EXAMINING MIDDLE SCHOOL STUDENTS' UNDERSTANDING OF THE NATURE OF SCIENCE

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I certify that this thesis satisfies all the requirements as a thesis for the degree of Master of Science.

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This is to certify that we have read this thesis and that in our opinion it is fully adequate, in scope and quality, as a thesis for the degree of Master of Science.

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ABSTRACT

EXAMINING MIDDLE SCHOOL STUDENTS' UNDERSTANDING OF THE NATURE OF SCIENCE

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The aim of this study is to investigate the elementary school students' understandings of the nature of science (NOS). A total of 1949 students (1026 sixth graders and 923 eighth graders) from six different elementary schools participated in the study. "Nature of Science Questionnaire for Elementary Level (E-NOS)" questionnaire, adapted from Views on Science-Technology-Society (VOSTS) developed by Aikenhead, Fleming and Ryan (1989) and Views on Nature of Science (VNOS-D) constructed by Lederman, Adb-El-Khalick, Bell and Schwartz (2002), was used to assess the students' views on the NOS. E-NOS consisted of eleven items that examined the students' views on seven constructs concerning the NOS, namely tentativeness, subjectivity and creativity of scientific knowledge, social and cultural embeddedness of science, the role of observations and inferences, theories and laws and uncertainty in developing science. Additionally, the definitions of science, the difference of science from the other disciplines and scientific approach in scientific investigations were examined. Semi-structured interviews were also conducted by twelve volunteer students (7 sixth and 5 eighth graders) to investigate the students' views on nature of science in depth.

Data were analyzed both frequency and Chi-squire analyses. Results of this study revealed that the majority of Turkish elementary school students held traditional views on some aspects of the nature of science. According to these results, it was especially notable that the largest group of the students was not aware of the fact that scientific theories and laws are different kinds of scientific knowledge. In addition, many of the students had the idea that there is certain and defined scientific method in order to develop scientific knowledge. It was also found that more 8th grade students held contemporary (realistic) views of the tentative and subjective nature of science and the role of precision and uncertainty in science and more 6th graders had contemporary views on the role of observations and inferences in science. Furthermore, it was indicated that more female students than males possessed contemporary views on the subjectivity and creativity of the nature of science.

Chi-square statistics also displayed that there are statistically significant differences in distributions of the students' responses on all aspects of the nature of science with respect to grade level. In addition, it was found that there are statistically significant differences in distributions of the students' responses on the subjective nature of scientific knowledge, social and cultural embeddedness of the scientific knowledge, creativity and the role of prediction and uncertainty in science and scientific approach to investigations in science with respect to gender.

Keywords: Nature of science, elementary school students, scientific knowledge, gender, grade level.

ÖZ

İLKÖĞRETİM ÖĞRENCİLERİNİN BİLİMİN DOĞASINI ANLAMA DÜZEYLERİNİN ARAŞTIRILMASI

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Bu çalışmanın amacı ilköğretim öğrencilerinin bilimin doğasını anlama düzeylerinin araştırılmasıdır. Çalışmaya altı farklı ilköğretim okulundan toplam 1949 öğrenci (1026 altıncı sınıf ve 923 sekizinci sınıf) katılmıştır. Öğrencilerin bilimin doğası hakkındaki görüşlerini değerlendirmek amacıyla "Nature of Science Questionnaire for Elementary Level" (İlköğretim Düzeyi İçin Bilimin Doğası) anketi uygulanmıştır. Bu anket Aikenhead, Fleming ve Ryan (1989) tarafından geliştirilen "Views on Science-Technology-Society" (Bilim, Teknoloji ve Toplum Hakkındaki Görüşler) ve Lederman, Adb-El-Khalick, Bell ve Schwartz (2002) tarafından geliştirilen "Views of The Nature of Science" (Bilimin Doğası Hakkındaki Görüşler) anketlerinin adapte edilmesiyle oluşturulmuştur. On bir sorudan oluşan " İlköğretim Düzeyi İçin Bilimin Doğası" anketi öğrencilerin bilimsel bilginin değişebilirliği, sübjektif ve yaratıcı doğası; sosyal ve kültürel yapısı; bilimde gözlem ve çıkarımların rolü; bilimsel teoriler ve kanunlar; bilimsel bilginin belirsizliği hakkındaki görüşlerini değerlendirmektedir. Ayrıca, bu anket bilimin tanımı, bilimi diğer disiplinlerden ayıran farklar ve bilimsel yöntem ile ilgili sorularda içermektedir. Öğrencilerin bilimin doğası hakkındaki görüşlerini daha detaylı incelemek amacıyla

12 gönüllü öğrencinin (7 altıncı sınıf ve 5 sekizinci sınıf) katıldığı görüşmeler yapılmıştır.

Sonuçlar, ilköğretim okulu öğrencilerinin büyük bir bölümünün bilimin doğası konusunda geleneksel bakış açısına sahip olduğunu göstermektedir. Bu sonuçlara göre özellikle öğrencilerin çoğunun bilimsel teori ve kanunların farklı birer bilimsel bilgi niteliğinde olduklarının farkında olmadıkları ortaya çıkmıştır. Ayrıca, bir çok öğrencinin bilimsel bilgiye ulaşmak için kesin ve tanımlanmış bir bilimsel metodun varlığına inandıkları belirlenmiştir. Bu sonuçlara ek olarak, 8.sınıf öğrencilerinin bilimsel bilginin değişebilirliği, sübjektif yapısı ve belirsizliği konularında çağdaş (gerçekçi) görüşe sahip oldukları bulunurken, 6. sınıf öğrencilerinin daha çok bilimde gözlem ve çıkarımların rolü konularında çağdaş görüşe sahip oldukları ortaya çıkmıştır. Bununla birlikte, kız öğrencilerin bilimin sübjektif ve yaratıcı doğası konularında erkek öğrencilere göre çağdaş düşünceye sahip oldukları tespit edilmiştir.

Bu çalışmanın başka bir sonucu olarak da ki-kare testi öğrencilerin bilimin doğası hakkındaki bütün görüşlerinde sınıf düzeylerine bağlı olarak anlamlı farklar olduğunu ortaya koymuştur. Ayrıca, öğrencilerin bilimsel bilginin subjektif, sosyal ve kültürel yapısı, yaratıcı doğası, belirsizliği ve bilimsel yöntem ile ilgili görüşlerinde de cinsiyete bağlı olarak anlamlı farklar olduğu bulunmuştur.

Anahtar kelimeler: Bilimin doğası, ilköğretim okulu öğrencileri, bilimsel bilgi, cinsiyet, sınıf düzeyi.

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CHAPTER 1

INTRODUCTION

The comprehension of the nature of science (NOS) and the characteristics of scientific knowledge recently have received considerable attention for learning and teaching of science. It is likely that the nature of science becomes a global framework of learner's total scientific knowledge (Hammrich, 1997). In parallel to this idea, one of the most important objectives for science education in many countries is defined as the development of valid understanding of the nature of science.

Before examining the nature of science and scientific knowledge, it is necessary to define science in order to have meaningful understandings of the nature of science. According to Yore (1986), science is a human enterprise and so it may be defined differently by all who view it. Similarly, Pearson (1990, p.317) defines science as "a people's attempts to search out, describe and explain patterns of events in the natural universe". Collette and Chiapetta (1984) states that science is often characterized as a body of knowledge, a way of investigation or method, and a way of thinking in order to understand the natural universe (cited in Pearson, 1990). As a body of scientific knowledge, for example, the structure of living things is the focus of biology; the forces that affect the physical word is a topic of physics; molecules, atoms and compounds are related to chemistry. As a way of investigation or method, science is considered as hands-on activities since it requires observation, measurement and formulation of hypothesis. The last component of science, a way of thinking or knowing, also commonly known as the nature of science (NOS) which focus on the values and assumptions inherent to scientific knowledge and its development. While the nature of science has been used to as terminology in the literature, it is usually presented in a broader context including nature of scientific knowledge, nature of scientific enterprise and the nature of scientists (Cooley & Klopfer, 1963; Kimball, 1968).

A theoretical model of the nature of science was developed by Kimball in 1968 out of extensive study of the literature on the nature and philosophy of science. The statements that simply clarify this model are stated in Meichtry's (1999, p.275) study as: "(1) curiosity is the fundamental driving force in science; (2) science is a dynamic, ongoing activity; (3) science aims at comprehensiveness and simplification; (4) there are many methods of science; (5) the methods of science are characterized by attitudes which are more in the realm of values than techniques; (6) a basic characteristic of science is a faith in the susceptibility of the physical universe to human ordering and understanding; (7) science has a unique attribute of openness; and (8) tentativeness and uncertainty mark all of science".

After the study of Kimball (1968), this model is examined by philosophers of science and many researchers with some agreements and disagreements or some additional supports for these declarations and a large body of literature has developed related to the teaching and learning about the nature of science. The nature of science is defined differently by educational researchers in the literature. McComas, Clough, and Almazroa (1998) explain the nature of science as a fertile hybrid arena including the history, sociology, psychology, and philosophy of science aiming to make the description of what science is, how it works, how society directs and reacts to scientific endeavours. Abd-El-Khalick, Bell and Lederman (1998, p.418) defined the nature of science as "the epistemology of science, science as a way of knowing, or the values and the beliefs inherent to the development of scientific knowledge". According to those researchers, although some disagreements present on a specific definition of NOS, the general community of philosophers and historians of science, and science educators agree on the empirical, tentative, the theory–laden and the creative and imaginative nature of scientific knowledge. Socially and culturally embeddedness of scientific knowledge, the distinctions between observations and inferences, the relationship between scientific theories and laws, and the absence of a certain set and sequence of steps known as scientific method for doing science are other important aspects of NOS which is relevant and accessible to K-12 students. Since the above aspects of scientific knowledge are emphasized in the present study, it is worthy to make explanations about them at this point. The aspects of the nature of science are explained by Lederman, Abd-El-Khalick, Bell and Schwartz (2002) as below:

1. **The Empirical Nature of Scientific Knowledge:** Science is based on observations on the natural world. According to the interpretations on the observations, the valid assumptions are made. Since scientists can not make observations for every topic which is investigated, the scientists also perform experiments.

2. **Observations, Inferences, and Theoretical Entities in Science:** Science is based on observations and inferences. These terms should be distinguished by the students. Observations are descriptive statements about natural phenomena that are gathered by the sense of human beings. However, inferences are interpretations of those observations. Scientists collect the data and make inferences to predict possible future behaviors of the phenomena under investigation. For examples, meteorologists gather data about clouds, temperature, winds' motion and speed to find out certain patterns which would allow them to make the possible predictions about whether. They can only predict what might happen in the future by appropriate explanations through their observations.

3. **Scientific Theories and Laws:** Theories and laws are different kinds of scientific knowledge both in meaning and function. Moreover, there is no hierarchical relationship between scientific theories and laws because scientific theories are well-organized and highly substantiated explanations but scientific laws are related to the relationships among observable phenomena. As an example, Boyle's law relates to pressure of gas to its volume but the kinetic molecular theory explains Boyle's law. In addition, although the scientific laws can be tested, scientific theories can not be directly tested.

4. **Subjectivity of Scientific Knowledge:** Science is grown by the influence of scientific theories and scientific laws which are developed so far. The development of investigations, new questions and explanation of the data are interpreted by considering the currently accepted scientific theories and laws. Scientists usually select the simplest explanations for the topic they are

investigating and make inferences that are consistent with their prior knowledge, understandings and values. This causes an unavoidable personal subjectivity which means that personal values, beliefs and prior experiences influence the scientists' work.

5. **The Creative and Imagination Nature of Scientific Knowledge:** Scientific knowledge is developed by the human imaginations and investigating the logical explanations of the origin of natural phenomena. This development is based on observations and inferences of the natural world. Science requires a great deal of human creativity and imagination because it is not entirely rational and ordered activity. The scientific explanations, discoveries and inventions are the results of the human creativity.

6. **The Social and Cultural Embeddedness of Scientific Knowledge:** Science is an activity performed by the human being and so it is affected by the social and cultural values of that society. The values and expectations of the society and culture have an important role in deciding what and how science is conducted, interpreted and developed.

7. **The Tentative Nature of Scientific Knowledge:** Scientific knowledge can change with new observations and/or explanations for existing observations. Although scientific knowledge is reliable and can be used for many years, it is not exactly true and certain. For example, there are many foods and medicine that have been considered healthy for many years but at the moment been considered harmful. This supports that facts which develop the scientific knowledge change with new and more evidences and technological advances that are used for reinterpretation of previously presented knowledge. Moreover, since scientific knowledge is influenced by the social and cultural values in which it is practiced, the changes in any of them will also cause the changes in existing scientific knowledge.

Table 1.1 states a consensus view of the nature of science objectives in their study. Some of the objectives overlap with the explanations made by Lederman, Abd-El-Khalick, Bell and Schwartz (2002) about the aspects of the nature of science such as tentative nature of scientific knowledge, the role of scientific theories and laws and creativity in science. Moreover, there are some additional objectives which are not considered by the other researchers such as ‘new knowledge must be reported clearly and openly’ and ‘science and technology impact each other’.

Table 1.1. The nature of science objectives

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

Source: McComas, Clough & Almazra, 1998, p.6.

The importance of understanding the nature of science is widely accepted by many science educators. For example, Abd-El–Khalick (2001, p.215) states that "helping students develop informed conceptions of the nature of science (NOS) is a perennial goal of science education". In addition, many science educators agree that encouraging students' understanding the nature of science, its presuppositions, values, aims and limitations should be central goal of science teaching (McComas, Clough & Almazroa, 1998). Lederman (1992) also claims that development of an adequate understanding of the nature of science continues to be advocated widely as a desired outcome of science teaching. According to Saunders (2001), future citizens in a democracy should have a very fundamental knowledge of the nature of science for participating in intelligent debate and decision-making about social related to science and technology.

Furthermore, possessing accurate views of the nature of science and scientific knowledge have been identified by many leaders in the field of science education as a basic requirement for the contribution of a person's scientific literacy (MEB, 2004; AAAS, 1989; AAAS, 1993; NRC, 1993; cited in Moss, Abrams & Robb, 2001). Although there is not a standardized definition of scientific literacy mentioned in the field of science education, the nature of science is considered in the literature as a part of the scientific literacy. According to Abd-El-Khalick, Bell and Lederman (1998), a scientifically literate individual is one who makes informed decisions on scientific and technological concepts by their rich scientific knowledge, such as understanding of the principles, theories and processes of science. From different perspective, Pearson (1990) defines a scientifically literate person as one who can stay awake and be familiar with some topics such as superconductors or residual magnetic imagining (RMI) through a science revolution that is going on in our world today. With regard to the objectives formulated by the National Assessment of Educational Progress (NAEP) in 1985-1986 in United States (cited in Meichtry, 1999), the major purpose of science education is to develop scientifically literate individuals which is possible by having accurate views on the nature of science. Similarly, developing scientifically literate individuals became the central goal of science education in Turkey by newly improved curricula which will be in full practice by the 2006 (Ministry of National Education, 2004). From the same perspective, the present study aiming to investigate the students' understandings of the nature of science will be potentially useful to a wide range of science educators and teachers since students' ability to become scientifically literate is greatly influenced when the nature of science is not completely understood.

1.1. Significance of the Study

Recently, there has been an increasing emphasis in helping students develop adequate conceptions of the nature of science and scientific knowledge in science education in many countries. However, the literature shows that relatively little attention has been paid to elementary-aged students' views about the NOS. The situation is also same for Turkey since the majority of the studies in Turkey aim to investigate preservice and inservice science teachers' understandings of the nature of science. In this regard, this cross-age study investigates the Turkish elementary students' views on NOS filling this gap in educational area.

