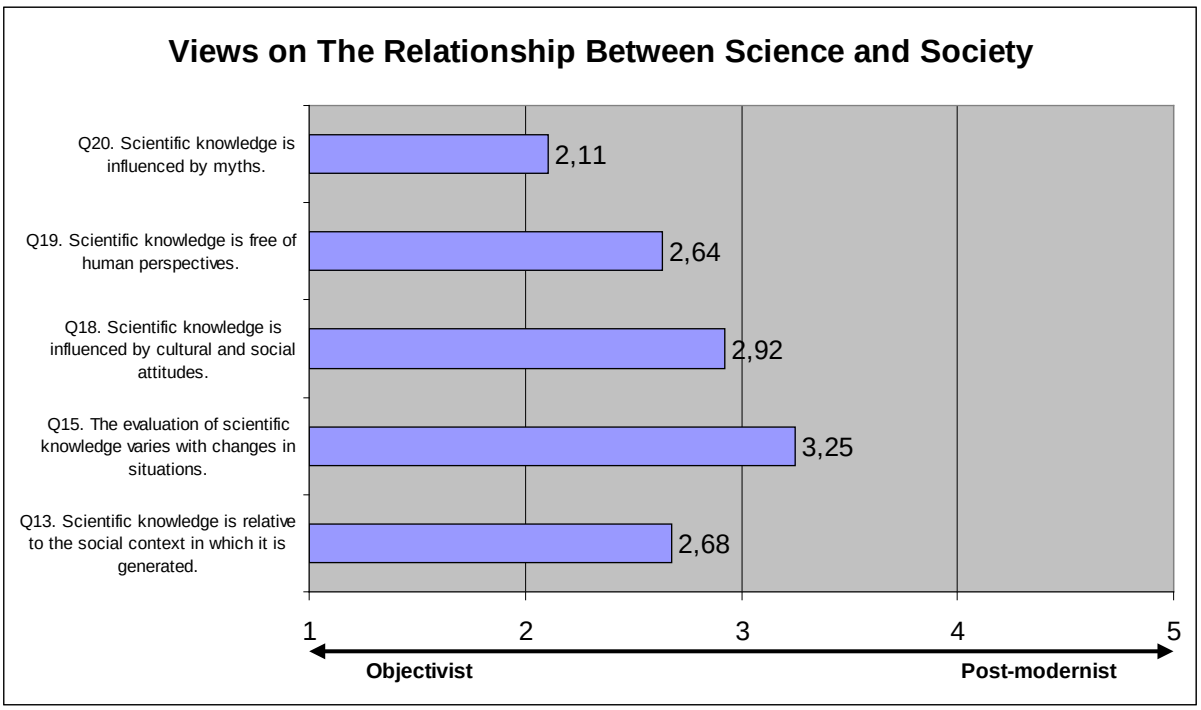

Figure 2 Mean Response Values for the Relationship between Science and Society.

The mean values for the questions assessing the subjectivity in science is presented in Figure 3. Although the total mean value for the questions about subjectivity in science are relatively high (M=3,39), the detailed analysis presented in figure 3 shows that this view is far from being straightforward and diverse in nature. While the mean values are quite high in questions 4 (M=4,27) and 1 (M=3,79), the mean values for the questions 3 and 6 were notably lower (M=2,75 and M=2,82 respectively).

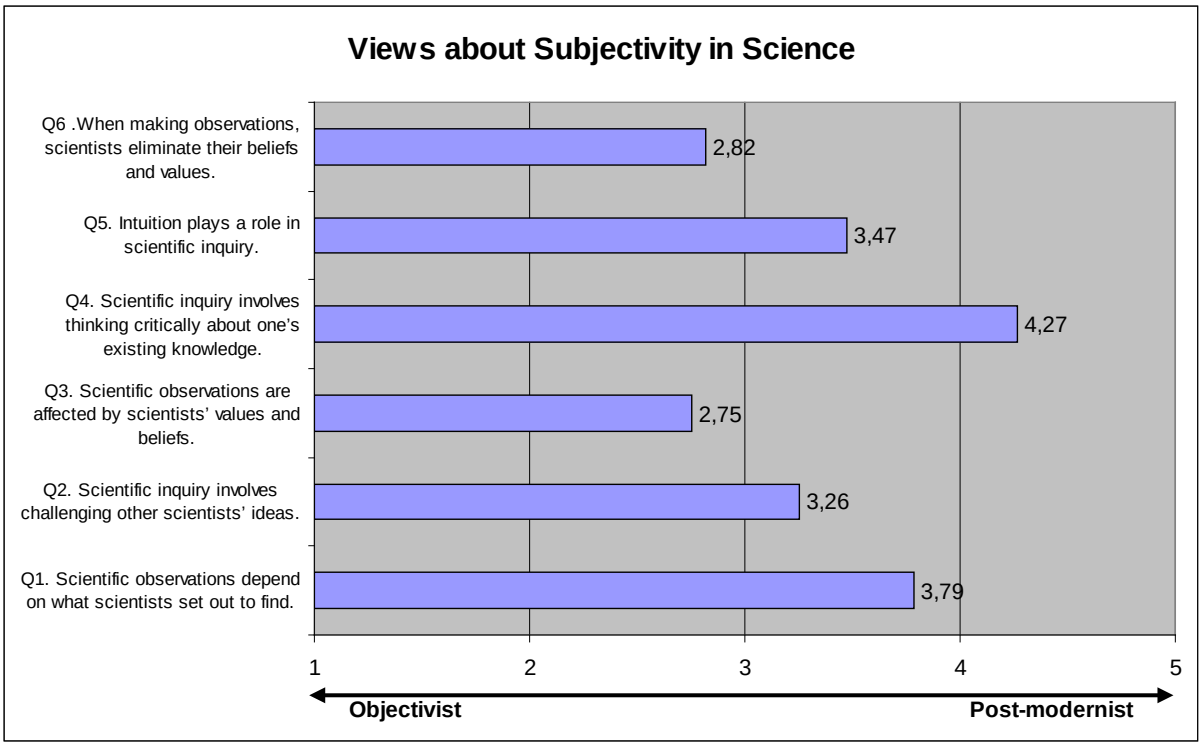

Figure 3 Mean Response Values for Subjectivity in Science.

