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# Turkish Middle School Students' Views about the Nature of Science

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**ABSTRACT**

*This study aimed to determine and compare 6th, 7th, and 8th graders' nature of science (NOS) views. The sample included total 276 students selected coincidently from 6th, 7th and 8th graders in a city which is quite far from the city centre of Turkey. In order to determine participants' views about the NOS a questionnaire study was done. This questionnaire was taken from the literature and adapted to Turkish by the researcher. By this measurement tool, participants' views about the NOS on five structures which are the aim of science, definition of scientific theories, nature of models, and tentativeness of scientific theories and origin of scientific theories were analyzed. This tool was applied to the sample by the 2012–2013 academic years. The data were analyzed by forming crosswise tables including student's ideas. It was concluded that Turkish middle school students have complete / experimental views about the NOS. However, there is not an expected correlation among 6th, 7th and 8th graders' views about the NOS based on their science teaching experiences in schools.*

**Keywords : Views about science; nature of science; middle school students**

**Introduction**

Teaching the nature of science (NOS) to students is quite important for them to be scientifically literate individuals. It is a common issue that the NOS would be best taught in the content of life science teaching programs. There is not a consensus among science educators, historians and philosophers on a special definition of science. The NOS is mostly referring to the epistemology of scientific knowledge; namely, values and beliefs inherent to the nature of the development of scientific knowledge. Nevertheless, there are some aspects of science which are available for K-12 students to learn. These aspects are accepted by most of the science educators. These are; tentative, experimental, subjective nature of science, partly a product of human inference, imagination and creativity, it is constructed socially and culturally. In addition to these, the other two aspects explain the relationships and functions between an observation and inference and a scientific theories and laws. Teaching NOS to students is beneficial from different points. Those are;

it can help students understand science, scientific products and methods encountered in daily life, it can help them to join discussions about the issues of science and decision making processes, understanding the NOS can help people to value the scientific efforts which are one of the most important product of scientific culture and also learn the norms of scientific society, learning the NOS can facilitate students to learn life science subjects better.

The NOS can be taught to children in their early years (Lederman & O'Malley, 1990). These researchers advocated that in order to prevent older children's' naive images about science, issue about the NOS needs to be solved in early times. Thus, elementary years gain more importance for students. Because they encounter for the first time formal science courses and this is a period in which they gain important knowledge about the world around them. In these years students gain their own epistemologies about science and scientific knowledge. Thus, for students' holding informed views about the NOS should be given much priority among the aims of life science education programs.

However, there are many studies which showed that students had quite naive views about the empirical, tentative, inferential, imaginative and creative nature of science (Akerson, Abd-El Khalick, & Lederman, 2000; Khishfe & Abd-El-Khalick, 2002; Küçük, 2006). Most of the elementary and middle school students have believed that scientific knowledge is a whole and complete and also theories can be proved when enough empirical evidence is accumulated. It is discussed that those students think that scientific knowledge is constructed by a universal scientific method which is progressed step by step. They are also not aware of the fact that creativity and imagination which are the two factors which guide scientific research. International documents such as National Science Education Standards, Benchmarks for Scientific Literacy (AAAS, 2000, 2001) included that 6-8th graders should know empirical, tentative, inferential, imaginative and creative nature of scientific knowledge. In the Turkish literature there are some studies about high school students' nature of science views, however there are a few studies in which elementary and/or middle school students' NOS views are examined.

The literature about middle school students' epistemological development presents an important view points about whether these students have their views about the NOS. Epistemology of science is directly related to the NOS and scientific knowledge. Educational theorists who holds Piaget's cognitive development theory (King & Kitchener, 1994), claims that elementary students are in the concrete operation period. Thus, they do not have a special epistemology however; they can only hold complete and/or pure realism. Those theorists believe that elementary students can not entirely understand the NOS. Nevertheless, other theorists as Montgomery (1992) believes that a student's epistemological views can considerably change and develop in elementary years. In a review work about the development of students' epistemological views done by Montgomery (1992), he found that even preschool students' views about science is something further than simple not connected facts order. This means that even preschool students can know an intellectual world and comprehend ideas come from mental activities.