Although the development of students' understanding concerning the nature of science has been considered one of the primary goals of science education and received considerable attention for many years, many studies revealed that both students and teachers have inappropriate views about the nature of science. Lederman and O'Malley (1990) suggested that teaching NOS to the students in their early academic careers might be more effective for their formation of images of science and scientific literacy. Kang, Scharmann and Noh (2005) also claimed that elementary school is the best time to teach the students NOS since they begin to exposed formal science instruction and acquire an understanding of world. Thus, they concluded that elementary school students can develop their own views on the nature of science and scientific knowledge in their early ages.

This study aims to investigate the elementary school students' understandings of the nature of science which will offer the science teachers better understanding of their students' background with respect to NOS, and be a guide for deciding where they can start to successfully teach about the NOS. For example, taking into account of students' existing conceptions on the NOS might be helpful for the science teachers about conceptual change strategies because if the students have inadequate understandings about the subject matter they can not make meaningful connections between the existing conceptions and the new ones which they are learning. This fact proofs that the students come to science class with inappropriate views about the particular subject matter, they are studying and there is an unavoidable need to examine and diagnose students' views to reveal their understanding of the NOS before instruction.

Examining the students' understandings of the nature of science is also very important for providing implications in designing the new curriculum which is the one of the most vital component of science education. In light of this view, Meichtry (1993) states that a curriculum that does not adequately reflect the nature of scientific knowledge will most likely be the source of the students' misunderstandings about NOS. For instance, a curriculum which lets the students to question data, to design and conduct real experiments, and to carry their thinking beyond the information given can facilitate students' understanding of nature of scientific knowledge. Additionally, a curriculum focusing on how scientific knowledge is generated and including activities about verification of it can help the teacher develop students' adequate understandings of NOS.

In responds to these evidences, the result of this study will be informative to science teachers and educators with respect to detecting the elementary students' conceptions on NOS in their early years, providing baseline data for planning the most effective instructional practices, and designing the curriculum that includes the provision of opportunities for the students to understand scientific literacy.

CHAPTER 2

LITERATURE REVIEW

This chapter is devoted to the presentation of previous studies that have produced theoritical and emprical background of this study, instruments and studies developed and used for assessing views of the nature of science. In recent years, educational researchers have started to give importance to the understanding the nature of science since it has become one of the critical objectives of science education in many countries. In the present study, the investigations performed about the nature of science will be mentioned in three titles; students' views of the nature of science, teachers' views of the nature of science and influential and developing factors of students' views on the nature of science.

2.1. Students' Views of the Nature of Science

In recent years, students' understandings on the nature of science has been considered as an important and a vital part of the science education by many researchers (e.g. Songer & Linn, 1991; Lederman, 1992; Griffiths & Barry, 1993; Hammer, 1994; BouJaude, 1996; Hogan, 1999; Hogan, 2000).

The studies performed to identify the students' views of NOS were conducted in several levels of education; from primary school level to university level and by different instruments. One of the earlier studies to evaluate the students' views about NOS conceptions was performed by Wilson in 1954 (cited in Lederman, 1992). Lederman (1992) stated that it was primarily an attempt to validate the Science Attitude Questionnaire (Wilson, 1954). It was applied to 43 Georgia high school students and found that the students' scientific knowledge was absolute and they believe that scientists' primary goal was to uncover natural laws and truths. In addition, the study showed that students had relatively negative attitudes toward science.

Mead and Metraw (1954) performed the most extensive early study which supported Wilson's (1954) findings on both attitude toward science and students' conceptions of the nature of science. This study was based on qualitative data which was formed by a nation-wide sample of 35,000 essays written by high school students. In general, the study showed that students explained the science as a very broad field which may seen a single unit as comprised of entitles such as biology, physics, and chemistry. Additionally, although the students saw the scientists as brilliant, powerful and essential for national life and for the world, they did not wish to commit themselves to being a scientist.

In 1961, Klopher and Cooley developed the most widely used paper-and-pencil type instrument called Test on Understanding Science (TOUS) which is a four-alternative sixty item multiple choice test in order to assess high school students' understanding of science. The study revealed that high school students had inadequate understandings of both the sientific enterprise and scientists.

Similarly, using the TOUS instrument Mackay (1971) evaluated 1,203 Australian secondary students' views on science and its aspects. He found that students had insufficient knowledge of the role of creativity in science, the function of scientific models, the importance of theories and scientific explanations in a research and the clear differences of hypothesis, laws and theories.

Another study aiming to investigate the high school students' understanding of hypothesis testing in scientific research was performed by Bady (1979). The participants were 20 ninth-graders and 20 eleventh-graders from a large urban high school and 32 ninth-graders and 41 twelfth-graders from a small private boys' school. Wason and Johnson-Lairds' (1972) task was followed to assess the participants understandings of hypothesis testing. In this task subjects were given a hypothesis and access the data. Improvements on the task for this study included using concrete, meaningful data, and presenting the task in the context of story for the participants to play the role of a biologist who tests the hypothesis. The study showed that most of the students believed that hypothesis can be adequately tested and proven by verification. This result revealed that most students had a simplistic and naively absolistic view of nature of scientific hypothesis and theories.

In 1987, Aikenhead, Fleming and Ryan studied with a large sample of high-school graduates to monitor their beliefs about characteristics and limitations of scientific knowledge. Instead of applying a Likert-type scale normally found in standardized instruments, researchers applied Views on Science-Technology-Society

(VOSTS) statements to a total of 10,800 high school students. This instrument let the students express their views by “agree”, “disagree”, “can’t tell” and argumentative paragraphs. According to the results of the study almost half of the partcipants (45%) believed that scientific models and scientific theories can be changed in time. They emphasized the criterion of being beneficial in understanding the nature and discounted the possibility of models duplicating reality.

By using the same sample and data collection instrument, Ryan (1987) investigated the high-school graduates’ views on the characteristics of scientists. The results revealed that a majority of the students saw the scientist as being responsible for their actions especially some harmful effects of their discoveries. Morever, although many of the students stated that being honesty and objectivity were necessary for the performance of scientists others believed that scientists would be much like other people in daily life.

Another study at high school level performed by Griffiths and Barry (1993). This qualitative study examined the students’ understanding of scientific facts, scientific theories and scientific laws. The sample consisted of 32 students in Canada in age between 17 and 20 years. The responds of the students revealed that they explained the scientific method as typical school cookbook approach. However, they mentioned science as changing and improving process becoming more complex and scientific by the light of new questions. Students believed that laws and facts represent certainty while theories are believed to be tentative. This indicated that they were also not aware of the fact that theories and laws have different functions. They considered laws as a higher level of knowledge of those theories.

Griffiths and Barman (1995) extended Griffiths and Barry’s study by the involvement of two further comparable groups of participants, formed by 32 students from Australia and the United States. This study aimed to investigate the students’ views about selected aspects of science from three different countries –Canada, United States, and Australia. At the end of the study, some more major differences and commonalities were observed among these three groups of students. For example, more than half of the Australian students defined the science with an environmental view and only 20% of them explained science with a more general view focusing on some other interpretation of science in everday world. On the other hand, this gap was not seen in the American and Canadian students’ views. They equally supported these two views. In addition, all three groups agreed on the idea that science is different. However, answers to the question “How scientists get information” showed considerable differences between these three groups. About 70% of the American students belived that scientists gain information by relatively set sequence of events traditionally such as formulating hypothesis, experimenting, drawing conclusion. On the contrary, none of the Australian students mentioned traditional scientific method and Canadian students were intermediate between these two beliefs. Another different answer was gained in the question “Does science change?” Although 60% of the American students stated that science does not change, none of the Canadian students suggested this view and only 15% of the Australian students believed in this.

Ryder, Leach, and Driver (1999) also studied with the high level students in a longitudial interview study for examining the students’ views about relationships between scientific knowledge and data, nature of lines of scientific enquiry, and social dimension of science. Eleven science students were asked the nature of science questions during a Project work lasted 8 months. The students worked alone under the supervision of a science lecturer in a professional research laboratory. The responses of the students were analyzed by categorization of them question by question. The data showed that the majority of the students focused on emprical data as the only grounds for proof rather than the social processes and fewer of them mentioned about the social dimension of science. However, many of them showed significant development in their understanding of how lines of scientific enquiry are affected by theorical developments.

Considering the high school students, Sadler, Chambers, and Zeidler (2004) investigated their conceptualizations of the nature of science (NOS) and and how they interpreted conflicting evidence regarding a socioscientific issue. Eighty-four high school students participated in the study by reading contradictory reports about the status of global warming. A total of 30 students were also interviewed in order to get deeper information about the students’ conceptions on the three distinct aspects of NOS: empiricism, tentativeness, and social embeddedness. A qualitative methodological approach was used for analysis of data. This study revealed that students had the range of views concerning the nature of science. For example, although the teacher explained the nature of data and its application and used the term in class, students still had naive views about what data is. On the other hand, most of the students were able to identify societal factors that influence the global warming debate such as economics, personal interests, social causes and effects. In addition, many students displayed a general understanding of the tentative the nature of science since they seemed very comfortable with the fact that researchers can make different conclusions in the future with the same type of data.

Moss and Robb (2001) have performed a study on the pre-college students' understanding of the nature of science and track those beliefs over the course of an academic year. In this qualitative study, students'understanding of NOS was assessed by observation and regular formal interviews over the course of one academic year. The students participated in four large projects over the course of the year. A model of NOS was developed in order to examine the pre-college students' understanding of the nature of science in this study. This model has eight tenets addressing both the nature of scientific enterprise and the nature of scientific knowledge. This study found that by the end of the academic year participants held fully formed conceptions of the nature of science consistent with for approximately one-half of the premises set out in the model. Students had more complete understandings of the nature of scientific knowledge than the nature of scientific enterprise. Their conceptions remained mostly unchanged over the year despite their participation in the project-based, hands-on science course.

One of the studies performed at the early school levels was the study of BouJaoude and Abd-El-Khalick (1995). They investigated Lebanese middle school students' beliefs about science and their perceptions of its purpose and usage in everday life affect their science world view. Eigthy middle school students from four schools in Beirut participated in this study. Two public and two private school were joined the study. Seventh and eighth grade students were samples of the study. Semi-structured interviews and questionnaire were administrated to the participants.The data were analyzed in two steps; first one was analytic induction in which the categories were formed and second one SPSS for counting frequencies of the categories. According to this data, they concluded that most students defined science as an academic subject and perceived its purpose as preparation for higher grades, higher studies and careers; and saw themselves and others using science in academic settings.

Similarly, Shiang and Lederman (2002) performed a study at the early school levels. They investigated the seventh grade Taiwanian students' conceptions of NOS. The purpose of this study was to assess students' initial views of NOS and any changes in these views after explicit NOS instruction. Twenty-nine students (10 female and 19 male) participated in the summer camp during the period of this investigation. The students attend in a 1-week science camp with emphasis on scientific inquiry and NOS. In this camp students engaged with activities for 6 days and two field trips to provide students with opportunities to make field observations. On the 4th day of the camp, a 3-hour lesson was designed to explicitly teach several aspects of NOS. Participants were engaged in four activities: "tricky tracks," "fossils," "mystery bones," and "mystery hag." An open-ended questionnaire was used to assess students' views of the aspects of NOS, including the tentative, empirical, creative, subjective, and socially and culturally embedded the nature of science, and the relationships between scientific theories and laws. The findings showed that the major part of the students had a basic understanding of the tentative, subjective, emprical, and socially and culturally embedded aspects of NOS. However, there were no significant changes in students' views on NOS both before and after instruction.

Recently, Korean 6th, 8th, and 10th grade students' views of the nature of science were examined by Kang, Scharmann and Noh (2005). In this cross-age study, 534 sixth grades, 511 eighth graders, and 617 tenth graders fill out a questionnaire consisting of five items focusing on the purpose of science, definition of scientific theory, nature of models, tentativeness of scientific theory, and origin of scientific theory. Interviews were also conducted with the participants. Chi-square statistics was used for analyzing the responses. The results of this study indicated that most Korean students possessed an empiricit perpective about the nature of science. In addition, it was found that there were no clear differences in the distributions of 6th, 8th, and 10th graders views on the NOS.

There have been limited numbers of studies for investigating the views of the students on the nature of science in Turkey. In addition, the studies on the NOS performed in Turkey were mostly about the preservice and inservice science teachers views. For example, Bora (2005) assessed the conceptions of physics, chemistry, biology teachers and 10th grade math-science students' on the nature of science in

Turkey. A total of 1994 students and 362 teachers from seven geographical regions of Turkey participated in the study. In order to assess the participants' views on the nature of science, a 25-item questionnaire developed from VOSTS and interviews were conducted with the participants. The analysis of data revealed that the participants possed traditional views (naive) on the nature of scientific models, the relationship between hypothesis, theories, and laws fundemental assumptions of science, and coherence of concepts across disiplines. On the other hand participants have contemporary (realistic) views on the nature of observation, the nature of classification schemes, the tentative nature of scientific knowledge, and cause and effect relationships.

Kılıç, Çakıroğlu and Tekkaya (2004) also investigated the views of the Turkish students' on the nature of science. The study also aimed to examine the differences in students' understanding of the nature of scientific knowledge by gender, grade levels and school types. A total 939 ninth and tenth grade students participated in this study. Data were collected by the adapted version of the Nature of Scientific Knowledge Scale (NSKS). The results of the study indicated that Turkish high school students had slightly above the moderate understanding of the nature of science. Moreover, the data analysis revealed that student' ideas of nature of scientific knowledge is changing depending on their gender, school type and grade level.

2.1 Teachers' Views of The nature of science

If we accept the importance of a sound understanding of the nature of science and scientific knowledge, it becomes especially important to examine conceptual position of science teachers with regard to how they view science (Tairab, 2001). This fact turned researchers' attention toward assessing teachers' conceptions of NOS (Akerson et.al. 2000).

The studies about techers' conceptions on NOS have gained great attention during 1950s (Lederman, 1992). There have been several notable assesments of both preservice and inservice teachers' understandings of the nature of science. The first assessment of teachers' conceptions of science was conducted by Anderson in 1950. Fifty-eight biology teachers and 55 chemistry teachers involved in this study and teachers answered the total eight questions about scientific method. Results of this study showed that the teachers of both groups had serious misconceptions about scientific method.

Behnke (1961) examined the understanding of scientists and science teachers by using a questionnaire consisting 50 statements in four categories as the nature of science, science and society, the scientists and society, and the teaching of science. The participants' responds were evaluated by using a three- option response format: "favoring", "opposing", and "neutral". The sample was consisted of 400 biology teachers, 600 physical science teachers and 300 scientists. According to this study, more than half of the science teachers and 20% scientists believed that scientific knowledge were fixed and unchangeable. Parallel to these findings Behnke concluded that this naive view of the scientists and teachers would certainly affects their teaching strategies.

Miller (1963) compared the secondary biology teachers' and secondary students' conceptions of the nature of science by using TOUS instrument. The sample of students in this study was involved 87 students from 11th and 12th-grade, 63 students from 10th-grade, 52 students from 9th-grade, 328 from 8th-grade and 205 students from 7th grade. The sample of teachers involved 51 biology teachers. Surprisingly, the findings revealed that teachers do not understand science as well as their students. Thus, Miller concluded that they do not have enough understanding of science to teach it effectively.

Another study compared the scientists' and science teachers' understandings of the nature of science were conducted by Kimball (1968). His main purpose to perform this study was to investigate whether science teacher preparation programs were responsible for inadequate conceptions of science held by science teachers. He used his own The nature of science Scale (NOSS) for comparing the two groups with respect to the year of graduation, school of graduation, and other academic variables. He stated that there are not significant differences between the groups in any cases. Consequently, this result showed that the scientists and qualified science teachers had similar and inadequate views in the concepts of the nature of science when their academic backgrounds are alike.

