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# UNDERSTANDINGS OF ADVANCED STUDENTS ON NATURE OF SCIENCE AND THEIR MOTIVATIONAL STATUS TO LEARN NATURE OF SCIENCE: A TURKISH CASE

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**Abstract.** *In this study, the purpose is to describe advanced students' motivational status to learn Nature of Science (NOS) and their understandings on NOS by using Ranking Questionnaire for "interest" and "importance" and modified version of Views on Nature of Science Questionnaire. The results indicated that the participants did not see NOS as an important subject compared to mathematics, science and social science subjects. Moreover, the participants were more interested in mathematics and science subjects than in NOS subject. The results on NOS understandings also showed that the participants were transitional in terms of "evidence and observation based science" and "subjectivity" while they had informed understandings on "place of imagination and creativity in science". They were also naïve in terms of "existence of one method in science", "no hierarchy between theory and law", "tentativeness" and "difference between observation and inference". The results explained an important motivational problem to implement any NOS teaching methods to change misunderstandings.*

**Key words:** *advanced high school students, motivation, nature of science, school subjects.*

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## Introduction

It is certain that people and their lives are affected by innovations which are the products of science. The number of innovations (gene technology, nanotechnology, stem cell cure) is so high that we are continually being introduced to new jobs, technologies and medicines as products of the innovations. In parallel, new learning areas and skills needed in life also emerged to operate life in line with these innovations. Based on these needs, new educational programs were prepared to teach about the required content knowledge and skills regarding science and scientific innovations (Project 2061, 2007; Turkish Ninth Grade Biology Curriculum, 2007). In science teaching literature, content knowledge and skills needed to be understood and used. Scientific innovations and scientific knowledge have been defined in daily life under the title of "scientific literacy" (Demastes & Wandersee, 1992; Uno & Bybee, 1994).

Scientific literacy includes understanding and using scientific knowledge to make informed decisions in life (Bybee, 1997). Acquiring skills as to be scientifically literate in modern society has been advocated by educational reformers (Dillon, 2009; Uno & Bybee, 1994) and has been emphasized in science curricula and reform papers (Project 2061, 2007; Turkish Ninth Grade Biology Curriculum, 2007). Palinscar, Anderson and David (1993) defined abilities of a scientifically literate person as applying scientific knowledge or concepts in principled ways in different situations and using the language of science for interpretation, production and evaluation of spoken and written texts. Hurd (1998, p. 413-414) specified other characteristics of the scientifically literate person as the ability to know about the requirement for a synthesis of knowledge from different fields including natural and social sciences in problem solving. By this ability, he/she can understand that synthesis is a requirement for dealing with science-social and personal–civic problems and also that synthesis is required for knowing about the existence of dimensions in political, judicial, ethical, and sometimes moral interpretations when science is considered in *social context* during problem solving. Hence, as emphasized by Hurd (1998), scientifically literate people should have the ability to use science knowledge when it is appropriate in making informed life and social decisions, forming judgments, resolving problems, and taking action. These characteristics have importance in daily life, since knowing about structure of science and its products and using this knowledge to solve problems and to make decisions give advantages to find a job, to evaluate alternatives based on information, to decide about the quality of scientific claims, to manage more effectively technological tools and to make informed decisions on social-scientific issues.

The two fundamental components of scientific literacy are learning *content knowledge* and learning about *aspects of nature of science (NOS)* in general (Damastes & Wandersee, 1992; Uno & Bybee, 1994). NOS refers to the epistemology and sociology of science, science as a way of knowing, and the values and beliefs inherent to scientific knowledge and its development (Lederman, 1992, p. 331). The aspects of NOS are described as follows (Lederman, Abd-El-Khalick, Bell, & Schwartz, 2002; McComas, 1998):

a) Scientific knowledge is tentative (Tentativeness)
b) Science is a way of knowing (Definition of science)
c) Scientific knowledge is based on evidence and observation (Evidence and observation based science)
d) Scientific knowledge is embedded in social and cultural context (Role of social and cultural factors in science)
e) Observation and inference do not have the same meaning (Difference between observation and inference)
f) The scientist is not objective when he or she begins to study; he or she has a background (Subjectivity)
g) Creativeness and imagination are also important to produce scientific knowledge (Place of creativity and imagination in science)
h) There is no hierarchy between theory and law and they have different roles (No hierarchy between theory and law)
i) There is no universally accepted one way to do science (Ways of doing science).

Understanding NOS aspects is a basic requirement to "help students improve their general understanding of science" (National Research Council, 1996, p. 200). Without holding adequate and informed understandings of NOS, teachers and students tend to believe unrealistic ideas that "science is 'done' and is a list of facts to memorize" instead of using scientific knowledge for life (Akerson, Morrison & McDuffie, 2006).

