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Horizon of Science Education Reform in Turkey: Challenges Ahead

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ABSTRACT

This paper presents a research study aimed at providing an account on Turkish biology teachers' views on the nature of scientific inquiry and assessing if these views comfort the vision and epistemological foundations of the new secondary biology curriculum. To this end, the paper starts with a comparison of the visions and perspectives on the nature of scientific inquiry presented by the previous and the new biology curricula in order to document the scale of shift on understandings between the two. This analysis is followed by the results of a research study conducted on 113 practising biology teachers' views of the nature of scientific inquiry. The results indicated that understandings of current biology teachers are generally objectivist in nature which, arguably, constitutes the major barrier for the successful implementation of the curriculum reform as intended. Finally, the article will be concluded with a discussion on the challenges ahead for successful implementation of the new curriculum.

KEYWORDS: Curriculum reform, biology teachers, nature of science

Türkiye'de Gerçekleşen Fen Eğitimi Reformunun Geleceği: Aşılması Gereken Engeller

ÖZET

Bu çalışma Türk ortaöğretim biyoloji öğretmenlerinin bilim ve bilimin doğasına yönelik anlayışlarını tespit etmek ve bu anlayışların yeni ortaöğretim biyoloji programının vizyonu ve epistemolojik temelleri ile uyumlu olup olmadığını araştırmak amacı ile yapılmıştır. Bu amaçla, çalışmanın ilk kısmında eski ve yeni biyoloji öğretim programlarının vizyonları ve bilimin doğasına bakış açıları yaklaşımlardaki farklılığın boyutlarını ortaya koyabilmek için karşılaştırılmıştır. Bu analizi 113 hizmet-içi biyoloji öğretmeninin bilimin doğası ile ilgili anlayışlarının araştırıldığı bir çalışmanın sonuçları takip etmektedir. Bu çalışmanın sonuçları çalışmaya katılan öğretmenlerin genel olarak objectivist bir bilim anlayışına sahip olduklarını göstermektedir. Bu durum yeni öğretim programının başarılı bir şekilde uygulamaya konulmasının önündeki en önemli engel olarak durmaktadır. Çalışma yeni öğretim programının başarılı bir şekilde uygulanabilmesinin önündeki engellerle ilgili bir tartışma ile sona ermektedir.

ANAHTAR KELİMELER: Öğretim programı reformu, biyoloji öğretmenleri, bilimin doğası

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INTRODUCTION

The twentieth century has experienced more social transformations than any other period in history due to the introduction of sophisticated communication technologies and recent developments in science. Revolutionary advances in the last century have proven that the horizons of science and technology are beyond our imagination. We have unravelled the mystery behind DNA and transcribed the entire genetic code of a human being, discovered antibiotics, travelled in space, etc. Progress in science and technology has brought unbelievable comfort to our lives. However, the twentieth century has also brought the dark and dangerous side of many scientific developments to public awareness. The image of science has been tarnished by a succession of scientific and technological developments with unforeseen environmental and societal consequences, such as DDT, the depletion of the ozone layer and Chernobyl (Millar & Osborne, 1998). In addition, many scientific developments, such as genetic manipulation and cloning, have led to public unease about their applications (*Ibid*). Indisputably, science has become a fundamental aspect of our culture and social life in the past century (DeBoer, 1991). Hurd (1998) argues that it is difficult to discuss human values, political and economic problems, or educational objectives today without a consideration of the role played by science.

Along with these revolutionary advances, the practice of science has also changed dramatically in the last century. Hurd (1998) argues that the traditional concept of a discipline (biology, chemistry, physics, earth science) as entities no longer have much meaning beyond that of cataloguing university and school science courses. Disciplines have now become fractionated into an unknown number of research fields each with its own language and research practices. Technological equipments have become the primary determinants of what could be studied and what is likely to be discovered in science. The scope of practices in science has also changed: less attention is being devoted to the establishment of new theories and laws, a procedure formerly recognized as basic research. Today more attention is focused on the functional aspects of science/technology as it relates to human welfare, economic development, social progress, and the quality of life (*Ibid*). Scientific research has become multi-disciplinary, multi-authored initiative supported by industry. Today 60% of all scientists are employed in industry, 35% in universities, and 5% are self-employed (*Ibid*). Science is not an individual and intellectual enterprise as once did, it is a social activity initiated, funded, directed and, sometimes abandoned by society.