With a much smaller sample, Oginniyi (1982) attempted to determine conceptions of the language of science held by preservice science teachers relative to conceptions held by seven selected philosophers of science. The instrument on the

Language of Science (LOS) consisted of 64 statements was applied to 53 preservice science teachers. The percentages of agreement and disagreement were calculated for each statement. The result of the study showed that the participants did not support the viewpoints of any philosophers about the language of science. However, to some degree they preferred Hempel's viewpoint which regarded laws and theories as true and verifiable assertions.

Pomeroy (1993) attempted to compare the beliefs of scientists, secondary science teachers, and elementary teachers. The purpose of this investigation was to examine how the scientist' and teachers' views differ on the nature of science, scientific method, and aspects related to science education. A survey consisting of 50 items and agree-disagree statements on a 5-1 Likert scale was prepared. This instrument was applied to 71 scientists and 109 teachers. The answers of the respondents were evaluated in two categories: the gender differences and the relative responses of scientists, secondary science teachers and elementary teachers. The findings showed that men in the sample fell into traditional patterns more than women. The data also indicated that traditional views were expressed most strongly by scientists, next by seconadry teachers, and least by elementary teachers.

Tairab (2001) investigated the views of both pre-service and in-service science teachers' views on the nature of science and technology. The data were collected by the instrument entitled "The Nature of Science and Technology Questionnaire (NSTQ) which is modified from the Views on Science-Technology-Society (VOSTS). The nature of science and Technology Questionnaire consisted of 26 items. Options for the questionnaire items were classified as "realistic", "has merit" and "naive". The options express an appropriate views of the nature of science were categorized as "realistic"; the options express a number of legitimate about the nature of science were categorized as "has merit", and the options express inappropriate or not legitimate views were categorized as "naive" for the interpretation of the data. In the study, 41 pre-service teachers and 54 in-service teachers were participated. The data were analysed by the frequency distrubition. The finding revealed that generally pre-service and in-service science teachers had similar views about science and technology. Although the majority of participants exhibited either content related or a process related view about science, a considerable proportion of the participants viewed science as a distinct discipline divided into biology, chemistry and physics. In addition, it was also found that participants tended to confuse technology and science and saw technology as an applied science.

There are few studies assessing the teachers' view on the nature of science conducted in Turkey. For example, Yakmacı (1998) attempted to determine the Turkish preservice and inservice science teachers' conceptions on the nature of science. Eighteen selected items from VOSTS pool were used for data collection instruments. The study revealed that science teachers held contemporary views on some aspects such as the nature of classification of schemes, tentativeness of scientific knowledge, the scientific approach in the investigations. Nevertheless, they had unrealistic views on some other points such as definition of science, the nature of observation, and the nature of scientific models.

Another study performed by Erdoğan, Çakıroğlu and Tekkaya (2006) in Turkey also supports the findings of the work of Yakmacı (1998). Similarly, she investigated the views of Turkish preservice science teachers on the nature of science. Twenty-one selected items from VOSTS pool were applied to 166 preservice science teachers from three different universities in this study. In addition, semi-structured interviews were conducted by 9 volunteer preservice teachers. The results of this study showed that the preservice science teachers possed traditional views on the definition of science, the nature of scientific models, the relationship and function of hypothesis, theories and laws, uncertanity in scientific knowledge, the scientific method used for formation of the scientific knowledge, and epistemological status of scientific knowledge and relationships between disciplines. However, it was also revealed that the participants had contemporary views on some items such as the nature of scientific observations and classification of schemes, the tentativeness of scientific knowledge and cause and effect relationship.

Moreover, Macaroğlu, Tasar and Cataloğlu (1998) evaluated the Turkish preservice elementary science teachers' views about the nature of science by The Beliefs about Science and School Science Questionnaire (BASSSQ). The study indicated that although the participants held the view in objectivity of scientific knowledge they were not aware of the fact that scientific knowledge is subject to change with new observations.

2.3. Influential and Developing Factors of Students' Views on The Nature of Science

Research studies have consistently revealed that students had naive views of NOS which do not overlap with current views of NOS as advocated in recent reform documents in science education (e.g. MEB, 2004; AAAS, 1993; NRC, 1996).

Many efforts have been directed toward helping students develop adequate understandings of NOS. Several curricular and research studies attempted to focus on this objective. For instance, Klopfer (1963) developed the first curriculum called "History of Science Cases for High Schools" (HOSC) to improve students' conceptions of NOS. The framework for this curriculum understood major features of science and scientists by using metarials from the history of science. Test on Understanding Science (TOUS) instrument was applied to 2808 students from biology, chemistry and physics classes for evaluating the effectiveness of the HOSC curriculum. The results showed that the experimental group gained significantly greater improvement on the overall test than control group who did not receive the HOSC curriculum. This finding exhibited the effectiveness of HOSC instructional approach to increase students' understandings of the nature of science. Similar findings resulted from the study of Jones (1965). He concluded that emphasizing historical development of science, philosophy of science and interaction of science with society were more effective than traditional approach for growing the students' conceptions of NOS.

The effectiveness of laboratory based curricula which are designed to promote inquiry and process-skills of the students was assessed by some researchers (e.g. Ramsey & Howe, 1969; Yager and Wick, 1966). Their studies revealed that with the addition the dimension of historical development of the scientific principles and concepts, laboratory-centered approach faciliated the students' understandings about biology topics.

BouJaoude and Abd-El-Khalick (1995) are the other researchers who claim that because of the traditional science curriculum students perceive science as a school subject and see the purpose of science as only a preparation for higher graders and careers. In the study, they investigated the Lebanese middle school students' defnition of science and perceptions of its purpose and usage. The study revealed that most of the students considered science as an academic subject necessary for higher graders. According to BouJaoude and Abd-El-Khalick (1995) students' had this unrealistic view because of the traditional science curriculum. They also emphasize that there is a need to prepare scientifically literate individuals and this is only possible by developing a curriculum addressing the relation between science and everday life problems, societal problems and technology.

Besides the researches that give support for curriculum development to increase the students' understandings of NOS, there are also some others not supporting any effects of curriculum on their understandings. For example, Tamir (1972) compared the relative effectiveness of the BSCS science program, CHEM study and PSSC with traditional approach curricula on the students' conceptions of NOS. Science Process Inventory was applied to 3500 high school students. The results showed that any of the curricula were effective for increasing the students' understandings of the nature of science concepts.

Recently, Meichtry (1992) investigated BSCS middle school science program on student understanding of the nature of science aspects. The experimental group receiving BSCS program and the control group exposed to traditional middle school science curriculum were applied Modified Nature of Scientific Knowledge Scale (MNSKS). Analysis of the results showed that although the students in experimental group possessed a significantly better understanding of the creative the nature of science, the students in control group gained a significantly better understanding of the developmental and testable the nature of science than students in experimental group.

There have been some research studies addressing the influence of textbooks and instructional practices on students' understandings on NOS. For example, Munby (1976) claimed that quite different understandings about science can be derived by students from different textbooks written by the statements representing realistic or instrumental views. According to him, explanatory statements and representative of a realist account of scientific knowledge caused the students to think that the scientific knowledge is absolute truth and not subject to change. He also pointed out the importance of implying the science as a concequences of man's explanations while writing textbooks.

In a similar study, Rubba, Horner, and Smith (1981) saw the textbook expositions as the most effective sources for students' misconceptions about the nature of science. They argued that both the curricula and textbooks portray scientific knowledge as fixed and unalterable truths Duschl (1990) critized the textbooks at another extent. He asserted that learning the scientific knowledge without knowing processes that generated this knowledge is not enough to develop meaningful understandings about scientific enterprise.

Focusing on the instructional practices in explaining the science topics, Solomon, Duveen, Scott and McCarthy (1992) examined whether using elements from history of science (HOS) effects the middle school students' views of NOS. The science topics were presented in a historical context by the help of the materials taken from exploring the nature of science (Solomon, 1991). Reseach result showed that there was a decrease in the number of students who thought that scientific theories are absolute facts. However, there were not significant changes regarding students' views about the subjectivity of scientific knowledge. Along the same line, Solomon, Duveen, and Scott (1994) investigated how students' views of the nature of science change when the historical context was embedded in science teaching. After the course, the result showed that students gained more epistemological images of scientists and their activities by the help of the historical stories of scientists.

Recently, Seker (2004) investigated whether using historical information related to the science topics affects eighth-grade students' learning of science, understanding the nature of science, and interest in science. Ninety-four eighth-grade students were randomly selected for the study. The students in experimental group were taught the concepts in the motion unit and in the force unit by historical contexts and the students in control group were taught the same concepts traditionally. During the lessons, the teacher developed discussion sessions on the ways scientists produce scientific knowledge. In order to compare differences between historical class contexts and the traditional class, the effects on student learning of science, understanding the nature of science, and interest in science were evaluated at the beginning, at the middle, and at the end of the study. Perspectives on Scientific Epistemology (POSE) instrument was used for measuring students' views of the nature of science. The students' responses to the POSE were categorized as 'Naïve', 'Intermediate' and 'Informed' for the four aspects of the nature of science: Scientific Method, Tentativeness, Inference, and Subjectivity. The results of the study revealed that the history of science (HOS) affected student perceptions of scientific process and role of inference in the process of science.

On the other hand, Abd-El- Khalick and Lederman (2000) stated the courses related to history of science had only few and limited influence on students' NOS views. According to them, although history of science courses are effective for teaching development of scientific knowledge and disciplines to the students, it is difficult for the students to transfer and apply the knowledge within one context to other similar contexts while going through the historical narratives. In this regard, they claimed that explicitly addressing NOS aspects enhance the effectiveness of HOS courses in developing students' adequate NOS views.

In their research, Abd-El-Khalick and Khishfe (2002) investigated the influence of an explicit and reflective inquiry- oriented approach compared with an implicit inquiry-oriented approach on sixth grade students' conception of four aspects of NOS: tentative, emprical, creative and imaginative nature of scientific scientific knowledge, and distinction between observation and inferences. In the study, 62 sixth- grade students are divided into two groups as the intervention or explicit group engaging in inquiry activities and reflective discussions of the target NOS aspects and the comparision or implicit group engaging in the same inquiry acrivities without any explicit references and discussions of any NOS aspects. Data were gathered from open-ended questionnaire and semistructed interviews before and at the conclusion of the intervention, which lasted 2,5 months. The data analysis revealed that an explicit and reflective inquiry-oriented approach was more effective than implicit inquiry-oriented approach in prompting students' NOS aspects. Schwarts and Lederman (2002) also saw the explicit/reflective approach as the desired approach to teaching about NOS. However, they also suggested that the students' background, their learning progression and their learning ability to be reflective about scientific enterprise affected their learning of NOS.

Focusing on the some epistemological entities such as theories, hypothesis and experiments, Sandoval and Morrison (2003) explored the effects of students' inquiry during a 4-week technology-supported unit on their beliefs about the nature of science. Conducting preinterviews and postinterviews with 8 high school students, they found that although students distinguished ideas from experiments and saw the purpose of experimentation as testing ideas, their epistemological conceptions did not appear to change as a result of their inquiry experiences. As a result, the researchers concluded that students' inquiry is partially successful in enabling students to understand science without explicit attention being paid to epistemological ideas.

More recently, Khishfe and Lederman (2006) examined the effects of two different explicit instructional approaches in order to promote more informed understandings of the nature of science (NOS) among ninth grade students. Fourty-two participants formed two different groups as 'integrated' group and 'nonintegrated' group in this study. Students in the two groups were taught environmental science by their regular classroom teacher, with the difference being the context in which NOS was explicitly taught. NOS instruction was related to the science content about global warming for the ''integrated'' group and NOS was taught through a set of activities that addressed NOS issues for the 'nonintegrated' group. The course lasted 6 weeks. Participants in the two groups were administered a five-item open-ended questionnaire, the nature of science questionnaire and conducted to semi-structured interviews both at the begining and at the end of the study. The results of the study revealed that regarless of the being in the different groups, students in both groups showed improvements in views of NOS. Comparison of differences between the two groups showed ''slightly'' greater improvement in the informed views of the integrated group participants. However, there was greater improvement in the transitional views of the nonintegrated group participants. Therefore, the researchers concluded that overall results did not give any conclusive evidence in favor of one approach over the other.

Different from the other studies related to the explicit instruction of NOS, Akerson and Volrich (2006) designed a case study to assess the change in first grade students' views of the inferential, tentative, and creative NOS as a result of the explicit instruction. The data were collected from weekly observations and videotapes, Views of The nature of science Questionnaire-Elementary/Middle School Version (VNOS-D) coupled with the interviews. Data sources included weekly classroom observations of explicit NOS science lessons focus on the topic of 'animals' taught by the teacher. Morever, pre- and post tests was applied to determine the influence of the teacher's instruction on the students' views of observation and inference, the tentative NOS, and the creative and imaginative NOS.

The results of data analysis revealed that the students recognized the role of evidence in the bones, and inferences from bones after explicit instruction. In addition, they realized that scientists' investigations and interpretations influence their claims and most students' views of scientists using creativity and imagination changed from imagining the ''unreal'' to using imagination during investigations. Thus, these findings implied that early elementary students are able to develop an understanding of particular NOS aspects, when in a classroom that features explicit instruction of these aspects.

Despite the critical role of curricula and instructional practices teachers are also the important influencial factors in educational area (Duffee & Aikenhead, 1992; Eylon & Linn, 1989) since " teachers translate the written curricula into a form ready for classroom application and decide what, how and why to learn (McComas, Almazroa, Clough, 1998, p.523).

Using the scores of TOUS instrument, Yager (1966) compared the students' understandings of the nature of science taught by different teachers. The extraneous variables such as discussions, laboratory activities, instructional materials and examinations enrolled by the teacher were held constant as nearly as possible. An analysis of data revealed that there are significant differences in students' ability to understand NOS when they are taught by different teachers (cited in Lederman, 1992). Some researchers claimed that this differentation between the students' views on NOS is because of the teachers' decisions affecting classroom practice and instructional planning and their language used in presenting the science subjects. For instance, by observing and making interviews by 13 science teachers, Duschl and Wright (1989) found that the participants did not include the aspects on the nature of science and ignore the nature of scientific knowledge during their instruction. Supporting this view, Gallagher (1992) stated in his study that the participants having inadequate views of the nature of science did not include discussions related to aspects of NOS.

More recently, Waters-Adams (2006) assessed the relationship between four English primary teachers' understanding of the nature of science and their practice in the class. The influences of both tacit and espoused understandings of the nature of science were considered alongside the teachers' beliefs about education, teaching, and learning. In this study, since the data were qualitative in nature they were gathered from lesson observations, notes of reflective discussions, and semi-structured interviews. Bi-polar semantic differential teaching strategies, teachers' reflective commentaries and researcher's analytic memo were also used for collecting the data by the researcher. The results of the study showed that the teachers acquired a confidence in their science practice only when there was a balance between their ideas about how to teach science, their understanding of the nature of science, and their general beliefs about how they should be teaching children. In addition, the study primarily revealed that teachers' beliefs were the determining factor in their decisions about classroom strategies.

In different extent, Zeidler and Lederman (1989) focused on the language used by the teachers while explaining the subject matter in science lessons. He examined whether or not the teachers' language has an influence on students' formulation of a world view of science. For this purpose, Nature of Scientific Knowledge Scale (NSKS) was administered to 18 science teachers and their 409 students at the beginning and end of a semester. The result of the study showed that although the ordinary language used by teachers during discussions causes the students to have a realistic conception of science, the students tended to have instrumentalists views of science when the teacher used precise language in presenting science constructs. According to this result, the researchers concluded that the way teachers verbally present science topics has impact on students' formation of their views of science.