Most of the studies about students' NOS views focus on middle school students (Carey, Evans, Honda, Jay & Unger, 1989; Songer & Linn, 1991), high school students (Griffiths & Barry, 1993; Moss, Abrams & Robb, 2001; Ryan & Aikenhead, 1992) and college level students (Ryder & Leach, 1999) in the international literature. In a few studies young children's NOS views were examined (Elder, 2002). Turkish literature includes quite a little study about middle school students' NOS views. The important source of students' beliefs about the NOS is experiences of students in learning science and making experiments (Solomon, Scott & Duveen, 1996; Songer & Linn, 1991).

Moving from this assumption, in the current study it is aimed whether Turkish middle school students' NOS views are affected from their science learning experiences by doing a cross-age study working with middle school students aged between 12 and 15. Thus, if obtained data shows that middle school student's epistemological views are insufficient, what can be done to solve this problem will be opened to discussion. This study aimed at illuminating Turkish middle school students' views about the nature of science.

**Study Methods**

**Participants**

For this study, data were collected from 276 students who were studying at 6th, 7th and 8th grades of six middle schools in a city of Turkey. 108 of the participants were female and 168 were male. The average age of the sixth graders is 12,2, seventh graders is 13.4 and eight graders is 14,6. Thus the participants' demographics can be accepted as similar to the general middle school students' population in Turkey.

**Instrument**

In this study in order to determine the participants' NOS views, a questionnaire study was done. This questionnaire was taken from the literature and adapted by the researcher to the Turkish language. The questionnaire includes five multiple-choice questions (Kang, Scharmann & Noh, 2005). In the questionnaire a space was also separated for students to write down why they selected which choice they marked about each questions. The pilot study of this measurement tool was done by 48 middle school students of 6th graders. In this process, it was controlled whether items in the questionnaire were available for them. Thus, it is said to them to draw a line under the sentences or words which they can not understand and/or feel any difficulty to understand. These sentences were revised by two Turkish language experts. In addition, content validity of this questionnaire was checked by interviewing with 18 sixth graders who are accepted as intermediate achievers in science courses.

**Data Collection and Analysis**

The questionnaire was administered to the participants in their classrooms with the guidance of the researcher. All the students were informed about the study purpose and their rights as participants were explained. Students were invited to participate in the study voluntarily. By using five questions in the questionnaire students' views about the NOS in five structures were examined. Those are; the purpose of science, definition of scientific theories, the nature of models, tentativeness of scientific theories and the origin of scientific theories as Kang and his colleagues (2005) followed. The collected data about the five structures was compared qualitatively by using frequencies and % values. In these comparisons the aim was to find out if there is a connection between students' grade levels and their science teaching experiences.

**Results**

The frequency distribution for each item was analyzed to characterize the trends in participant's' perception of science. Results are organized under five headings that are also the titles of subscales.

**The Purpose of Science**

Learners' images of science forms their thoughts about scientific epistemology. Based on this knowledge, studying students' views about science can provide in-depth knowledge about their views about the NOS. For this reason, students' responses to the first question in the questionnaire are presented below in Table 1.

Table 1. Frequency and % values of students' responses to the Question of 1.

| Choice | 6. Grade | 7. Grade | 8. Grade |
|---|---|---|---|
| A | 36 (39,1) | 44 (50,0) | 36(37,5) |
| B | 28 (30,4) | 12 (13,6) | 12 (12,5) |
| C | 28 (30,4) | 24 (27,2) | 48(50,0) |
| D | - | 8 (9,0) | - |
| Total | 92 (100) | 88 (100) | 96 (100) |

Based on studies in the literature (Carey et al., 1989), the B choice "scientists are those who are working on science. To put scientist' work I brief, *it is investigating natural phenomena and explaining the reasons for those phenomena"* is the best correct answer for the studied sample. However in the current study only 30% and even less of them hold this contemporary view. It is amazing that this choice was mostly pointed by six graders who have less science experience. Nevertheless, a few of the students who selected B choice explained why they selected it. Based on these explanations, it can be said that some of them hold instrumentalist and pragmatist views.