Our understanding of the nature of scientific inquiry has also experienced a major transformation in the last century. Positivistic understanding of scientific inquiry which defends the application of inductive methods and argues that science employs value-neutral experimental observation which yields the discovery of incontestable facts about nature has fallen out of favour. Contemporary understanding of science describes science as a special way of knowing and argues that scientific inquiry is shaped ‘ineluctably’ by human values, scientific knowledge is produced rather than discovered, scientific observation is theory laden (Kuhn, 1970), and that there is no single correct scientific method (Lakatos, 1970).

These changes in the practice science and perception of the nature of scientific inquiry have revealed a need to re-examine the traditional purposes of science education (Hurd, 1998). In 1970, the National Science Foundation Advisory Committee for Science Education in the United States recommended that the traditional approach to science education in the sciences be rethought with more *'emphasis on the understanding of science and technology by those who are not and do not expect to be professional scientists and technologists'* (Report, 1970, p. iii, cited in Hurd, 1998: 409). The implication is that notions of scientific literacy should be embedded in contexts that promote a socially responsible and competent citizen (*Ibid*). 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 teaching about the nature of these concepts and how they function with regard to other beliefs about the physical world (Eichinger, Abell, & Dagher, 1997). Therefore, teaching and learning about 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). 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).

Today, calls for reform in science education in Turkey are as loud and clear as elsewhere in the developed world. 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 has introduced many reforms at various levels of education in the last ten years. The latest of these reform efforts took place in the secondary education. With this movement, both the structure and content of the secondary education was targeted. The length of the secondary education, which was three years, has become four years. The content and philosophy of secondary education has also been targeted. In secondary biology, for example, a new curriculum and teaching materials have been introduced. This new curriculum has presented a new vision for the aims, learning and teaching approaches, and methods of assessment for secondary biology teaching. More importantly, the new curriculum has presented a new understanding with regard to the nature of scientific knowledge. Before proceeding any further in our discussion, then, we must analyse what kind of new approaches this reform movement have brought about for school science in Turkey. It is also useful to compare the conceptual framework of the new curriculum with that of previous one in order to understand the scale of the shift. In line with the aims of this study, the previous and new biology curricula are compared with regard to their curriculum emphases and approaches to the nature of scientific inquiry.

Science Education Reform in Turkey: A Paradigm Shift?

Curriculum Emphases

One of the important steps in curriculum development process is the identification of coherent set of messages to the student about science (Roberts, 1982). Because, Roberts argues, such messages *'constitute objectives which go beyond learning the facts, principles, laws, and theories of the subject matter itself – objectives which provide answers to the student question: "Why am I learning this?"'* (p. 245). This answer to this question reflects the emphasis on what is valued and desired in the curriculum. Roberts calls this *curriculum emphasis* and, discusses and describes seven different emphases utilized by curriculum developers in the last century. He argues that each emphasis, naturally, shapes the content and the structure of the curriculum.

The framework and classification defined by Roberts was used in analysing the differences regarding the emphases of both curricula. To this end, the overall objective of the previous biology curriculum emerged as;

> ... to help individuals who will constitute the science-society to acquire scientific problem solving skills for the problems they may encounter in their everyday life ... (Ministry of National Education [MNE], 1998: 131).

This overall objective was followed by a list of attainment targets. *'Learning the general structure of living things'* was, somewhat inconsistent with the overall objective, on the top of the list. This was followed by *'learning about and caring environment'* and *'developing habits needed for a healthy life'*. Parallel to these attainment targets, the previous curriculum put emphasis on the learning of biology content and developing skills to solve everyday problems utilizing a scientific approach.

In light of this analysis, the previous curriculum's approach falls into the *Correct Explanations* and the *Everyday Coping* emphasis in Roberts's (1982) framework. Roberts argues that the Correct Explanations emphasis stresses science products that are accepted by scientific community. This emphasis gives the messages *'master now, question later'* (*Ibid.*). The Everyday Coping emphasis, on the other hand, declares that science is an important means for understanding and controlling one's environment (*Ibid*).

The overall objective, or the 'vision' as it is called, of the new curriculum is stated as;

> ... to educate scientifically literate individuals that understand the nature of science…
> appreciate the necessity of learning biology… possess adequate cognitive conceptual frameworks regarding biological concepts… comprehend the relationship between science-society-technology… approach problems with the principles of scientific inquiry. (MNE, 2007: 3).