The results of the studies discussed in this chapter revealed that neither teachers nor students have adequate conceptions of the nature of science. In addition, it was stated that the teacher beliefs on the nature of science concepts, curriculum followed in the schools and the instructional techniques designed by the teacher were all influential factor for the students' understandings of the nature of science. These results were similar for different countries. As mentioned before, the studies focused on the elementary school students' views on the nature of science were very few in Turkey. Therefore, in this study, the conceptions of Turkish elementary school students on the nature of science were investigated to learn more about their views and so understand them better as a teacher.

CHAPTER 3

METHOD

This chapter of the study presents the main problem, the research questions, information about the subjects of the study, the data collection procedure, and the data analysis.

3.1. Main Problem

This cross-age study was designed to investigate the views of Turkish 6th and 8th grade elementary school students' on the nature of science concepts.

3.2. Research Question

The research questions that guided the present investigation were:

(1) What kinds of views do the elementary students have on the nature of science concepts?

(2) Are there notable similarities and differences in elementary school students' views on the nature of science across grade levels?

(3) Are there notable similarities and differences in elementary school students' views on the nature of science respect to gender?

3.3. Population and Sample Selection

The sample of this study consisted of 1026 sixth graders (486 female, 540 male) with an age of 11-12 and 923 eight graders (472 female, 451 male) with an age of 13-14 randomly selected from 6 different schools in Yenimahalle district of Ankara (Table 3.1). Since Ankara is a cosmopolitan city of Turkey, it was assumed that it would be accommodate many different groups of students. Therefore the sample is considered to supply sufficient heterogenity in terms of elementary school students profile in Turkey. Furthermore, since all elementary schools in Turkey follow the national curriculum, it was assumed that the selected schools would be the representative of other schools which are quite homogeneous in terms of their academic standards.

The present study included both a quantative and a qualitative part. While a total of 1949 students participated in the quantative part, 12 students involved in qualitative part. For the qualitative part of the study, two students were voluntarily selected from each of six elementary schools.

Table 3.1. Distributions of sample by grade level and gender

Grade Level	Gender		TOTAL
	Female	Male	
6	486	540	1026
8	472	451	923
TOTAL	958	991	1949

3.4. Data Collection Instruments

The present study includes both the quantative and qualitative assessment approaches. For the quantative part of the study, The Nature of Science Questionnaire for Elementary Level (E-NOS) was developed based on the previous studies (Aikenhead, Fleming and Ryan, 1989; Lederman, Adb-El-Khalick, Bell and Schwartz, 2002) in order to assess elementary school students' views on the nature of science. Besides the questionnaire, Views of The Nature of Science (VNOS-D) were used for the qualitative part of the study.

3.4.1. The Nature of Science Questionnaire for Elementary Level (E-NOS)

Although there are several instruments that have been developed to evaluate the views on the nature of science, there are not any instruments in order to assess the large sample of elementary students' conceptions on NOS. For that reason, it was a necessity to design an instrument in multiple-choice format which would appropriately serve as a data collection instrument for evaluating in large sample of early level students' beliefs on the nature of science. During the preparation of the questionnaire the tentative and subjective nature of scientific knowledge, the role of human inference and imagination in science, social and cultural embeddedness of scientific knowledge and the relationship between scientific theories and laws as well as the definition of science, the role of uncertanity and scientific approach in science were considered as a framework which would primarily assess.

E-NOS including eleven items is an empirically derived questionnaire in a multiple-choice format which aims to reduce the disadvantages inherent to traditional Likert-type or multiple-choice format questionnaires. In addition, the option "none of the choices do not fit my basic viewpoint" decreases the limitation of the E-NOS being kind of a multiple choice questionnaire and required students to write an argumentative response to the items. As shown in the Table 3.2, the items 1,5,8 and 10 adapted with some modifications from VOSTS and the items 2, 3, 4, 6, 7, 9 and 11 were selected from VNOS-D.

Table 3.2. Items used in Nature of Science Questionnaire for Elementary Level (E-NOS)

Item Number	Item	Subscales	Origin
1	What is science?	Defining Science	VOSTS
2	How is science different from the other subjects (such as religion, psychology and art)?	Difference of Science	VNOS-D
3	Scientists produce scientific knowledge. Some of this knowledge is found in your science books. Do you think this knowledge may change in the future?	Tentativeness	VNOS-D
4	Scientists agree that about 65 millions of years ago the dinosaurs became extinct (all died away). However, scientists disagree about what had caused this to happen. Why do you think they disagree even though they all have the same information?	Subjectivity	VNOS-D
5	Scientists do many studies to reach the knowledge. Do you think that scientists may make errors in their work?	Subjectivity	VOSTS
6	How do scientists know that dinosaurs really existed?	Observation and Inferences	VNOS-D
7	Scientists try to find answers to their questions by doing investigations / experiments. Do you think that scientists use their imaginations and creativity when they do these investigations / experiments?	Creativity	VNOS-D
8	Do you think that the scientists are affected by the social and cultural values of their society during their studies?	Social / Cultural Embeddedness	VOSTS
9	Is there a difference between a scientific theory and a scientific law?	Theories and Laws	VNOS-D
10	What do you think that how the scientific knowledge is gained?	Scientific approach to investigations	VOSTS
11	Do you think weather persons are certain (sure) about weather patterns?	Prediction and Uncertanity	VNOS-D

The items forming Nature of Science Questionnaire for Elementary Level scale are described as below:

The first item of the questionnaire assesses the students' views on science and what science refers to them. Special attention is given to this item since it points out the meaning of science which is very important and serves as a central point for understanding the nature of science.

The second item is used for assessing the respondents' perceptions regarding science as a discipline to address questions about the natural word, the role of science in providing explanations for natural phenomena, and the importance of emprical evidence in science that distinguishes science from the other disciplines such as religion, philosophy and art.

The third item investigates the respondents' understandings of the tentative nature of scientific theories and in which way they change through the time. Since all other aspects of the nature of science provide rationale for the tentativeness of scientific knowledge, it was vital to learn the students' conceptions about these aspects of NOS.

Forth item examines whether the students' are aware of the role of human inferences and subjectivity in developing the scientific explanations. Thus, this question reveals the students' beliefs on what influence data interpretation including personal preferences and bias which is the reason of the different explanations and commands of the different scientists on the same phenomena.

The fifth item of the questionnaire focuses on the subjectivity of the nature of scientific knowledge. It examines whether the students have a perception that the scientists are the human beings just as they are and there is always a possibility for making errors for human beings as well as the scientists.

The students' views on the role of observations and inferences in developing scientific knowledge are investigated by the sixth item of the questionnaire. This item is beneficial to understand the students' awareness of the fact that science is based on observations and inferences. Observations are gathered from senses of human and inferences are the indications of those observations.

Considering the role of human creativity and imagination in science, the seventh question assesses if the students are aware of the fact that scientific knowledge is created from human imaginations and logical reasoning based on observations and inferences of the natural world.

The impact of social and cultural values and expectations on the scientific endeavor is the subject of the eighth question. Thus, this item serves as a basis for identification the students' views about the social and cultural embeddedness of the scientific knowledge and evaluation of their responses with regard to the fact that the values and expectations of the culture in which it is practiced determine what and how scientific knowledge is conducted, defining, and accepted.

The ninth item of the E-NOS assesses the participants' views of the development of and relationship between scientific theories and laws. Since the students' conceptions of the nature of scientific knowledge are closely related to their understandings of the meanings and functions of these terms, this question is added after the pilot study. By this way, it is possible to evaluate whether the students know that theories and laws do not progress into one and another in the hierarchical sense and they are distinctly and functionally different types of knowledge.

Next question which is selected from VOSTS is about the way how the scientific knowledge is gained by the scientists and the last question which is selected from VNOSD is related to the role of prediciton in developing the scientific knowledge and the uncertanity of the explanations done by the scientists.

E-NOS was applied to 123 students for a pilot study. The reliability of E-NOS was found to be 0.71. In addition, the wordings and translation of the items were primarily took attention of the researcher. Students were asked to underline the words that were difficult to understand. These words were revised by the one elementary science teacher and two English teachers. The quality of the translation of the items was finally checked by two experts who are good commands of science in English. In addition, the option "None of these choices fit my basic viewpoint" was added in order to require students to write an argumentative response and make their meaning out of the items.

3.4.2. Interview with Students

The literature interprets that research on students' conceptions on the nature of science has slowly moved from being primarily quantative to more qualitative assessment approaches over the years (Lederman, 1992). This makes the interviews more important data collection instrument and takes the caution of many researchers studying on the nature of science since the interviews give students an opportunity to elaborate on their views and provide researchers with deeper interpretation for the participants' responses (Griffiths & Barman, 1995). They also give the researchers a wealth of information not obtained by the students' multiple-choice and likert type responses (Schoneweg & Rubba, 1993).

In present study, the Turkish version of VNOS-D (see Appendix B) was used as a data collection instrument to assess the students' understandings of the target aspects of NOS. For this purpose, a total of 12 students (6 female, 6 male) held these interviews individually after the administration of the E-NOS. Before the interviews, the students were informed that their participations was voluntarily and confidental.

During these semi-structured interviews, which were conducted by the researcher, students were asked to clarify their responses and support them with additional examples. Furthermore, follow-up questions were posed to probe students' ideas in-depth and explore the reason behind their answers why they thought in this way. The researcher was careful not to give directive cues about the answers of the questions, to aviod time limitation, and to listen the participants' responses with a great patient without distrupting them while they were making explanations, giving examples, and clarifying their ideas. All interviews approximately lasted for about 20-30 minutes and they were audiotaped and transcribed verbatim for data analysis.

3.5. Data Collection Procedure

The data were collected in Ankara in the spring term of 2005-2006 academic years from six different public schools. The questionnaire was carried out by the researcher herself during the regular class hours of elementary science lessons. Before the application of the questionnaire, the students were informed that their course grades would not affected by the result of the questionnaire. Likewise, they were instructed that their answers were very important and considerable for us as a teacher to understand them better.

3.6. Methods Used for Data Analysis

The students' views on the nature of science were evaluated into two groups as 'naive' and 'contemporary (realistic)'. During the data analysis, two different methods were used since the study is both in quantitative and qualitative nature. Descriptive analyses were carried out for data obtained from newly developed questionnaire forming the quantitave part of the study. Percentages were computed for each item for each grade level by using the statistical package SPSS for Windows, Version 13.0. In addition, chi-square statistics were performed in order to assess the difference for the distribution of students' responses by grade level and gender.

For the analysis of data collected by the interviews, the interviews were audio-taped and transcribed. Since the data obtained in this part of the study were not quantifiable, it was only possible to classify interviewees' responses according to main idea supported by the students for each item.

3.7. Assumptions and Limitations

Assumptions and limitations considered in this study are stated as below:

3.7.1. Assumptions

1. The survey was performed under standard conditions.
2. All the responses of the participants to the E-NOS were obtained sincerely.
3. All the participants answered interview questions in a serious way.

3.7.2. Limitations

1. The subjects of the survey were limited to 1949 elemantary school students.
2. The schools selected for the data collection were limited in Yenimahalle region in Ankara.
3. The subjects in the interview were limited to twelve elemantary school students.
4. Translated instruments may have defects that are indispensible.

CHAPTER 4

RESULTS AND CONCLUSION

This section of the study presents a summary of descriptive analysis on each E-NOS item and includes the information obtained from the interviews with elementary school students' view on the nature of science.

4.1. Descriptive Analysis of E-NOS Items

In this part, percentage and chi-square analysis of students' responds on the aspects of the nature of science were reported. The items of E-NOS questionnaire assessed students' views concerning the tentative, empirical, inferential, creative, and subjective nature of scientific knowledge. Additionally, aspects related to the scientific method, and the functions of, and relationship between scientific theories and laws were the topic of the E-NOS items. The students' views on those aspects of the nature of science with respect to the gender and grade level were summarized in Tables 4.1- 4.11.

Definition of Science (Item 1)

As shown in table 4.1, students had various responses about definition of science. Concerning 6^{th} graders, one quarter of them chose alternative C defining science as exploring the unknown and discovering new things about our world and universe and how they work which is considered as the contemporary view (Schoneweg and Rubba, 1993). Moreover, 20% selected alternative F which expresses science as finding and using knowledge to make the world a better place to live in. In addition, approximately 14% defined science as a study of fields such as biology, chemistry and physics (alternative A), 14% perceived science as a body of knowledge (alternative B), 10% believed that science meant inventing or designing things (alternative E), 4% of them expressed science as doing experiments (alternative D), and 7% of them saw science as social institution (alternative G).

Similar to 6th graders, majority of 8th grade students (23.4%) chose alternative C for the first item. Moreover, 17% considered science as a study of fields such as biology, chemistry and physics (alternative A), 13% considered science as an activity in order to make the world a better place to live (alternative F), Moreover, 12% of 8th graders saw science as body of knowledge (alternative B), 9.5% of them considered science as carrying out experiments (alternative D) and 12% of them believed that science means inventing and designing things (alternative E). The students who chose alternative E and F confused the science and technology with each other since they consider science as a tool for social purpose and development of technology such as for engineering, medicine and environmental inventions. The tendency that the students have a technologically oriented view of science has been considered as a naive view in many studies (Duveen, Scott, & Solomon, 1993; Schoneweg & Rubba, 1993). The data also indicated that although 2.4% of 6th graders selected the alternative "no one can define science", 5.4% of 8th grade students chose this alternative.

Considering 8th graders, 9.3% of females and 9.8% of males considered science as carrying out experiments and 18.6% of males and 15.7% of males indicated science as as a study of fields such as biology, chemistry and physics. Similarly, with respect to 6th graders, 28.8% of females and 22.4% of males defined science as exploring the new things and 3.5% of females and 4.1% of males considered science as carrying out experiments.

The chi-square statistics were applied to conduct the cross-tabulations between the students' responses to the different options and to look for significance. According to the chi-square statistics, a statistically significant difference was found for the distribution of students' responses by grade level (χ^2 = 64.341, df = 10, p = .000). On the other hand, no statistically significant difference was found between the females' and males' responses (χ^2 = 16.527, df = 10, p = .086).

Table 4.1. Percentages of Students' Responses to Item 1

Item 1: What is science?							
	6th grade			8th grade			
Choice	F	M	T	F	M	T	GT
	%	%	%	%	%	%	%
A. A study of fields such as biology, chemistry and physics.	13.0	15.2	14.1	18.6	15.7	17.2	15.6
B. A body of knowledge, such as principles, laws and theories, which explain the world around us.	15.6	12.4	13.9	10.6	12.9	11.7	12.9
C. Exploring the unknown and discovering new things about our world ad universe and how they work.	28.8	22.4	25.4	24.8	22.0	23.4	24.5
D. Carrying out experiments to solve problems of interest about the world around us.	3.5	4.1	3.8	9.3	9.8	9.5	6.5
E. Inventing or designing things.	8.6	10.9	9.8	10.2	14.0	12.0	10.9
F. Finding and using knowledge to make his world a better place to live in.	18.5	23.1	21.0	11.9	13.7	12.8	17.1
G. An organization of people (called scientists) who have ideas and techniques for discovering new knowledge.	7.2	7.2	7.2	5.7	5.3	5.5	6.4
H. No one can define science.	2.1	3.1	2.6	5.9	4.9	5.4	4.0
İ. I don't know enough about this subject to make a choice.	1.6	0.9	1.3	2.1	1.3	1.7	1.5
J. None of these choices fits my basic viewpoint.	1.0	0.6	0.8	0.8	0.4	0.7	0.7

F: Female M: Male T: Total GT: Grand Total

Difference of Science from other disciplines (Item 2)

As evidence by table 4.2, many of the 6th grade students (39.8%) agreed that science is based on facts rather that the beliefs and thoughts (alternative A) which is considered as naïve view (Cochrane, 2003). As the second highest percentage, they selected alternative C which refers that although science is concerned with matter other subjects like religion and art focus on the explanation of abstract topic like soul, intelligence and God considered as realistic view. In addition, approximately 19% thought that scientific knowledge can be tested while others can not (alternative B), and 11% selected option D believing “there is no difference between the science and other subjects”. Opposite of the 6th graders, the 8th grade students chose alternative C which is labeled as realistic view in greater amount than alternative A. However, similar to the 6th graders, 20% of 8th graders believe that the main difference of scientific knowledge is its testable future. Alternative D, E, and F are selected by few of both 6th and 8th grade students. A chi-square analysis on the distribution of the 6th and 8th grade students’ responses detected a statistically significant difference ($\chi^2 = 54.245$, df = 5, p = .000).