37-50% of the students from different grades pointed the choice A "scientists are those who are working on science. To put scientist' work I brief*, it is making new discoveries and adding them to the knowledge of nature"*. This can be interpreted that students perceive science as a vehicle with which knowledge about the world is explored, gathered and expanded. This view of the students explains science as "gathering and exploring new facts" was found in previous studies (Carey et al, 1989; Solomon et al, 1996). Mostly 8th graders accept science *as "inventing things to make this world a better place to live in"* (C). This data can be interpreted as last year of middle school students hold science as it is important whenever it contribute to people's life.

This can be also interpreted as science education experiences in schools let students to hold a pragmatic view in the C choice. This pragmatic view – science is a tool for social purposes-can let them draw a conclusion, which can lead students to believe that most important characteristics of science is doing or inventing pragmatic and useful things. In addition to this, it can be said that a reason why student holds this instrumentalist views is because of the relationship between science and technology. Before the scientific knowledge itself, students first face technological materials, which are reflection of scientific knowledge to life but not the knowledge itself. For this reason, pragmatic dimension of science is the most important epistemology when they teach science.

**Definition of Scientific Theories**

The scientific theories are the most important components of scientific knowledge. It plays an important role in the development of scientific knowledge. In addition, nearly all students have some naïve views about theories as "scientific knowledge is scientific facts or scientific facts are most important then scientific theories". This is a common view among all students. The second question in the questionnaire examined this statement. The obtained data was presented below in Table 2.

Table 2. Frequency and % values of students' responses to the Question of 2.

| Choice | 6. Grade | 7. Grade | 8. Grade |
|---|---|---|---|
| A | 24(26.0) | 24(27.2) | 24(25.0) |
| B | 20(21.7) | 32(36.3) | 32(33.3) |
| C | 48(52.1) | 32(36.3) | 36(37.5) |
| D | - | - | 4(4.1) |
| Total | 92(100) | 88(100) | 96(100) |

Medium of 30% of participant students in the sample hold an epistemological thought that can be accepted as scientifically represented in the B choice as "*theory is an explanation about the reasons for how things happen*". The number of students who have selected this choice increased as parallel to students' science learning experiences. 25-27% of the students selected A choice "*a plausible but not yet completely proven fact*". The preceding studies showed that this view point – theories are assumptions or quality guesses- are common within students and also society (Solomon et al, 1996). For example, Solomon and his colleagues (1996) explained that 46, 5% of English 10th graders hold this view. However, just nearly 25% of the sample consisting of 6th, 7th, and 8th graders in the current study selected this choice. These students had the idea of theories are tentative and un-confirmative ideas and it is an idea which becomes facts when proved by scientists. The number of students who believe that scientific theories are assumptions is less then the number of students when compared to the preceding study results. This means Turkish middle school students in the sample do not load "tentativeness" to theory term like as in Western countries.

**Nature of Models**

Models about the natural events and theoretical constructs are accepted as important tools in science education. However, there is a little knowledge about how much knowledge students at different ages have about models in the literature. In the third question of the questionnaire, sample students' views about models which include important parts of scientific theories were examined. The data is presented below in the Table 3.