The structure and content of the new curriculum were shaped in order to achieve the overall objective. To this end, the new curriculum targets developing skills and attitudes related to the aforementioned overall objective (that is educating scientifically literate citizens) as well as developing knowledge of biology. The attainment targets are divided into three groups in the new curriculum. These are; a) *Science-Technology-Society-Environment*, b) *Communication Skills, Attitudes and Values*, c) *Scientific Inquiry and Science Process Skills*.

Considering such an overall objective and related attainment targets, the new curriculum's emphasis bears the aspects of three emphases in Roberts's (1982) classification. These are the *Structure of Science* emphasis, the *Science, Technology, and Decisions* emphasis and, the *Scientific Skill Development* emphasis.

The new curriculum's emphasis includes the Structure of Science emphasis as it stresses and gives messages about how science functions intellectually in its growth and development (Roberts, 1982). The new curriculum targets student understanding on the nature and status of scientific knowledge, the interplay between evidence and theory, the role of models for explaining natural phenomena, the subjective nature of science, etc. Unlike the previous curriculum's emphasis on Everyday Coping, the new curriculum puts an emphasis on the limits of science in coping with practical affairs. The new curriculum also stresses the development of scientific process skills as opposed to learning the products or content of science, which were emphasized in the previous curriculum.

To conclude, as discussed above, the two biology curricula have radically different emphases regarding the objective of biology education at secondary level. This difference in the emphases shows that these two curricula have different worldviews. Consistent with their difference in worldviews, analysis revealed that the two curricula also have different understandings about the nature of science and scientific knowledge.

The Nature of Scientific Inquiry

Close inspection of the two curricula reveals that while the previous biology curriculum presented the nature of knowledge from a positivist perspective, the new curriculum presents a constructivist perspective. Science, for example, was defined as *'cumulative knowledge gathered through observations and experiments'* (MNE, 1998: 139) in the previous biology curriculum. What is immediately evident from this description is an introduction of science as body of knowledge. The view that science represents a body of knowledge was implicitly supported in the following units by portraying biology as a collection of facts. For example in the unit titled *Views about the Origins of Life* in which the theory of evolution was introduced, the curriculum stated that;

> ... the factual knowledge in biology was presented in the earlier sections, this section, however, presents interpretations of these. (MNE, 1998: 211).

Such a description of science and scientific knowledge also underpinned another view that there is an existing truth or reality out there and science represents the way of reaching that reality or truth. This view portrayed science as a process of *discovering* (or collecting, exploring) what is out there. The previous curriculum presented this process as the scientific method. The scientific method, according to the previous curriculum, was a step-wise and universal procedure in science. The previous curriculum's expectations from the students were;

> Write and/or articulate the steps of the scientific method.
> Decide whether the steps of the scientific method were used in a given example of a scientific investigation.
> Write and/or articulate that it is required to follow the steps of the scientific method in the solution of problems in biology.
> (MNE, 1998: 139-140)

The previous curriculum saw following the steps of scientific method as necessary in order to produce and guarantee objective knowledge. Another requirement in obtaining objective knowledge in science, according to the previous curriculum, was the characteristics that scientists should have.

> (Students should)
> Explain the characteristics that a scientist should have.
> (MNE, 1998: 139)

Further, the previous curriculum suggested teachers to ask questions such as *'List the characteristics of a scientist'* in the assessment of learning. Although the curriculum did not provide a list of these characteristics, the textbooks that used the previous curriculum as the framework did. The research study by Irez (2009) revealed that the secondary biology textbooks reflecting the previous curriculum's approach provided list of characteristics that a scientist should have. These included characteristics such as being objective, honest, hard-working, determined, logical, and sceptical amongst many others.

On the other hand, science is described from a constructivist perspective in the new biology curriculum. For example, the new curriculum introduces science as a dynamic process of generating testable and falsifiable explanations about natural phenomena.

> (students should)
> Develop an understanding that science [scientific knowledge] has testable, experimental and falsifiable nature.
> Realize that scientific knowledge is tested, corrected or renewed in the light of new evidence. (MNE, 2007: 17)

These statements also imply the tentative nature of scientific knowledge. Indeed, in various places, the new curriculum emphasizes that all scientific knowledge is subject to change. It views the tentativeness of scientific knowledge from a Kuhnian perspective in that change in science is explained as a paradigmatic shift.