Considering the 6th graders, 37.4% of males and 42.4% of the females selected alternative A believing that science is based on facts, but other disciplines are based on belief. Then, 23.5% of females and 25.7% of males selected alternative C believing that science is interested in matters and others are concerned with soul, spirit and God. Unlike the views of 6th graders, 8th grade male (38.1%) and female (38.6%) students’ mostly selected alternative C believing that science is concerned with matter other subjects like religion and art focus on the explanation of abstract topic like soul, intelligence and God. Then, 29.4% of females and 27.5% of males chose alternative A which refers that science is based on facts rather that the beliefs and thoughts. Furthermore, 17.8% of females and 22.4% of males signed alternative B indicating that scientific knowledge can be tested while others can not. Chi-square analysis revealed no statistically significant difference was found between the males’ and females’ responses on the item 2 ($\chi^2 = 7.021$, df = 5, p = .219).

Table 4.2. Percentages of Students' Responses to Item 2

Item 2: How is science different from the other subjects (such as religion, psychology and art)?

Choice	6th grade			8th grade			GT
	F %	M %	T %	F %	M %	T %	%
A. Science is based on facts, but others based on belief.	42.4	37.4	39.8	29.4	27.5	28.5	34.4
B. Science can be tested and it gives proof whereas others usually provide factual explanations.	18.3	20.4	19.4	17.8	22.4	20.0	19.7
C. Science is most concerned with matter, how it works and exists but others touch on things that science cannot, i.e. soul, spirit, God.	23.5	25.7	24.7	38.6	38.1	38.4	31.1
D. There is no difference between science and any other subjects.	10.7	10.9	10.8	8.9	5.5	7.3	9.1
E. I don't know enough about this subject to make a choice	4.3	4.8	406	5.1	4.9	5.0	4.7
F. None of these choices fits my basic viewpoint.	0.8	0.7	0.8	0.2	1.6	0.9	0.8

F: Female M: Male T: Total GT: Grand Total

Tentativeness of Scientific Knowledge (Item 3)

In this study, group one included alternatives A, B, C, and E were considered as naive views which refer that scientific knowledge was subject to change (Haidar, 1999; BouJaoude, 1996; Cochrane, 2003). Group two included alternative D was considered as realistic view which refers that facts were unchangeably true (Haidar, 1999; BouJaoude, 1996; Cochrane, 2003). For 6th graders, many students (34.3%) had naïve view believing that scientific knowledge does not change but new knowledge simply added to old ones (alternative C). However, only 19.3% of them agreed on the realistic view that scientific facts can change in the light of the new discoveries (alternative D). The 6th grade students who signed for alternative A (23.3%) and alternative B (18.5 %) thought that scientific knowledge does not change in the future since it is a proven fact and gained by many experiments. Although many of the 6th graders believed that scientific knowledge does not change, about half of the 8th graders answered that it can change in the future which indicates that 6th grade students mostly had naive view but 8th graders possessed realistic view on the tentative nature of scientific knowledge. The difference between the 6th grade and 8th grade students' responses was found statistically significant by using chi-square statistics (χ^2 = 107.219, df = 6, p = .000).

Considering the gender, 37.4% females and 31.5% males had naive view and nearly equal number of them (19%) possessed realistic view for 6th grade level. For the 8th graders, 44.5% of the males and 33.7% females chose alternative D which supports the realistic view. Approximately, 15% of females and 20.8% males selected alternative A, 12% of female and 21% of male signed for alternative B, 22% of female and 26.6 % of male chose alternative C. The chi-square analysis of the students' responses with respect to gender indicated that there was no statistically significant difference between the females' and males' views on the tentative nature of scientific knowledge (χ^2 = 11.851, df = 6, p = .065).

Table 4.3. Percentages of Students' Responses to Item 3

Item 3: Scientists produce scientific knowledge. Some of this knowledge is found in your science books. Do you think this knowledge may change in the future?

Choice	6th grade F %	M %	T %	8th grade F %	M %	T %	GT %
A Scientific knowledge and theories are proven facts and so they never change in the future.	21.0	25.4	23.3	14.8	20.8	17.8	20.7
B. Scientists gain the scientific knowledge by doing lots of experiments and that is why their finding are always true and they do not change any more.	19.8	17.4	18.5	12.1	15.1	13.5	16.2
C. Scientific knowledge appears to change because new knowledge is added to old knowledge, the old knowledge doesn't change.	37.4	31.5	34.3	21.8	26.6	24.2	29.5
D Scientific facts can change because the old knowledge is reinterpreted in the light of new discoveries.	18.1	20.4	19.3	44.5	33.7	39.2	28.7
E. I don't know enough about this subject to make a choice	3.5	4.8	4.2	4.9	2.4	3.7	4.0
F. None of these choices fits my basic viewpoint.	0.2	0.6	0.4	1.9	1.3	1.6	1.0

F: Female M: Male T: Total GT: Grand Total

Subjectivity of Scientific Knowledge (Item 4 and Item 5)

The students' views on the subjective nature of scientific knowledge were examined by item 4 and 5. For item 4, options A, B, C, and E were considered as naive views. Students who chose these items are not aware of the role of subjectivity in the production of scientific knowledge. Alternative D was labeled as realistic view which refers that different results are possible because they have different minds, backgrounds and education (Schoneweg & Rubba, 1993).

For the fourth item, the answers of the students' answers on why scientists disagree on the extinction of dinosaurs even though they all have the same information (table 4.4) varied with respect to grade level. For instance, considerable amount of the 6^{th} grade students (33.7%) believe that scientists disagree because they reach the conclusion by following different procedure (alternative A) which supports naive view. On the other hand, 8^{th} graders (32.9%) answered that scientists disagree because their background, education, beliefs and ideas affect their work (alternative D) which supports realistic view. In addition, 22.5% of the 6^{th} graders and 17.6% of 8^{th} graders believe that scientists disagree on the extinction of dinosaurs since they do not see them. Approximately, equal number of the 6^{th} grade and 8^{th} grade students agree that scientists have different findings because of their lack of knowledge. The students responses with regard to grade level were analyzed by chi-square statistics and found that there was statistically significant difference between the 6^{th} grade students' and 8^{th} grade students' responses to item 4 (χ^2= 44.677, df = 5, p= .000).

In the consideration of gender for both 6^{th} and 8^{th} grade students, table 4.4 shows that more females had realistic view than males in percentages. For example, 25.7% of the females and 19.3 % of males for 6^{th} grade level and 39% of female and 26.6% of male for 8^{th} grade level chose alternative D which supports realistic view. This difference in distribution of female and male students' responses was found statistically significant by using chi-square statistics (χ^2= 45.055, df = 5, p=. 000).

Table 4.4. Percentages of Students' Responses to Item 4.

Item 4: Scientists agree that about 65 millions of years ago the dinosaurs became extinct (all died away). However, scientists disagree about what had caused this to happen. Why do you think they disagree even though they all have the same information?

Choice	6th grade F %	6th grade M %	6th grade T %	8th grade F %	8th grade M %	8th grade T %	GT %
A. Scientists disagree because they reach the conclusion by following different procedure.	35.4	32.2	33.7	28.0	23.1	25.6	29.9
B. Scientists disagree because they don't have enough knowledge about this topic.	10.1	15.9	13.2	14.0	14.9	14.4	13.8
C. Scientists disagree because they don't see the dinosaurs.	21.2	23.7	22.5	11.2	24.2	17.6	20.2
D. Scientists disagree because their background, education, beliefs and ideas affect their works.	25.7	19.3	22.3	39.0	26.6	32.9	27.3
E. I don't know enough about this subject to make a choice	7.0	8.0	7.5	4.7	10.0	7.3	7.4
F. None of these choices fits my basic viewpoint.	0.6	0.9	0.8	3.2	1.3	2.3	1.5

F: Female M: Male T: Total GT: Grand Total

In the fifth item, the students were asked whether the scientists make mistakes during their work (table 4.5). According to the responses of 6th grade students, considerable amount of them (41.7%) believe that scientists may make errors as every human beings (alternative C) which is considered as realistic view (Aikenhead, Fleming, & Ryan, 1987). The data also revealed that 15.6 (alternative A), 20.2 (alternative B), and 18.3 (alternative D) percentages of 6th grade students believed that the scientists do not make errors and in fact there is no possibility to make errors because they reach scientific knowledge by the help of many investigations and experiments which are naïve views. Similarly, nearly half of the 8th graders (45.6%) had an idea that scientists may make mistakes as a human being since they are not different from the other people in nature. In addition, 19.1 (alternative B), 15.9 (alternative D), and 13.1 (alternative A) percentages of them have naive views. A chi-square analysis on item 5 indicated that there was statistically significant difference between the 6th grade students' and 8th grade students' responses (χ^2 =16.427, df= 6, p= .012).

As indicated by table 4.5, there are some differences between the percentages of females' and males' responses to item 5 for 6th grade students. For instance, although 18.9% of males chose alternative A, only 11.9% of females from 6th grade selected this option. Moreover, 26.1% of females chose alternative B while only 14.8% of males selected the same option for 6th grade level. However, these differences were not observed for the percentages of 8th grade female and male students. For instance, the percentages of alternative A for females and males are approximately same (12.9%, 13.3% respectively). On the other hand, The chi-square analysis of the students' responses with respect to gender indicated that there was statistically significant difference between the females' and males' views on item 5 (χ^2 = 34.982, df= 6, p=. 000).

Table 4.5. Percentages of Students' Responses to Item 5

Item 5: Scientists do many studies to reach the knowledge. Do you think that scientists may make errors in their work?

Choice	6th grade			8th grade			GT
	F %	M %	T %	F %	M %	T %	%
A. Scientists do not make errors; in fact they should never make errors.	11.9	18.9	15.6	12.9	13.3	13.1	14.4
B. Since scientists reach knowledge by the help of many investigations there is no possibility to make errors.	26.1	14.8	20.2	20.8	17.3	19.1	19.7
C. Scientists may make errors as every human being.	40.9	42.4	41.7	47.2	43.9	45.6	43.6
D. Errors slow the development of science that is why scientists do not have any rights to make errors.	17.9	18.7	18.3	14.2	17.7	15.9	17.2
E. I don't know enough about this subject to make a choice	2.5	3.7	3.1	1.1	5.8	3.4	3.2
F. None of these choices fits my basic viewpoint.	0.6	1.5	1.1	3.8	2.0	2.9	1.9

F: Female M: Male T: Total GT: Grand Total

The Role of Observations and Inferences in Scientific Knowledge (Item 6)

Item 6 investigated the views of the students on the role of observations and inferences for development of scientific knowledge. The table 4.6 revealed that about half of the 6^{th} graders (44.6%) and many of the 8^{th} graders (42.5%) selected alternative C which refers that scientists reach a conclusion by the help of the observations and making inferences about the research topics considered as realistic view (Cochrane, 2003). The alternatives A, B, and D which do not mention about the role of observation and inferences in science were labeled as naive views for item 6. As shown in the table 4.6, nearly 13% of 6^{th} graders and 19% of 8^{th} graders chose alternative A, 33% of 6th graders and 31% of 8^{th} graders signed for alternative B. A chi-square analysis of 6^{th} grade and 8^{th} grade students' responses was revealed that there was statistically significant difference between the students' views on the role of observations and inferences in science across grade level (χ^2 =29.413, df= 5, p= . 000).

According to gender, the data also gave same results for female and male students. For the 6^{th} graders, it was found that considerable amount of females (45.5%) and males (43.9%) are aware of the role of observations and inferences made by the scientists for development of scientific knowledge and so it can be clearly concluded that they had realistic views (alternative C). The situation is also same for the 8^{th} grade students since 43.2% of females and 41.7% of males selected alternative C. Furthermore, it was revealed by using chi-square analysis that there was no statistically significant difference between the students' responses on item 6 with regard to gender (χ^2 = 1.715, df= 5. p= .885).

Table 4.6. Percentages of Students' Responses to Item 6

Item 6: How do scientists know that dinosaurs really existed?

Choice	6th grade F %	6th grade M %	6th grade T %	8th grade F %	8th grade M %	8th grade T %	GT %
A. They only guess.	13.4	13.7	13.5	17.4	20.0	18.6	16.0
B. They can not give us right information about these topics because they do not see the dinosaurs.	32.3	32.8	32.6	31.1	30.2	30.7	31.7
C. They reach this conclusion by the help of the fossils although they do not see the dinosaurs.	45.5	43.9	44.6	43.2	41.7	42.5	43.6
D. I don't know enough about this subject to make a choice	8.2	8.7	8.5	5.5	5.3	5.4	7.0
E. None of these choices fits my basic viewpoint.	0.6	0.9	0.8	2.8	2.9	2.8	1.7

F: Female M: Male T: Total GT: Grand Total

The Role of Creativity in Scientific Knowledge (Item 7)

The students' views on the role of creativity were assessed by the item 7. About half of the 6th graders and 8th graders agreed that scientists do not use creativity in their work which is naïve view (alternative A and B). According to the results, 27.2% of 6th graders and 16.8% of 8th graders considered that scientists never use their imaginations and creativity when they do investigations and 22.7% of 6th graders and 30.4% of 8th graders believed that scientists do not use their creativity because they rely on empirical evidence and certain fact. On the other hand, about 45% of all the 6th grade students and 47% of 8th graders are aware of the role of creativity for development of scientific knowledge which is considered as realistic view. However, they think differently about how and when the scientists use creativity and imagination during their studies. For instance, 28.3% of 6th graders believe that imagination and creativity are used during the planning and designing procedure as well as in making assumptions about what the data represents which is realistic view (alternative D) while 16.9% of them consider that scientists completely rely on their creativity and imaginations which is naïve view (alternative C). In addition, it was revealed that this difference was statistically significant across grade level (χ^2 = 87.980, df= 5, p= .000).

Considering the gender for 6th graders, although females mostly had realistic view (alternative D), males mostly signed for naïve view (alternative A). However, it was revealed that regarding to the gender for 8th graders both females and males mostly had realistic view. Furthermore, a chi-square analysis indicated that there was statistically significant difference on the distribution of the students' responses with regard to gender (χ^2 = 16.025, df= 5, p= .007).

Table 4.7. Percentages of Students' Responses to Item 7

Item 7: Scientists try to find answers to their questions by doing investigations / experiments. Do you think that scientists use their imaginations and creativity when they do these investigations / experiments?