Table 3. Frequency and % values of students' responses to the Question of 3.

| Choice | 6. Grade | 7. Grade | 8. Grade |
|---|---|---|---|
| A | 24(26.0) | 20 (22.7) | 12 (12.5) |
| B | 20 (21.7) | 40 (45.4) | 39 (54.1) |
| C | 36 (52.1) | 28 (31.8) | 28 (29.1) |
| D | - | - | 4 (4.1) |
| Total | 92 (100) | 88 (100) | 96 (100) |

From the table 3, 26% of 6th graders, 22% of 7th graders and 12% of 8th graders hold the view explained in A choice "scientists can see the particles under a high performance microscope" which can be accepted as appropriate to naive realistic epistemology. The students who selected this choice are believed they accept scientific models as exact copies of the reality rather than representative constructs which make some theoretical view points concrete. However from 6th to 8th graders, this view point starts to decrease. This can be interpreted as students started to go away from naive realism. 21% of 6th graders, 45% of 7th graders and 54% of 8th graders selected B choice "scientists have proven through many experiments that the matter is made up of particles".

This data shows that when students' science experiences increase, they start to gain more empirical views to science. To those students, even though models are not seen by any one; nevertheless they exist in the nature. This is because, impressions students gained up to now make them think that models are "proved facts". In this context, students who hold this view have naive realist epistemology.

This result is supported by the literature (Grosslight et al., 1991; Solomon et al, 1996). For example, Grosslight and his colleagues (1991) explained that most of the 7th graders (67%) of mixed abilities think models are exact copies of reality. Like this, Solomon and his colleagues (1996) also explained that most of the English 10th graders (60%) and even half of the students at 17–18 years old have this strictly empirical stance. It is interesting that most of the students who have empirical stance about the models in Eastern countries have also a hypothetical stance in the theory question. This inconsistent tendency is believed to come from different meanings given to theory term in society. However, Turkish middle school students in the current study have empirical stance about both scientific theories and models.

**Tentativeness of Scientific Theories**

Theories can change whenever there is new data and scientists analyze natural events according to new/different view points. Tentativeness is the basic character of scientific knowledge. Thus, students' understanding of whether scientific knowledge is tentative is an important sign whether someone has informed views about the NOS. Nevertheless, literature shows that students do not know tentative NOS. This is really an unexpected case for both science teachers and educators. From all levels of students, even teachers and student teachers have naïve/insufficient views about the tentative NOS (Lederman & O'Malley, 1990; Küçük, 2006). The distributions of the responses of the current study samples to the fourth question in the questionnaire are presented below in table 4.

Table 4. Frequency and % values of students' responses to the Question of 4.

| Choice | 6. Grade | 7. Grade | 8. Grade |
|---|---|---|---|
| A | 8 (8.6) | 28 (31.8) | 12 (16.6) |
| B | 32 (34.7) | 12 (13.6) | 28 (29.1) |
| C | 44 (47.8) | 44 (50.0) | 48 (50.0) |
| D | 8 (8.6) | 4 (4.5) | 4 (4.1) |
| Total | 92 (100) | 88 (100) | 96 (100) |

Nearly half of the students from the three grades, examined in the current study have a view about tentativeness of scientific theories as explained in C choice as "a lot of knowledge has been added to old theories. However, new theories are almost the same as old theories in essence". These students are seen quite pleased with their cumulative view point to science. This is maybe why this answer is appropriate to the empirical stance of scientific theories/models are proved facts.

**The Origin of Scientific Theories**

The scientific knowledge is not a result of a basic activity which are used to state facts organized concerning to the outer world. Instead, scientific knowledge is a tool used to talk about constructed objects on relations. Essentially science comes from this relation. There are two cases for philosophy of scientific theories in the fifth question of the questionnaire. These are; ontological view point with a logical view point and an epistemological view consistent with modern thought. In order to explain whether sample students discriminate the relation between two, two sample statements were used. These are; discovery of gold by miners and invention of songs by composers. Responses to these questions presented below in the Table 5.