> (Students should)
> Explain the role of evidence, theories and/or paradigms in change of scientific knowledge.
> Realize that change in science is continuous and sometimes in the form of paradigmatic shift. (MNE, 2007: 17)

In contrast to the previous curriculum, the new curriculum does not present science as an objective enterprise. Instead, it suggests that science and society influence each other and perceives science as a product of society and human-culture.

> (Students should)
> Understand that socio-economic and cultural contexts influence the development of biology.
> Understand and gives examples about the contributions of societies that have different historical and cultural pasts to the development of biology. (MNE, 2007: 17)

Further, the new curriculum does not claim that scientists should have certain characteristics to ensure objectivity in science; instead, it discusses that subjectivity is natural and expected in science.

> (Students should)
> Realize and discuss the effects of different attitudes and values in science. (MNE, 2007: 17)

In sum, the analysis conducted with regard to approaches of the previous and new biology curriculum pointed out a significant difference between their depictions of science and scientific enterprise.

What this summary illustrated is that important changes have taken place at secondary level biology education in Turkey. The curriculum reform experienced in Turkey has introduced a new world for teachers, which is fundamentally different from the previous one. Irez and Han (2010) liken this change Kuhn's (1970) paradigm shifts in the history of science. They argue that large scale educational reforms, as in paradigm shifts in science, bring new conceptual frameworks, introduce new educational aims and view on how people learn, require to adopt new teaching and assessment approaches and materials, etc. In this new educational world, teachers face with new educational aims and new understanding of the nature of scientific knowledge.

No doubt that the success of any reform attempt depends on the practitioners' ability in adequately reflecting the vision of the reform in the classroom. Teachers' proficiency is especially important when it comes to teaching nature of science as research indicates that a teacher's understanding of the NOS affects his/her students' conceptions, and teacher's behaviour 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 have informed 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). What the discussion presented so far indicated is that the reform movement in secondary biology in Turkey predominantly depends on biology teachers who have deep and adequate understandings that are consistent with the vision of the reform. To this end, the following is a research study aiming at providing an account on Turkish biology teachers' views on the nature of scientific inquiry.

METHODOLOGICAL FRAMEWORK

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 biology 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 biology teachers' ideas were consistent with those stated by the new biology curriculum. Reflecting the radical change with regard to the nature of scientific knowledge in the previous and new biology curricula, 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 biology 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 biology 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.

The final form of the questionnaire was administered total of 113 practicing biology teachers in Istanbul area in spring 2009.

RESULTS

Table 1 presents the mean values, standard deviations, standard error of the means, and the %99 confidence intervals for mean values of biology 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=3.10) and the role of subjectivity in science (M=3.06), their views of scientific method (M=1.41) and the relationship between science and society (M=2.16) were mostly objectivist. Variability of the views is reflected in confidence interval of the means. Confidence intervals indicate that biology teachers' view of scientific method is the most homogenous and closer to objectivist while their view of tentative nature of scientific knowledge is the most heterogeneous.

Table 1. *Mean Values, Standard Deviations, and Confidence Intervals (%99) of Biology Science Teachers' Views about Science*

Scales	Mean	Std. Dev.	SE of the mean	Confidence interval (%99)
Tentativeness	3.10	1.28	0,12	2,80-3,40
Science&Society	2.16	1.22	0,115	1,86-2,45
Subjectivity	3.06	1.36	0,128	2,73 -3,39
Scientific Method	1.41	0.67	0,063	1,25-1,57

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 quite close to each other (M=1.54 for Q8 and M=1.28 for Q9) indicating that the participants tended to believe that scientific investigations start with observations of nature and scientific investigations follow the scientific method. This finding has been commonly reported in many studies of students' and teachers' beliefs (e.g., Akerson, Abd-El-Khalick, & Lederman, 2000; Lakin &Wellington, 1994) and attributed as one of the most widely held misconceptions about science (Abd-El-Khalick, Lederman, Bell, & Schwartz, 2001; McComas, 1998). As explained earlier, the previous curriculum promoted the idea of the existence of a universal step-by-step scientific method which guarantees objective scientific knowledge. From this perspective, the participants' views were in line with the previous curriculum's depiction of scientific method. These views, however, stand in stark contrast to the idea of scientific method described in the new biology curriculum. Generally, the new curriculum emphasizes that there is no single scientific method that captures the complexity of doing science and close inspection of scientists' work will reveal that they approach and solve problems with imagination, creativity, prior knowledge, and perseverance.