Finally, the participants reflected relatively post-modern views regarding certainty of scientific knowledge (Figure 4). The mean values for the three questions in this scale were above the level three indicating that the participants perceived scientific knowledge subject to change and modifications in the future.

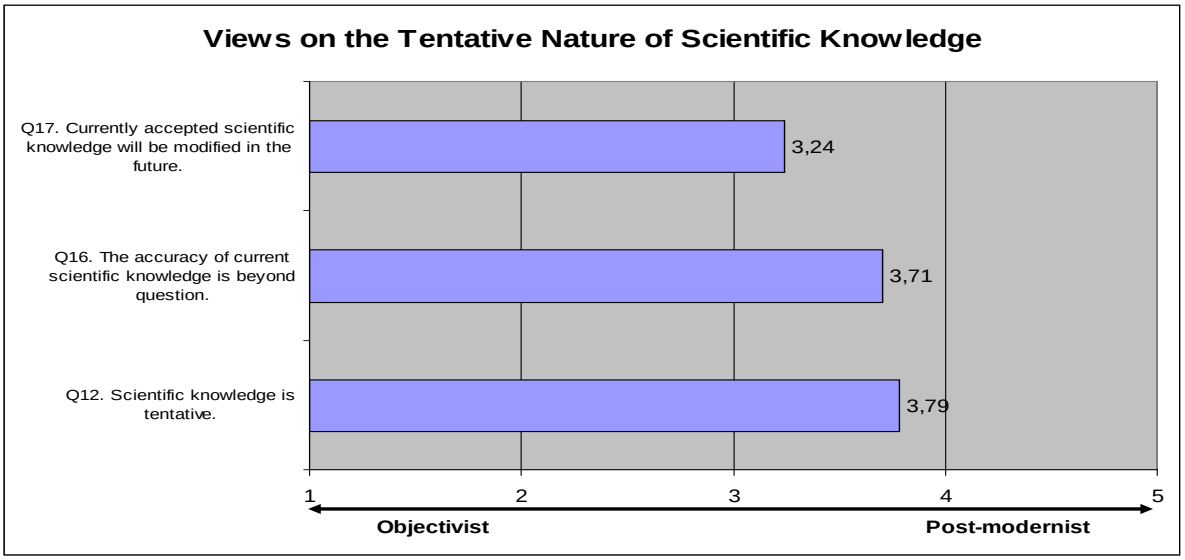

Figure 4 Mean Response Values for the Tentative Nature of Scientific Knowledge.

Conclusion and Implications

As the new complexities of teaching and learning emerge so do the complexities of preparing adequate and effective courses for the future teachers. Science education and science teacher education are no exceptions in this case. There is a lack of consensus amongst science educators concerning the specific content or method of instruction to be included in science teacher education programs (Lederman, 1992); however, there is an strong agreement that science instruction should facilitate the development of an adequate understanding of the NOS or an understanding of science as a way of knowing (Hammrich, 1997). Despite this agreement, international studies have reported that both practicing and pre-service science teachers do not possess adequate conceptions of the NOS (Mellado, 1997; Nott & Wellington, 1998; amongst others). The findings of this study indicate that prospective science teachers in Turkey, like their counterparts in the world, generally have uninformed views about the scientific enterprise. Evidence from this research points out that Turkish science teachers' views are generally compartmentalized and lacked consistency; features which are expected given that learners are often not provided with opportunities to reflect on and clarify their views of NOS (Akerson *et al.*, 2000).

The results of this study should not be surprising considering that science teacher education programs in Turkey do not pay attention to the conceptual development of prospective science teachers with regard to the NOS. Courses on the history and philosophy of science are rare (if any) in teacher education programs. What the findings of this research suggest is that close attention should be paid to the pre-service preparation of science teachers. Otherwise, the vast majority of newly trained science teachers will go out into schools with unexamined and unclear conceptions of NOS. This would inevitably jeopardize the promotion of scientific literacy in society.

Reflection should lay at the core of pre-service education of science teacher educators. Pre-service teachers enter graduate level programs holding ideas, beliefs, and values (Abell & Bryan, 1997; Lainer & Little, 1986). Therefore, science teachers should be encouraged throughout their studies to explore these pre-existing beliefs in order to develop them. Such reflection is especially crucial if science teachers are to improve their understandings of the NOS as this requires a critical deliberation of one's own beliefs (Irez & Cakir, 2006). An ideal environment for this reflection would be a special course on NOS. The necessity of such a course in science teacher education has already been emphasized by many researchers in the last decade (e.g. Eichinger et al., 1997).

In summary, science teachers need to be aware of any inconsistencies and misconceptions they may have regarding the NOS and what the effects of these inconsistencies might be on their practice. Without a doubt, science teachers with differentiated and integrated understanding of the NOS will have greater ability than those whose understanding is limited and inconsistent, to plan and deliver lessons that help students develop deep and adequate understandings.

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