Choice	6th grade F %	6th grade M %	6th grade T %	8th grade F %	8th grade M %	8th grade T %	GT %
A. No, they don't use their imaginations and creativity when they do investigations.	24.3	29.8	27.2	15.9	17.7	16.8	22.3
B. No, they don't use their creativity because they rely on empirical evidence and facts in their investigations.	23.7	21.9	22.7	30.7	30.2	30.4	26.4
C. Yes, they completely rely on their imaginations and creativity when they do investigations and experiments.	17.3	16.5	16.9	7.2	10.4	8.8	13.0
D. Yes, they use imagination and creativity during the planning and designing process, as well as in referring what the data represents.	30.9	25.9	28.3	39.6	37.3	38.5	33.1
E. I don't know enough about this subject to make a choice	3.1	5.4	4.3	2.8	3.1	2.9	3.6
F. None of these choices fits my basic viewpoint.	0.8	0.6	0.7	3.8	1.3	2.6	1.6

F: Female M: Male T: Total GT: Grand Total

Social / Cultural Embeddedness of Scientific Knowledge (Item 8)

In item 8, the students' awareness of the fact that science is influenced by the society and culture in which it is practiced was investigated. According to the responses of 6th grade students, considerable amount of them (39.1%) believe that scientists are parts of their society and they have their social and cultural characteristics as every human beings, so these characteristics can influence their studies which is considered as realistic view (alternative C) according to many researchers (Aikenhead, Fleming, & Ryan, 1987; Haidar, 1999; BouJaoude, 1996). The data also revealed that approximately 13% of them considered that scientists are not affected by the social and cultural values since they are completely apart from society during their investigations which is considered as naïve view. In addition, 21.9% of 6th graders believed that scientists' social life does not affect their studies because they make their investigations by the experiments and scientific methods which are also considered as naïve view (alternative B). About 21% of them thought that scientists can take precautions to not to be affected by these values. Similarly, 8th graders also mostly (41.9%) selected alternative C which refers the realistic view on the effect of society and culture in science. Moreover, 26.8% of them chose alternative B, 16.5% of them signed for alternative D, and 8.2% of them chose alternative A. A chi-square analysis indicated that there was statistically significant difference between the 6th grade and 8th grade students' views on the social and cultural embeddedness of scientific knowledge (χ^2 = 38.424, df= 5, p= .000).

In consideration the 6th grade, both females (38%) and males (40%) mostly believed that scientists are parts of their society and they have their social and cultural characteristics as every human beings, so these characteristics can influence their studies which is considered as realistic view. Similarly, both female and male students in 8th grade mostly had realistic view. In addition, a chi-square analysis on the distribution of students' responses detected a statistically significant difference with respect to gender (χ^2 = 25.323, df= 5, p= .000).

Table 4.8. Percentages of Students' Responses to Item 8

Item 8: Do you think that the scientists are affected by the social and cultural values of their society during their studies?

Choice	6th grade F %	6th grade M %	6th grade T %	8th grade F %	8th grade M %	8th grade T %	GT %
A. Scientists are not affected by the social and cultural values of their society during their studies because they become completely apart from them during their investigations.	12.8	13.3	13.1	3.2	13.5	8.2	10.8
B. Since scientists make their investigations by the experiments and scientific methods, their social life does not affect their studies.	20.4	23.3	21.9	28.0	25.5	26.8	24.2
C. Scientists are parts of their society and they have their social and cultural characteristics as every human being, so these characteristics can influence their studies.	37.7	40.4	39.1	43.4	40.4	41.9	40.4
D. Whether the scientist is affected by his/her social and cultural values is depends on the scientist because he/she can take precautions to not to be affected by these values.	24.5	18.1	21.2	19.7	13.1	16.5	18.9
E. I don't know enough about this subject to make a choice.	4.5	4.4	4.5	3.0	5.5	4.2	4.4
F. None of these choices fits my basic viewpoint.	0.2	0.4	0.3	2.8	2.0	2.4	1.3

F: Female M: Male T: Total GT: Grand Total

Theories and Laws (Item 9)

The aim of the item 9 was to investigate whether the participants knew the fact that theories and laws are different kinds of scientific knowledge (BouJaoude, 1996; Cochrane, 2003). As seen from the table 4.9, only 12 % of 6th grade students and 14.7 % of 8th grade students had this realistic view (alternative C). The data also revealed that both 6th and 8th grade students mostly expressed a simplistic hierarchical relationship in which theories become laws when they are proven which is considered as naïve view (alternative B). Thus, it can be concluded that students tended to ignore the fact that many laws were known before any theories developed to explain them. Furthermore, about 17% of both 6th and 8th graders considered the scientific theories and laws as same type of statements which is also considered as naïve view (alternative A). The students' responses with regard to grade level were analyzed by using chi-square statistics and found that there was a statistically significant difference between the 6th grade and 8th students' views on scientific theories/laws (χ^2= 31.276, df= 5, p= .000).

As shown in the table 4.9, females and males mostly had naive views for both 6th and 8th grade levels. The results also indicated that 14.6% of the females and 18.7% of males of 6th graders thought that scientific theories and laws are same kind of statements which is naïve view (alternative, A). In addition, approximately 13% of females and 12% of males for 6th graders considered that scientific theories explain why something happen but scientific laws explain what happens which is considered as realistic view. Considering the percentages of the female and male students' responses, it is seen that there is not much difference on the percentages of their selected items. This situation is also same for the 8th graders since the females and males chose the item in nearly similar percentages. As an example, the alternative D was selected about 20% by both females and males, separately. A chi- square statistics also showed that there was no statistically significant difference between the distribution of the female and male students' responses to item 9 (χ^2= 4.946, df= 5, p= .422).

Table 4.9. Percentages of Students' Responses to Item 9

Item 9: Is there a difference between a scientific theory and a scientific law?

Choice	6th grade F %	6th grade M %	6th grade T %	8th grade F %	8th grade M %	8th grade T %	GT %
A. There is no difference between the scientific theory and the scientific law.	14.6	18.7	16.8	16.1	14.2	15.2	16.0
B. Theory becomes law when it has been tested many times and has been proven.	28.8	32.4	30.7	28.8	31.7	30.2	30.5
C. A scientific theory explains something, or why it happens. A scientific law explains what happens.	13.2	12.2	12.7	12.1	13.3	12.7	12.7
D. Scientific law is more certain than scientific theory.	28.8	23.7	26.1	20.8	21.3	21.0	23.7
E. I don't know enough about this subject to make a choice.	14.0	12.4	13.2	18.9	16.4	17.7	15.3
F. None of these choices fits my basic viewpoint.	0.6	0.6	0.6	3.4	3.1	3.3	1.8

F: Female M: Male T: Total GT: Grand Total

Scientific Approach to Investigations (Item 10)

Item 10 was related to the way how the scientists reach a scientific knowledge. When 6th graders were asked to choose a description, the largest group (36.6%) selected alternative D stating that doing experiments and collecting data, making hypothesis and later testing this hypothesis are the steps for gaining a scientific knowledge which is considered as naïve view (Aikenhead, Fleming,& Ryan, 1987). The second largest group (29.5%) of 6th graders chose the alternative C which is also considered as naïve view describing that there must be a defined and certain method to reach the scientific knowledge. The remaining respondents spread their choices over two options. About 16% of the 6th grade students believed that only scientists produce scientific knowledge (alternative A) which is also labeled as naive view and unfortunately, only 12.3% of the 6th graders had realistic view who were aware of the fact that there is not a certain set of steps for making scientific investigations (alternative B).

As seen from the table 4.10, the percentages of selected options for 8th graders were similar to 6th graders. About half of 8th grade students chose alternative D, 22% of the 8th grade students selected alternative C, and 9% of them signed for alternative A. Thus, it means that the considerable amount of 8th grade students believed the necessity of certain scientific method like 6th graders. However, it was revealed that only 13.3% of the 8th graders have realistic view (alternative B). It was also concluded that the percentages of 6th grade students who had realistic view (12.3%) is very close to the percentages of 8th graders had such view (13.3%). A chi-square analysis detected a statistically significant difference between the students' responses with regard to grade level on item 10 (χ^2 = 56.555, df= 5, p= .000).

If the gender was considered, according to the results, 8.8% of females and 15.4% of males of 6th grade students and 11.2% of females and 15.5% of males of 8th grade students had realistic views (alternative B). This means that a few amounts of both females and males for each grade level are aware of the lack of definite scientific method for investigations. In addition, according to chi-square statistics, there was statistically significant difference on the males' and females' views of scientific approach to investigations (χ^2= 56.555, df= 5, p=. 000).

Table 4.10. Percentages of Students' Responses to Item 10

Item 10: What do you think that how the scientific knowledge is gained?

Choice	6th grade			8th grade			GT
	F	M	T	F	M	T	
	%	%	%	%	%	%	%
A. Being a scientist is a necessity to reach a scientific knowledge.	13.0	18.1	15.7	8.5	10.2	9.3	12.7
B. The best scientists are those who use any method that might get favorable results.	8.8	15.4	12.3	11.2	15.5	13.3	12.8
C. There must be a defined and certain method to reach the scientific knowledge.	31.3	28.0	29.5	21.0	22.8	21.9	25.9
D. First, doing experiments and collecting data, second making hypothesis and later testing this hypothesis are the steps for gaining a scientific knowledge.	41.8	32.0	36.6	53.6	45.0	49.4	42.7
E. I don't know enough about this subject to make a choice	4.9	5.6	5.3	3.2	4.7	3.9	4.6
F. None of these choices fits my basic viewpoint.	0.2	0.9	0.6	2.5	1.8	2.2	1.3

F: Female M: Male T: Total GT: Grand Total

The Role of Prediction and Uncertainty in Scientific Knowledge (Item 11)

Item 11 investigated the view about prediction and uncertainty in scientific knowledge. Many of the 6^{th} grade students (43.6%) and more than half of the 8^{th} grade students (52.2%) were aware of the uncertainty of scientific knowledge and predictions made by scientists (alternative A) so it can be concluded that they had realistic views. However, about 33% of 6^{th} graders and 27% of 8^{th} graders believed that scientists gave us certain information because they had developed equipments which is considered as naïve view (alternative B). Moreover, 15.7% of 6^{th} graders and 11.6% of 8^{th} graders thought that the scientists gave us accurate information since they were well educated people which are also labeled as naïve view (alternative C). A chi-square analysis of 6^{th} grade and 8^{th} grade students' responses was revealed that there was statistically significant difference between the students' views on the role of prediciton and uncertainty in scientific knowledge across grade level (χ^2 =48.174, df= 5, p= . 000).

Approximately 45% of female and 42% of male had realistic view for the 6^{th} grade level and 59% of female and 53% of male had such a view for the 8^{th} grade level (option A). For the next largest group both females and males of 6th graders selected alternative B. The situation was also same for 8^{th} graders since they also selected alternative B in the second highest percentage. According to chi-square analysis, there is statistically significant difference on the distribution of the students' responses with regard to gender (χ^2 = 31.550, df= 5, p= .000).

Table 4.11. Percentages of Students' Responses to Item 11

Item 11: Do you think weather persons are certain (sure) about weather patterns?

Choice	6th grade F %	6th grade M %	6th grade T %	8th grade F %	8th grade M %	8th grade T %	GT %
A. They don't give us certain information about weather patterns because there is always a probability for error and unforeseen events which will affect a result.	45.3	42.0	43.6	59.3	53.4	56.4	49.7
B. They give us certain information about weather because they have developed equipments.	37.0	29.6	33.1	24.8	23.3	24.1	28.8
C. They give us certain information about weather because they are well educated people on their subjects.	10.5	20.4	15.7	9.7	13.5	11.6	13.8
D. I don't know enough about this subject to make a choice.	6.2	6.7	6.4	2.5	7.1	4.8	5.6
E. None of these choices fits my basic viewpoint.	1.0	1.3	1.2	3.6	2.7	3.1	2.1

F: Female M: Male T: Total GT: Grand Total

The students' understandings of the nature of science were investigated by the descriptive analysis of the data. Nature of Science Questionnaire for Elementary Level (E-NOS) was used in order to collect data for descriptive analysis. The results of data analysis revealed that majority of Turkish elementary school students held traditional views on nature of science. For instance, many of them were not aware of the fact that scientific theories and laws are different kinds of scientific knowledge. Morever, lots of the students had the idea that there is certain and defined scientific method in order to develop scientific knowledge. The data analysis also revealed that there are significant differences in distributions of the students' responses with regard to grade level and gender. For example, 8th grade students held more contemporary (realistic) views of the tentative and subjective nature of science and the role of prediction and uncertainty in science while more 6th graders had contemporary views on the role of observations and inferences in science.

4.2. Analysis of Interviews

In this study, the individual interviews were conducted to seven 6th grade students (three females and four males) and five 8th grade students (three females and two males) in order to identify their views on the nature of science. The selection of the students based on their willingness to participate in the present study. Students were asked to respond to VNOS-D which has ten open-ended questions about the nature of science. The heading of the items and answers given by the students for these items were indicated below.

Definition of science

When asked to define science, it was revealed that the students' answers were quite different. They defined science as life, technology, making experiments, finding the truths and exploring unknown things. According to the interview results, it was notable that the 8th grade students tended to have more realistic views about the definition of science while 6th grade students tended to have more naïve views. For instance, three of the 6th graders defining science stated that:

"… Science is something related the universe (female)…"

"Science gives information about humans, animals and plants because science means life (male)…"

" To me, science refers technology. Thanks to science we now have mobile phones, dics-mans and highly developed computers (male)…"

On the other hand, two of the 8th graders expressed more realistic view about the definition of science:

"Science helps us to understand the world and the origin of things (male)…"

"… Science means exploring things, discovering unknowns about nature and tring to make the explanations about them (female)…"

Difference of Science from Other Disciplines

When asked the difference of science from other disciplines, many of the students stated the differences between science and other disciplines in the same way. They believed that science is concrete, whereas other disciplines such as religion and pshycology are abstract. One participant stated that:

> "Science is based on fact, but religion is based on beliefs and art is based on intelligence (female, 6th grade)"

In parallel, one of the 8th graders said that:

> "… Science is concerned with observable things, and how it works, but religion and pshycology are concerned with abstract things such as views, ideas, and emotions (female)…"

The interview results also revealed that although many of the students knew the main difference of science from other disciplines, they could not clearly explain the reason why they thought like this way. In addition to these, two of the respondents claimed that although science is important and beneficial, other subjects are not as important as science which supports naive view. They claimed that:

> "… Science is more beneficial for us, but other disciplines are not (male, 6th grade)…"
>
> "We should give importance to science because it is part of the life, but we do not have to learn about other disciplines (male, 8th grade)…"

Moreover, one of the participants mentioned about the testable and observable features of the scientific knowledge. She stated that:

> "… Science is different from other subjects because it can be tested by experiments, whereas religion and pshycology gives factual explanations (female, 6th grade)…"

Tentativeness of Scientific Knowledge

Students' views on the tentative nature of scientific knowledge are also examined by the interviews. According to the interview results, four of the students who had naive views (two students from each grade level) claimed that scientific knowledge does not change. For instance, two of the 6^{th} graders stated that:

> "… Scientific knowledge in our books is proven facts and so it never changes. For example, it has been known for many years that living things consist of cells (male)…"

> "… Scientists tested this knowledge many times and so they are in our books now. That is why, scientific knowledge does not change even after so many years (female)…"

On the other hand, eight of the participants (five from 6^{th} grade and three from 8^{th} grade) expressed realistic view about the tentative the nature of science. These participants noted that scientists might find new evidence that might change scientific knowledge. Two of the student stated that:

> "… New theories and ideas can change the existing knowledge (male, 8^{th} grade)…"

> "The scientific knowledge in our book can be wrong and it can be replaced by the new and accurate ones in the future (female, 8^{th} grade)…"

One of the participants believed that the change in the scientific knowledge is caused by advancement in technology. He stated that:

> "To me, scientific knowledge will change in the future because scientists will have better tools to find out more information on what we need since we are getting more advance technology (male, 8^{th} grade)…"

During the interview, it was revealed that although some students were aware of the tentativeness of scientific knowledge, they could not support their views with suitable explanations. For example, one of the participants stated that:

> "…Scientific knowledge changes in the future because everything changes by time and replaced by new ones with regard to new developments (female, 6^{th} grade)…"

The Role of Observation and Inferences in Science

The students' awareness of the role of observations and inferences in producing scientific knowledge was investigated by a given situation about dinasours. It was revealed that majority of the students (six from 6th grade and five from 8th grade) had realistic view referring that scientists develop scientific knowledge by making observations and inferences about the subjects they are studying. For instance, three participants noted that:

> "…Scientists did not see the dinosaurs but they have fossils which guide them in making explanations about dinosaurs (female, 6th grade)…"
>
> "Scientists can know about dinosaurs by making inferences based on the remains of them (male, 6th grade)…"
>
> "…Scientists believed that dinosaurs are big creatures because they make inferences about dinasours and stated their opinion about what they look like (male, 8th grade)…"

Only one student out of twelve had naive view believing that scientists would not know about the dinosaurs unless they can see them. She stated that:

> "…Although scientists are well educated people, they can not know about dinasours because they do not examine them by their eyes (female, 6th grade)"

Considering the grade level, it can be concluded that the amount of the students from 6th grade and 8th grade had approximately similar views on the role of observation and inferences in science.