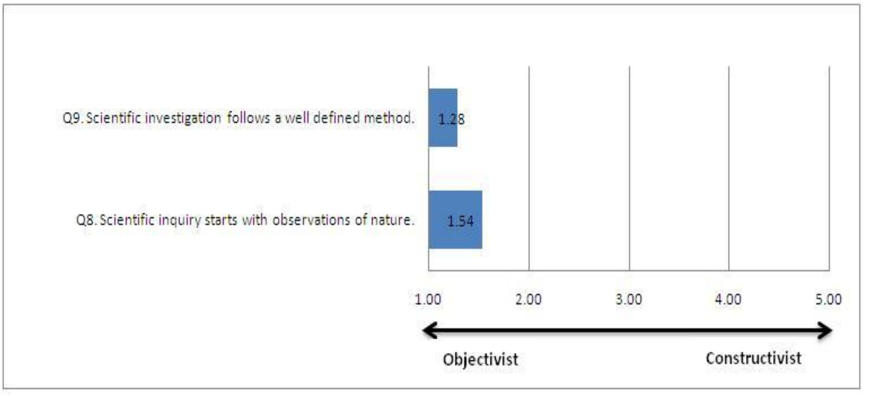

Figure 1. Mean Response Values for the Nature of Scientific Method.

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. Generally, the participants believed that scientific knowledge is free of human perspectives (Q19, M=1.83), is not influenced by myths (Q20, M=1.55) and social or cultural attitudes (Q18, M=2.38) and, is not relative to the social context in which it is generated (Q13, M=2.34). Again, all these views are closely associated with an objectivist view of scientific inquiry which was emphasized by the previous biology curriculum. The new curriculum, however, requires biology teachers to give references to human-side of scientific inquiry; that is, as a social activity, the influence of personal attitudes, values, beliefs as well as socio-cultural and socio-economic contexts on scientific enterprise. It is worth to note that the mean values were slightly higher for the question 15 (M=2.82), indicating the participants' belief that the evaluation of scientific knowledge varies with changes in situations. An explanation to this somewhat contradictory finding might be that this question is closely related to the tentativeness of scientific knowledge and, therefore, the participants might have considered this question from the tentativeness point of view. As presented in the following, the participants' views about the tentative nature of science were relatively informed.

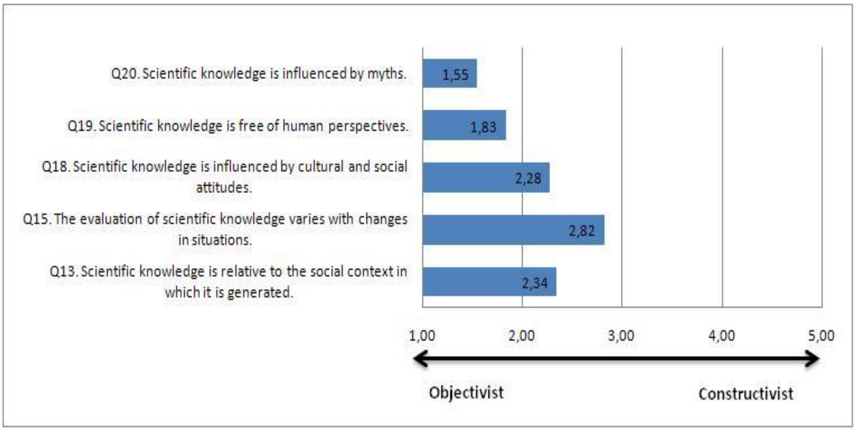

Figure 2. Mean Response Values for the Relationship between Science and Society.