Table 5. Frequency and % values of students' responses to the Question of 5.

| Choice | 6. Grade | 7. Grade | 8. Grade |
|---|---|---|---|
| A | 44 (47.8) | 24 (27.2) | 64 (66.6) |
| B | 28 (30.4) | 16 (18.1) | 12 (12.5) |
| C | 14 (17.3) | 36 (40.9) | 16 (16.6) |
| D | 4 (4.3) | 12 (13.6) | 4 (4.1) |
| Total | 92 (100) | 88 (100) | 96 (100) |

Nearly half of the sample students and mostly 8th graders (66%) have an ontological view about scientific theories. To these students, theories are mostly there to be found by scientists. Thus, scientists discover theories which already exist as real objects. Theories are equivalent with correct explanations of organized ontological facts beforehand, independent of ones who found it. No students who have selected this choice could explain that theories are constructed ideas/explanations about the natural events.

**Discussion and Conclusion**

There are many studies which showed that students accept science as making something to make human life more quality or invent something (Solomon et al, 1996). On the other hand, student at the early ages remember science outside of technology (Solomon, Duween & Scott, 1994). However inclinations of the current study samples' responses are a bit different form this case.

Solomon and his colleagues (1996) explained that only 8% of English 10th graders have instrumentalist view, and also showed that this percentage decrease if you go into higher levels. In a comparison, for the current study sample, this view is hold by 50.7% of 8. graders, 27% of 7. graders and 30% of 6th graders. Most of the 6th graders (52%) and a medium of 36% of the other students selected C choice represented as "inventing things to make this world a better place to live in". Contrary to the students in Western countries, Turkish middle school students explained theories as correct or very near to correct. This statement can be analyzed as Turkish middle school students are inclined to hold a complete view to scientific knowledge. Hodson (1988) expressed that students who teach science without understanding the NOS, inevitably gain empirical views to scientific theories. In this context, science teaching programs in Turkey need much revision to make students gain the NOS.

29-52 % of the sample students selected C choice about the question of models as "scientist can explain the reasons for many phenomena by thinking of matter as being made up of particles". It is clear that ratio of students who hold modern epistemological view decrease according to students' learning levels (52-31-29%). However, Kang and his colleagues (2005) explained opposite of this result. It is concluded that Turkish middle school students in the sample are inclined to select B choice "scientists have proven through many experiments that the matter is made up of particles" which represent naive realist view rather than selecting C choice which represent modern view when their experiences increase about science subjects and models. In this context, student as a result of experiences they gained from experiments done in science courses, tend to hold strict empirical stance. That is to say, scientists' proving something via experiments when they expose something is perceived as necessary. It is important in this result that science teachers mostly saying "come on, let's prove out learning by one experiment". These kinds of approaches are known as deduction-based laboratory approach. This approach is really much more hold by Turkish science teachers. In addition to this, there is also one another possibility that Turkish science teachers hold an empirical stance about scientific models. Thus, this problem should be addressed.

34% of the 6th graders, 13% of the 7th graders and 29% of the 8th graders selected B choice "old theories have been proven wrong by the development of technology and the growth of knowledge" about the question of the origin of theories. Duveen and his colleagues (1993) "better equipment/technology was the most common rationale for students explaining the change in science. This case explained their study was not held by Turkish students examined in the current study.

Naive realist, determinist and/or positivist nature of scientific knowledge is the most hold views points in the previous studies (Stein & McRobbie, 1997). In the last question about the origin of scientific theories, mostly 6th graders selected B choice "scientists invent scientific theories. Scientific theories did not exist in the world and come from the imagination of scientists. Thus, scientists invent scientific theories" which is appropriate to scientific epistemology. This ratio decrease in the advanced learning levels. It can be analyzed that science teaching experiences in the studied case is ineffective to teach student the NOS.

It is claimed that teaching students the NOS via teaching programs based on investigation and research is difficult. Thus, it can be suggested that NOS teaching should be taken as a cognitive learning goal within science teaching programs and it should be taught to all of the students by using an explicit-reflective approach as advocated by researchers (Abd-El Khalick, Bell, & Lederman, 1998; Akerson, Abd-El Khalick, & Lederman, 2000; Khishfe & Abd-El-Khalick, 2002).

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