Subjectivity of Scientific Knowledge

The students were asked how scientists disagree about the extinction of dinasours although they have same information in order to examine their views on the subjectivity of science which means that scientific knowledge is influenced by the personal values, prior experiences and presently accepted scientific theories and laws. The results of the interviews revealed that the students' responses to this question were varied. According to these results, out of twelve students five of them (one from 8th grade and four from 6th grade) had naive views. For example, three of the participant explained their views as:

> "Scientists disagree about what had caused extinction of dinasours althgough they have same data because they do not have enough information about dinasours (male, 6th grade).
>
> "Scientists know wrong things about dinasours (male, 6th grade).
>
> "If they use same data, they should have always reach same conclusion (female, 8th grade).

In addition, it was revealed that some students had the idea that scientists' values and existing knowledge might influence the scientific knowledge but they could not explaind the reason behing this fact. Two of them stated that:

> "…because different scientists believe different things (female, 6th grade)…"
>
> "All the facts about dinasours have not been discovered yet and so sometimes scientists' beliefs direct their investigations (female, 6th grade)…"

Morever, it can be concluded that 8th grade students demostrated more realistic view in response to the subjectivity of scientific knowledge during the interviews. Two of the 8th graders explained that:

> "…Scientists have same data, but they have different views, personal opinions and values (female, 8th grade)…"
>
> "Scientists may make different comments on the same data since they are different people they have different minds (male, 8th grade)…"

Precision and Uncertanity in Scientific Knowledge

The question "Do you think weather persons are certain (sure) about the information they collected about weather patterns?" were asked to the students in order to examine their views on the role of precision and uncertanity in science. Four of the students (three students from 6th grade and one student from 8th grade) claimed that scientists always make correct predictions which supports naive view and eight of the students (four students from 6th grade and four students from 8th grade) believed that scientists might make wrong predictions which supports realistic view. Two students having naive view stated that:

> "I think, scientists are hundred percent sure about prediction of whether because this is their job (male, 6th grade)…"
>
> "…Since scientists predict the whether by technologically developed devices such as photographs from space, they always make correct predictions (male, 8th grade)…"

Some of the students supported their views by giving examples. For instance, two of the participants said that:

> "…Scientists usually make wrong predictions. For example, they say "the whether is rainy tomorrow" but it does not rain (male, 6th grade)…"
>
> "…Since whether persons sometimes do not guess velocity of clouds, they make wrong predictions (male, 8th grade)…"

In addition, one of the students from each 6th and 8th grade made a clear explanationootisquestion:

"…There is always a possibility to make an error and so whether persons may also make wrong predictions (female, 6^{th} grade)…"

"…They can not be sure about whether because some factors that are not considered before can influence the results (female, 8^{th} grade)…"

The Role of Creativity in Scientific Knowledge

Students' view on the role of creativity in developing the scientific knowledge was also examined by the interview. Only one of the students out of twelve believed that scientists do not use creativity and imaginations during their works which refers naive view. He stated that:

"Scientists do not use creativity in their work because they rely on emprical evidence and facts (male, 6^{th} grade)…"

Other eleven students stated that scientists use imaginations and creativity in their investigations and they claimed that their creativity direct their investigations. Some of the participants answered the question by the help of the examples:

"Yes, scientists use creactivity during their investigations. For example, Galileo claimed that "earth turns around the sun" by imagining the places of them (female, 8^{th} grade)…"

"Of course, scientists use creativity and imagination during their investigations. For example, although scientists did not see dinasours, they use their creativity and tried to clear up the knowledge they have about dinasours (female, 8^{th} grade)…"

One of the students mentioned about in which steps during their investigation the scientists use creativity and imagination. He explained that:

"Scientists use creativity and imaginations during desinging the process, planning and inferring what the data represents (male, 8^{th} grade)…"

Considering the grade level, it was observed that 8^{th} grade students are more aware of the role of creativity and imagination in science than 6^{th} grade students since they made more rational explanations and gave clear examples supporting their view.

Social / Cultural Embeddedness of Scientific Knowledge

The students' views of social and cultural embeddedness of scientific knowledge were also assessed. When asked to students whether social and cultural values affect the science or not, all of the students revealed that scientific kowledge influenced by the society and culture in which it is practiced. One of the students answered this question with an example which focused on the influence of religion as well as the culture and society. She stated that:

> "To me, scientists certainly reflect their social and cultural values on their works. For example, I think that if Darwin was a Muslim he would not think about conducting research on evolution theory which contradicts to Muslims beliefs (female, 8^{th} grade)…"

With regard the grade level, it was observed that although both 6^{th} and 8^{th} grade students had realistic view, 8^{th} grade students' made more meaningful explanations for clarifying their views. For example, two of the 8^{th} grade students explained their views as:

> "Yes, they are affected by the social and cultural values. For example, scientists from different countries discover different things. In our country, one technological development might be popular while in other countries other developments are popular (male, 8^{th} grade)…"
>
> "Yes, they are affected by the social and cultural values. For example, scientists from different countries discover different things (male, 8^{th} grade)…"

Scientific Approach to Investigations

When students were asked whether the scientists follow only one scientific method which has the certain and definite steps, eleven students out of twelve (seven from 6^{th} grade and four from 8^{th} grade) tended to favor that there is a definite way to doing science which supports the naive view. They defined the method as the way many of the science books wrote; observing, making hypothesis, experimenting, collecting data, gaining results. One of the students stated that:

> "We learnt in the school that scientists first define the question, second they collect data, then make experiments (female, 8^{th} grade).

One of the students believed that scientists should use definite scientific method accepted by the all countries in order to provide proper communication. He also added that:

“Scientists follow the certain steps of scientific method because scientific method gives valid and accurate results (male, 6th grade).

On the other hand, only one of the students stated that scientists may use any methods that might get valuable results which supports the realistic view. She explained that:

> “No, there is not one scientific method followed by the scientists step by step. Scientists can use any methods that will be appropriate for them to get the results (female, 8th grade).

In addition, one student also claimed that using only one specific method in scientific investigations limits the scientists during their studies. That is, some students who are aware of that many methods can be used in developing science did not support their views with appropriate rationales. As evidence from the interviews, it can be concluded that majority of the both 6th grade students and the 8th grade students had naive view.

Theories and Laws

Lastly, the students’ views on scientific theories and scientific laws in science were investigated. It was revealed from the students’ responses that all the students tended to have naive views stating that:

> “Scientific theories are not certain, but laws are certain (female, 6th grade)…”
>
> “Theory becomes a law after proven to be true many times (male, 6th grade)…”
>
> “Theory is tested by the experiments and if it seems to be correct, it becomes a law (male, 8th grade)…”

In addition to these views, one student had more realistic view which was related to the use of a scientific theory and a scientific law in science. She explained her view as:

> “…Theories explain why something happen and laws explain what something happens…”(8th grade).

Results of the interview clarified the several points about the participants’ views and were useful to get deeper information about their view on the nature of science. It can be concluded from the interviews that participants have some traditional views on some aspects of the nature of science such as definiton of science, theories and laws and scientific approach in developing science and but they also have some contemporary views on some other aspects such as cultural and social embeddedness of science, tentative the nature of science and the role of creativity in science.

CHAPTER 5

DISCUSSIONS, IMPLICATIONS AND RECOMMENDATIONS

This study aimed to investigate the views of elementary school students on the nature of science. This chapter presents discussions of the results, implications for practice and recommendations for future studies.

5.1. Discussions

There is a consensus among science educators that fostering an understanding of the nature of science for students should be a primary aim of science instruction (e.g. BouJaude, 1996; Hammrich, 1997; Hogan, 1999; Hogan, 2000; Moss, Abrams & Robb, 2001). However, the examining the existing beliefs of the students and possessing their currently present ideas on the nature of science should be a starting point before encouraging them to develop an understanding of NOS. With the same line, the purpose of this study reveals the 6^{th} and 8^{th} grade students' views on the nature of science.

In general, this study displayed that regardless of the grade level and gender relatively low number of the elementary school students had contemporary (realistic) views on the some aspects of the nature of science. For instance, it was revealed that less than thirteen percentages of the elementary school students had realistic views on the scientific theories/laws and scientific approach to investigations in science. Most of the students considered scientific laws and theories in a hierarchical relationship, but according to realistic view, scientific theories and laws are different kinds of statements. This result was also supported by the interviews since none of the participants indicated realistic view. In fact, the interview results showed it was a common mistake among the students to consider scientific laws as proven scientific theories and even scientific laws are more important than theories. Some researchers claimed that teachers might be the source of this myth on the relationships among scientific theories and laws because many studies in the literature revealed that science teachers had dogmatic assumption about the scientific theories and laws (Oginniyi, 1982; Erdoğan, Çakıroğlu & Tekkaya 2006; Pomeroy, 1993) which also influences the teachers' practices and instructions in the classroom (Zeidler and Lederman, 1989; Gallagher, 1992; Waters-Adams, 2006).

The result of this study also showed that the students' views on the definition of science are varied and there was no consensus on their statements which is also supported by some other studies in the literature (Griffiths & Barman, 1995; Moss, Abrams & Robb, 2001; Kang, Scharmann & Noh, 2005). The present study also revealed that although most of the students had contemporarily accepted view on the definition of science which defines science as investigating new things and explaining the working of the world (Kang, Scharmann & Noh, 2005; Schoneweg & Rubba, 1993), many of the students tended to consider science as an instrument for development of technology which formulates the primary aim of science as inventing practical and useful things. One possible reason for this view may be the confusion between science and technology. This result was also supported by the interviews since many students defined science as inventing highly developed technological devices. The students' responses showed that students imagine designing new devices, genetics, medical and environment developments when they are thinking about the meaning of science. This may be the result of fact that in 21th century, technology directs our lives and it surrounds us especially by the influence of mass media which tend to report technological developments under the name of science (Ryan & Aikenhead, 1992).

Present study also displayed the students' misconceptions in various aspects of the NOS. For example, the contemporary accepted view of scientific approach indicates that the questions guide the investigation and any approaches can be used to get favorable results (Lederman, 2004). When the students were asked about the nature of scientific method, they tended to believe that there should be a certain set of steps such as questioning, hypothesizing, gathering data, and coming up to a conclusion followed by the scientists which is consistent with traditional view. In the interview, one of the students who had this naïve view claimed that she learnt these steps in the lesson at the beginning of the academic year. In fact, this is the situation for many countries as well as Turkey in which scientific method is taught in many schools with definite steps.

Like many other studies (Schoneweg & Rubba, 1993; Erdoğan, Çakıroğlu & Tekkaya, 2006) the results of the present study also indicated that majority of the students were not aware of the social aspects of science and/or as a form of human activity. The reason might be neglecting the social related part of science in the science curriculum which causes the students unable to address science-related everyday and societal problems. However, in a developing country, like Turkey, there is a need to produce citizens who are good decision makers in confronting environmental and other science-related issues.

Considering the students' views on the difference of science from the other subjects, it was revealed that only a quarter of 6th graders believed that science is related with matter, but other disciplines such as religion, psychology, and art touch on things that science can not which represents realistic view. However, nearly forty percent of 8th graders had this realistic view. Thus, it can be concluded that more 8th grade students than 6th graders had contemporary view on the difference of science from the other disciplines. This might be the result of the fact that 8th graders are in older age and so they might be more logical and careful in observing the nature. Although chi-square analysis indicated statistically significant differences in the distribution of the students' responses with respect to grade level, the statistical significant differences were not found with respect to gender considering the students' views on the difference of science from the other subjects.

When the students asked whether the scientific knowledge in their textbooks may change in the future, the differences were observed in the distribution of the students' responses with regard to grade level. It was revealed that while forty percent of 8th graders were aware of the tentative nature of scientific knowledge, only twenty percent of the 6th graders believe that scientific knowledge may change by the new interpretations and discoveries. Thus, it can be concluded that more 8th grade students had views consistent with contemporary epistemology whereas more 6th grade students had views which are based on traditional epistemology. This result is supported by the many researchers (Lederman & Q' Malley, 1990; Kang, Scharmann, & Noh; 2005). For example, Stein and McRobbie (1997) reported that although there was a clear indication concerning the tentative nature of scientific knowledge for older students (9th, 11th, and 12th graders), younger students (4th, 6th, and 7th grade) did not indicate any recognition of the changeability of scientific knowledge (cited in Kang, Scharmann, & Noh; 2005). There are also some other studies that reported a lack of students' understandings of the tentativeness of scientific knowledge (e.g. Griffiths &Barry, 1993; Ryan & Aikenhead, 1992). Interview results indicated that 6th graders mostly tended to believe that since scientific knowledge is constructed after many researches, it does not change even so many years later. Considering the gender it was found that there was no difference on the students' views and only thirty percent of female and male students had realistic view on the tentativeness of the nature of science.

With regard to the role of creativity and imagination in developing scientific knowledge, it can be concluded that a good proportion of 8th grade students were aware of the fact that scientific knowledge is created from human imaginations and logical reasoning based on observations and inferences of nature while less than 6th grade students held this realistic view.

Considering the subjectivity of the nature of science, the present study showed that more 8th grade students were aware of the fact that scientists' disagree about what had caused the extinction of the dinosaurs because of the differences in their background, education, beliefs and ideas. However, 6th grade students were tended to have traditional view considering that following different procedure caused the disagreement among the scientists which indicated that 6th grade students had no recognition of the subjective nature of the scientific knowledge. The interview results also displayed that 8th grade students had an idea that scientists differ from each other because of their personal differences, while none of the 6th grade students mentioned about this subjective nature of scientific knowledge. The reason why more 6th graders had traditional view might be that since 6th graders are younger than 8th graders, they could not realize that every person has his/her own characteristics which give direction to his/her life. According to McComas (1996), scientists like all other people hold some preconceptions and biases about the world. The students might not consider that these preconceptions influence scientists' observations and decisions. The results also indicated that the females' and males' responses differed from each other on the subjective the nature of science. The distribution of the students' responses with regard to gender revealed that nearly thirty percent of the females and twenty percent of males had the most contemporary view. The success of the female students might be related to the fact that girls' are more confident and interested in the topics related to social issues (Jones, Howe & Rua, 1999).