The participants reflected relatively informed views regarding the certainty of scientific knowledge (Figure 3). The mean values for the three questions in this scale indicated that the participants perceived scientific knowledge subject to change and modifications in the future. Detailed analysis of the mean values revealed that the participants generally did not perceived the accuracy of current scientific knowledge as beyond question (Q16, M=2.81) and presented a tendency towards the idea that currently accepted scientific knowledge will be modified in the future (Q17, M=2.98). Importantly, the mean value for the Q12 (Scientific knowledge is tentative) was remarkably high (M=3.36). Although not at desired level, these findings indicate that participants' views about the tentative nature of scientific knowledge are similar to those stated in the new curriculum. However, the research literature warns us to handle these findings with caution. Research acknowledge that individuals have a tendency to accept scientific knowledge as tentative in first the examination, however, as many of them do not have well defined concepts of theories, laws, and facts, they do not attribute the same value to these and perceive some scientific knowledge (e.g., laws and facts) as established and certain (Irez, 2006; Mueller & Wavering; 1999).

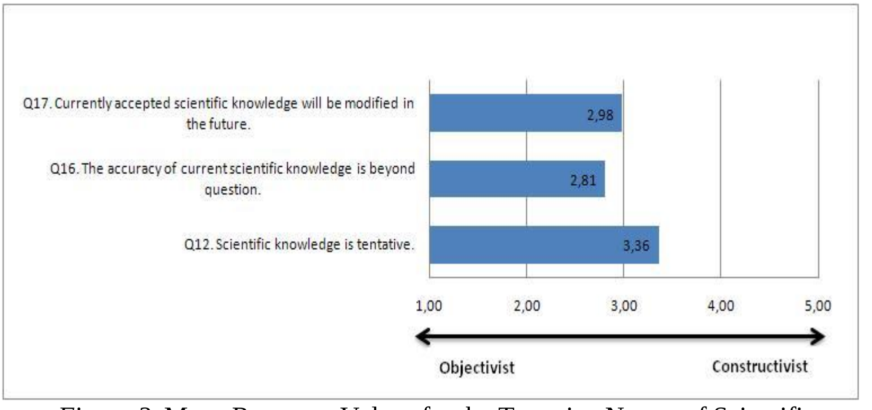

Figure 3. Mean Response Values for the Tentative Nature of Scientific Knowledge.

The mean values for the questions assessing the subjectivity in science are presented in figure 4. Although the total mean value for the questions about subjectivity in science are relatively high (M=3.06), the detailed analysis presented in figure 3 shows that this view is far from being straightforward, and instead, eclectic in nature. While the mean values are quite high in some questions, the mean values for other questions were notably lower. The participants agreed that scientific observations depend on what scientists set out to find (Q1, M=3.65), scientific inquiry involves challenging other scientists' ideas (Q2, M=3.38), intuition plays a role in science (Q5, M=3.39) and, scientific ideas come from both scientific and non-scientific sources. These views are quite aligned with contemporary understanding of the nature of scientific inquiry. On the other hand, the participants presented contrasting views about the remaining two questions in this subscale. Overall, they rejected the idea that scientific observations are affected by scientists' values and beliefs (Q3, M=2.25) and presented a view that scientists eliminate their beliefs and values when making observations (Q6, M=2.35). These views are quite in line with the participants' responses to the items related to the relationship between science and society in which the participants presented an objectivist view about the scientific enterprise.

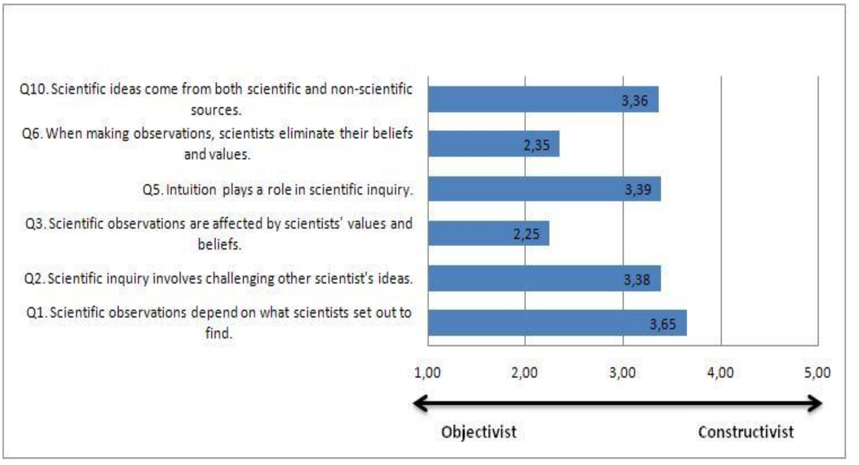

Figure 4. Mean Response Values for Subjectivity in Science.

DISCUSSION and CONCLUSION

The main aim of any reform in education is to improve educational programs and practices which will, in turn, assist to meet overall objectives of education in more effective ways (Fullan, 1991). Change is a difficult process, because, educational change of any significance involves changes in organizational structures, communications, resource allocation, practices, and beliefs and attitudes (Avenstrup, 2007). Research acknowledges that reform efforts often face with many challenges, particularly on the part of teachers as their attitudes and beliefs play important roles in their teaching orientations (Irez & Han, 2010). Turkish teachers have witnessed many reform movements at all levels of education in the last decade. The latest of these targeted secondary science education. With this movement, new science curricula which included new perspectives on many aspects of school science were introduced. Focusing on the new biology curriculum, this paper discussed that the most important change has taken place at the epistemological level. The objectivist characterisation of the NOS in the previous curriculum was abandoned and a constructivist understanding of scientific inquiry has been introduced.

Without a doubt, the success of any reform attempt depends on the practitioners' ability to reflect the vision of the reform in the classroom. Then, the reform movement in secondary biology in Turkey predominantly depends on biology teachers who have deep and adequate understandings that are consistent with the vision of the reform. However, the findings of this study revealed that biology teachers in Turkey, generally, have objectivist views about certain aspects of the NOS (the nature of scientific method and the relationship between science and society). The results also indicate that the participant biology teachers have generally eclectic views about the subjectivity in science and the tentative nature of science. Overall, evidence from this research points out that the participant biology teachers' views were 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 the NOS (Akerson et al., 2000). These results should not be surprising considering that science teacher education programs in Turkey generally 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, moreover, there are questions over the understandings and proficiency of teacher educators who are responsible for delivering such courses (Irez, 2006).

Considering the results of this study, it is not possible to think that the aim of the new curriculum which is to promote a constructivist view of scientific inquiry in the nation's schools is attainable in the foreseeable future. The importance of the knowledge and skills the learners already have is well acknowledged in any learning situation. Similarly, in order to implement the new curriculum successfully as intended, curriculum reform efforts should take into account of teachers' knowledge, beliefs, and personal philosophies (Cotton, 2006). Teachers, the real driving forces of reform, undoubtedly need to update their knowledge, skills, and orientations to be able to implement the new curriculum. Even when teachers are willing to subscribe to a reform and change their practices accordingly, research (Davis, 2003; Rousseau, 2004; Van Veen et al., 2005) reports that there is no guarantee that reform is implemented or sustained. Furthermore, sometimes teachers developed negative emotions toward the reform itself.

Of course, in-service teacher education is one of the most important and critical components of any education reform. Because, the reality in schools is that teachers are not able to inform their instruction from the curriculum as they lack a practical framework. Unfortunately, the question of how to help science teachers incorporate the various aspects of reform pedagogy yet to be answered. Huffman (2006) reported that while helping teachers to incorporate more curriculum-dependent changes such as assessment and doing experiments are relatively easy; helping them to capture the philosophical foundations of the reform which would necessary to create adequate learning environments is more problematic. From this perspective, it is difficult consider that in-service courses aiming to introduce the epistemological perspectives and approaches brought by the new curriculum to practicing teachers would be effective at a desired extent.

Ensuring a successful reform in science education requires taking a long term approach and involving teachers from the very beginning so they can achieve the philosophical re-orientation by adapting new practices to their own circumstances and the innovations can develop from the within the classroom (Huffman, 2006). However, the teachers are rarely involved in the initiation, preparation, design, and development of a new curriculum (Van Veen et al., 2005). Another way to promote new curriculum is to make it an integral part of pre-service teacher education during their science methods courses, school, and practicum experiences. Research indicate that self-efficacy improves during course work where teacher candidates can have a professional support from teacher educators and during school experiences and practicum where they interact with mentor teachers (Kang, 2008; Woolfolk Hoy & Burke-Spero 2005). High self efficacy towards new curriculum expected to facilitate transition of reform into classrooms. What this discussion suggests 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 the NOS. This would inevitably jeopardize the promotion of scientific literacy in society which is the overall vision of the new science curricula.

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