To sum up, the results of this study revealed that the majority of Turkish elementary school students held traditional view on some aspects of the nature of science such as scientific theory and law in science and scientific approach in investigations. However, it was also found that a good proportion of them had realistic views on some other aspects of the nature of science such as the role of prediction and uncertainty in science and the importance of observations and inferences in science. The results also showed more 8th grade students held contemporary (realistic) views of the tentative and subjective nature of science and the role of precision and uncertainty in science and more 6th graders had contemporary views on the role of observations and inferences in science. Furthermore, it was indicated that more female students than males possessed contemporary views on the subjectivity and creativity of the nature of science.

5.2. Implications

One of the most important objectives for science education in many countries is the development of contemporary understanding of the nature of science in order to train scientifically literate citizens. Therefore, it is vital for the students to gain contemporary views about the nature of science and the scientific knowledge in their early ages. For that reason, examining the students' views and helping them in order to construct meaningful understanding of the nature of science is the primary focus of the science educators. In the same direction, present study reveals the views of the students on the nature of science which can be considered as the first step to start educating scientifically literate students. With the guidance of the results of this study, some interventions can be made in order to improve the students' inconsistent views on the nature of science concepts.

According to results of this study, it was indicated that students held traditional views on some aspects of the nature of science and about scientific knowledge. The sources of the students' inconsistent views on the nature of science issues must be taken account in science education. The attempts for the reducing the myths that are caused by the textbooks must be focus of the science educators. In addition, the teachers' naïve views or their lack of knowledge on the nature of science might cause the students to hold incontemporary views on science. For this reason, in-service courses should be arranged for the teachers to improve themselves on the nature of science concepts. Moreover, it is also important to educate the preservice science teachers in order to prevent the problems caused by the teachers on the students' understandings of the nature of science.

Moreover, the curriculum should emphasize the importance of the nature of science In Turkey, the new science curriculum was designed for elementary schools. This curriculum will be used for 6^{th} grade level in the academic year of 2006-2007 for the first time. The curriculum has aims to improve Turkish educational system to align it with recent international trends in science education. In order to achieve this aim, epistemology and sociology of science are considered as a priority of new curriculum. For that reason, the present study can be a guide for the curriculum developers in order to understand the students' views on the nature of science concepts and emphasize the issues which are not comprehensible for the most of the students.

5.3. Recommendations

According to the findings of this study, the following recommendations can be given:

The study was performed at only six elementary schools in Ankara. For that reason, it is worth to conduct similar studies in different school and cities in Turkey in order to generalize the results confidently.

This study revealed that students held traditional views on some the nature of science issues. Therefore, another study can focus on these views, and investigate the ways to reduce these naïve views.

This study was performed with descriptive technique to investigate the elementary students' views on the nature of science. Another study may be conducted with a larger sample by using inferential statistics as data analysis procedure.

The present study examined the 6^{th} and 8^{th} grade students' views on the nature of science. The views of science teachers in elementary schools can be also investigated. Moreover, primary and high school students' view, the beliefs of university professors, pre-service and in-service science teachers may be assessed by the researchers.

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APPENDICES

APPENDIX A

E-NOS

Sevgili Öğrenciler,

Bu anket sizin bilime ve bilimsel bilgiye bakış açınızı ölçmek amacı ile hazırlanmıştır. Bu sorulara vereceğiniz yanıtlar, araştırma amacıyla kullanılacak ve gizli tutulacaktır.Yanıtlarınız, Türkiye'de uygulanacak Fen Bilgisi ders programları ve ders kitaplarının geliştirilmesine ışık tutacaktır. Cevaplar "doğru" veya "yanlış" olarak değerlendirilmeyecek, sadece sizin bu konudaki düşünceleriniz üzerinde durulacaktır ve sizlerin görüşleri bizler için çok önemlidir. Yardımlarınız için teşekkür ederiz.

ODTÜ Eğitim Fakültesi, İlköğretim Bölümü.

AÇIKLAMALAR

Bilimin Doğasını konu alan bu anket 11 sorudan oluşmaktadır. Her soru için BİR TEK seçeneği işaretlemeniz gerekmektedir. Bu anketin uygulanma amacı sizin bilimin doğası hakkındaki görüşlerinizi öğrenmektir. Verdiğiniz cevaplar Fen Bilgisi dersi notunuzu etkilemeyecektir.

KİŞİSEL BİLGİLER

Adınız ve Soyadınız:

Okulunuzun Adı :

Sınıfınız **:** □6 □8

Cinsiyetiniz **:** □Kız □Erkek

Doğum Tarihiniz (yıl) **:**

Geçen Yıl Sonundaki Fen Bilgisi Notunuz **:**

Annenizin eğitim durumu: □Okuma-yazma bilmiyor □İlkokul □Ortaokul □Lise □Üniversite

Babanızın eğitim durumu: □Okuma-yazma bilmiyor □İlkokul □Ortaokul □Lise □Üniversite

1. Bilim nedir?

A) Biyoloji, kimya ve fizik gibi alanlarda yapılan çalışmalardır.
B) Yaşadığımız dünyayı (maddeyi, enerjiyi ve yaşamı) açıklayan prensipler, kanunlar ve teorilerdir.
C) Dünyamız ve evren hakkında bilinmeyenleri araştırmak, yeni şeyleri ve nasıl çalıştıklarını keşfetmektir.
D) Yaşadığımız dünya ile ilgili problemleri çözmek için deneyler yapmaktır.
E) Bir şeyler icat etmek ya da tasarlamaktır (yapay kalpler, bilgisayarlar ve uzay araçları gibi).
F) Bu dünyayı yaşam için daha iyi bir yer haline getirmek için gerekli olan bilgiyi bulma ve kullanmadır (hastalıkları tedavi etmek, kirliliği çözümlemek ve tarımı geliştirmek gibi).
G) Yeni bilgileri keşfetmek için fikir ve tekniklere sahip olan insanların (yani bilim insanlarının) bir arada olduğu organizasyondur.
H) Hiç kimse bilimi tanımlayamaz.
I) Bu konu hakkında yeterli bilgiye sahip değilim.
İ) Hiçbir şık benim görüşüme uymuyor. Çünkü bence bilim;

____

2. Bilimi diğer alanlardan (mesela; din, psikoloji ve resim) ayıran özellikler nelerdir?

A) Bilim gerçeğe dayanır ama diğerleri düşünce ve inanca göre değişir.
B) Bilimsel bilgi test edilebilir ve ispatlanabilir ama diğerleri sadece teorik bilgi içerir.
C) Bilim madde ve maddenin oluşumu ile ilgilenir. Din ve psikoloji ise bilimin açıklayamadığı soyut konuları açıklar.
D) Bilimi diğer alanlardan ayıran hiçbir özellik yoktur.
E) Bu konu hakkında yeterli bilgiye sahip değilim.
F) Hiçbir şık benim görüşüme uymuyor. Bence bilimi diğer alanlardan ayıran özellik;

____

3. Bilim insanları bilgi üretirler ve bu bilgilerin bazıları Fen Bilgisi kitaplarında yer
alır. Sizce bu bilgiler gelecekte değişebilir mi

A) Bilimsel bilgiler ve teoriler ispatlanmış gerçeklerdir ve hiçbir zaman değişmez.
B) Bilim insanları birçok deneyler yaparak bu bilgilere ulaşmışlardır, bu yüzden buldukları her zaman doğrudur, değişmez.
C) Bilimsel bilgi değişir gibi görünür ama aslında değişmez; çünkü eski bilgiye yeni bilgiler eklenir; eski bilgiler aynen kalır.
D) Eski bilgiler yeni buluşların ışığında yeniden yorumlanır; dolayısıyla hiçbir bilgi kalıcı değildir.
E) Bu konu hakkında yeterli bilgiye sahip değilim.
F) Hiçbir şık benim görüşüme uymuyor. Bence ;

____

4. Bilim insanları dinozorların 65 milyon yıl önce yok oldukları konusunda aynı fikre sahiptirler. Ancak bilim insanları bu yok oluşa neyin sebep olduğu hakkında farklı görüşlere sahipler. Sizce bilim insanlarının aynı bilgilere sahip olmalarına rağmen farklı sonuçlara ulaşmalarının sebebi ne olabilir?

A) Bilim insanları farklı yollardan sonuca ulaştıkları için farklı sonuçlara varırlar.
B) Bilim insanları yeteri kadar bilgiye sahip olmadıkları için farklı sonuçlara varırlar.
C) Bilim insanları dinozorları gerçekten görmedikleri için farklı sonuçlara varırlar.
D) Bilim insanlarının eğitimi, düşünce ve inançları çalışmasını etkilediği için farklı sonuçlara varırlar.
E) Bu konu hakkında yeterli bilgiye sahip değilim.
F) Hiçbir şık benim görüşüme uymuyor. Bence ;

____

5. Bilim insanı bilgiye ulaşmak için birçok çalışmalar yapar. Sizce bilim insanı bu çalışmaları sırasında hata yapabilir mi?

A) Bilim insanı kesinlikle hata yapmaz. Zaten hata yapmaması da gerekir.
B) Bilim insanı bilgiye araştırmalar sonucu ulaşır; dolayısıyla hata yapma riski yoktur.
C) Her insan gibi bilim insanı da hata yapabilir.
D) Hatalar bilimin ilerlemesini yavaşlatır ve bizi yanıltır; bu yüzden bilim insanının hata yapma hakkı yoktur.
E) Bu konu hakkında yeterli bilgiye sahip değilim.
F) Hiçbir şık benim görüşüme uymuyor. Bence ;

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6. Bilim insanları dinozorların bir zamanlar gerçekten yaşadıklarını nereden biliyorlar?

A) Bilim insanları sadece tahmin ediyorlar.
B) Bilim insanları dinozorları görmedikleri için bize bu konuda doğru bir bilgi veremezler.
C) Bilim insanları dinozorları görmeseler bile fosillerden yararlanarak bu sonuca ulaşıyorlar.
D) Bu konu hakkında yeterli bilgiye sahip değilim.
E) Hiçbir şık benim görüşüme uymuyor. Bence;

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7. Bilim insanları yaptıkları araştırma ve deneyler yardımıyla sorularına cevap bulmaya çalışırlar. Sizce bilim insanları bunu yaparken hayal güçlerini ve yaratıcılıklarını kullanırlar mı?

A) Hayır kullanmazlar. Bilim insanları araştırmalarında hayal gücüne yer vermez.
B) Hayır kullanmazlar. Bilim insanları gerçekler ve kesin kurallar içerisinde çalışır.
C) Evet kullanırlar. Bilim insanları tamamen hayal güçlerini ve yaratıcılıklarına dayanarak araştırmalarını gerçekleştirirler.
D) Evet kullanırlar. Bilim insanları nasıl çalışacaklarını planlarken ve buldukları verileri yorumlarken hayal güçlerini ve yaratıcılıklarını kullanırlar.
E) Bu konu hakkında yeterli bilgiye sahip değilim.
F) Hiçbir şık benim görüşüme uymuyor. Bence;

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8. Bilim insanı, çalışmalarını yaparken içinde bulunduğu toplumdan ve bu toplumun sosyal ve kültürel yapısından etkilenir mi?

A) Hayır etkilenmez. Çünkü bilim insanı çalışmalarını yaparken yaşadığı ortamla tamamen ilişkisi kesilir.
B) Hayır etkilenmez. Çünkü bilim insanı buluşlarını deneyler ve bazı bilimsel yollar uygulayarak yapar, sosyal hayatı çalışmalarını etkilemez.
C) Evet etkilenir. Bilim insanları da o toplumun bir üyesidir ve herkes gibi o toplumun özelliklerini taşımaktadır; dolayısıyla toplumun sosyal ve kültürel yapısı bilim insanının çalışmalarına da yansıyacaktır.
D) Etkilenip etkilenmeyeceği her bilim insanına göre değişir. Bilim insani toplumun sosyal ve kültürel yapısından etkilenmemek için önlemler alabilir.
E) Bu konu hakkında yeterli bilgiye sahip değilim.
F) Hiçbir şık benim görüşüme uymuyor. Bence;

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9. Sizce bilimsel teori ve kanun arasında bir fark var mıdır?

A) Hayır, fark yoktur; teori ve kanun aslında aynı şeydir.
B) Evet, fark vardır; çünkü, teori çok defa test edilip ispatlandığında kanun adını alır.
C) Evet, fark vardır; çünkü, teori bir şeyin niçin ve nasıl olduğunu açıklar. Kanun ise ne olduğunu açıklar.
D) Evet, fark vardır; çünkü, kanun daha kesin olan bilgidir. Teoriye güvenilmez ama kanuna güvenebilirsin.
E) Bu konu hakkında yeterli bilgiye sahip değilim.
F) Hiçbir şık benim görüşüme uymuyor. Bence;

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10. Sizce bilimsel bilgiye nasıl ulaşılır?

A) Bilimsel bilgiye ulaşmak için bilim adamı olmak gerekir.
B) Bilim insanı onu sonuca götürecek herhangi bir yolu izleyebilir.
C) Bilgiye ulaşmak için belirli ve kesin bir yol olması gerekir.
D) Bilgiye ulaşmak için sırasıyla deney yaparak veri toplamak, sonra hipotez kurmak ve bu hipotezi test etmek gerekir.
E) Bu konu hakkında yeterli bilgiye sahip değilim.
F) Hiçbir şık benim görüşüme uymuyor. Bence;

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11. Sizce meteoroloji uzmanları hava durumunu tahmin etmede ne kadar kesindirler?

A) Meteoroloji uzmanları bize kesin bilgi veremezler; çünkü daima sonucu etkileyecek önceden tahmin edilemeyen olaylar ve hata olasılığı vardır.
B) Meteoroloji uzmanları bize kesin bilgi verirler; çünkü çok gelişmiş araçlarla çalışırlar.
C) Meteoroloji uzmanları bize kesin bilgi verirler; çünkü çok iyi eğitim almışlardır.
D) Bu konu hakkında yeterli bilgiye sahip değilim.
E) Hiçbir şık benim görüşüme uymuyor. Bence;

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APPENDIX B

GÖRÜŞME SORULARI

1. Sizce bilim nedir?

2. Bilimi ya da feni diğer derslerden (din, resim, matematik, Türkçe gibi) ayıran özellikler nelerdir?

3. Bilim insanı bilimsel bilgi üretir. Bu bilgilerin bazıları Fen Bilgisi kitaplarında yer almaktadır. Sizce bu bilgiler gelecekte değişebilir mi? Cevabınızı örnek vererek açıklayabilirsiniz.

4. Bilim insanları dinozorların bir zamanlar yaşadıklarını nereden biliyorlar? Bilim insanları dinozorların dış görünüşleri hakkındaki düşüncelerinden ne kadar emindirler?

5. Bilim insanları dinozorların yaklaşık 65 milyon yıl önce yok oldukları konusunda aynı fikre sahipler. Ancak bu yok oluşa neyin sebep olduğu hakkında farklı görüşleri var. Sizce bilim insanları aynı bilgilere sahip olmalarına rağmen neden farklı düşünmektedirler?

6. Hava durumunu tahmin etmek için meteoroloji uzmanları birçok farklı bilgi toplarlar. Farklı hava durumları için bilgisayar modelleri yaparlar. Meteoroloji uzmanları bu tahmin ettikleri hava durumlarından sizce ne kadar eminler? Neden?

7. Bilim insanları yaptığı araştırmalar ve deneyler yardımıyla sorularına cevap bulmaya çalışırlar. Sizce bilim insanları bunu yaparken hayal güçlerini ve yaratıcılıklarını kullanırlar mı? Neden? Cevabınızı bir örnekle açıklar mısınız?

8. Bilimsel bilgi toplumun sosyal ve kültürel değerlerinden etkilenir mi? Neden?

9. Bilim insanlarınca kullanılan tek bir bilimsel yöntem mi var? Örnek vererek açıklayınız.

10. Sizce bilimsel teori ve kanun arasında bir fark var mıdır? Örnek vererek açıklayınız.