Quality of learning and teaching NOS aspects as a knowledge type presented in schools, similar to learning of other knowledge types presented in schools, depends on certain measurable affective and cognitive factors. Frequently considered measurable factors in cognitive domain include reasoning ability, information processing level, academic achievement and understandings (Lawson, 2006; Lawson, Banks & Logvin, 2007; McComas, 2003; Schunk, 2000; Tunc Sahin and Koksal, 2010;Yumuşak, Sungur, & Çakıroğlu, 2007). Especially understandings of NOS are a current and frequently studied factor (Khishfe, 2012; Köksal, Cakıroglu & Geban, 2013). The most frequently measured affective factors include attitude, self-efficacy, anxiety and motivation (Baldwin, Ebert-May, & Burns, 1999; Ekici, 2005; Glynn & Koballa, 2006; Mallow, 2006; Osborne, Simon, & Collins, 2003; Savran & Çakıroğlu, 2001, Yumuşak, Sungur, & Çakıroğlu, 2007). Among the affective factors, motivation was determined as effective in action for learning science by some researchers (Osborne, Simon, & Collins, 2003). Based on the importance of motivation to learn and NOS understandings, this study purposed to examine the motivational status of Turkish advanced students to learn NOS knowledge as a school subject and their NOS understandings.

Currently, Pintrich and Schunk (2002) defined motivation as the process which instigates and sustains a goal directed activity in learning. Motivational factors are also effective in learning NOS simi-

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larly to other learning processes, so motivational status of students in learning NOS is thought to be a starting point to increase scientific literacy (Tunc Sahin and Koksal, 2010). There are different models for explaining motivation in education and psychology literature (Keller, 1999; Ryan & Deci, 2000; Wigfield & Eccles, 2000). But, motivation for learning, understanding and using scientific knowledge for daily life purposes, requires a more dynamic explanatory model, considering the active knowledge construction process of individuals. Based on the importance of scientific literacy components, making informed decisions and life-long individual learning, it should be said, that motivational situations of students to learn NOS should be taken into account by considering their active and idiosyncratic construction of knowledge on NOS, when studying motivational aspect of misunderstandings regarding NOS. Among the most emphasized models, expectancy-value model has merits to explain motivation in learning NOS, since the model accepts the individual as an active, constructive and rational decision maker (Pintrich & Schunk, 2002). The model has a strong potential for explaining the motivational status of individuals who have been acquiring, using and constructing knowledge about science for their daily lives (Pintrich & Schunk, 2002). The model has two components: expectancies and values. Based on these components the model explains that individuals' choice, persistence and performance in learning situations can be explained by their beliefs in doing a task well and giving value to a task. In other words, the model asserts that expectancies and values are main motivational factors that are directly effective on performance, effort, achievement choices and persistence (Wigfield & Eccles, 2000). In the literature, it was shown that task value component of the model was positively correlated with other variables, including intrinsic motivation, extrinsic motivation, control of learning beliefs, self-efficacy and cognitive factors (Bong, 2001; Douglas, 2006, Pintrich, 1999; Pintrich & De Groot, 1990, Yumuşak, Sungur, & Çakıroğlu, 2007). The relationship between task value and, affective and cognitive factors make task value a powerful predictor of the motivational status of individuals on a learning task regarding science. The task value like overall model of expectancy-value has also sub-components. Wigfield and Eccles (2000) pointed out that the most studied subcomponents of the task value were importance, interest (intrinsic value) and utility. The researchers defined "importance" component as "the importance of doing well of a given task" (p.72), "interest" component as "the enjoyment one gets from doing a given task" (p.72), and "utility" component as "a degree of how a given task fits into an individual's future plans" (p.72). Among the sub-components of task value, importance and interest factors are more associated with intrinsic processes in explaining choices, persistence and performance during a learning task while utility factor is more associated with external benefit of learning. Intrinsic factors are composed of complex, comprehensive and unobservable constructs; therefore, they have the potential to explain learning choices, persistence and performance in learning more than pragmatist surface ideas such as useful or not useful for the aim. Therefore, importance and interest components of the motivation have a strong potential to predict educationally important outcomes that might be associated with the construction of misunderstandings in learning NOS aspects.

The NOS aspects are not understood well enough by the advanced science students, ordinary students, even scientists, teachers and prospective teachers, they present misunderstandings on NOS aspects (Blanco & Niaz, 1997; Dagher & Boujaoude, 2005; Irez, 2006; Koksal & Sormunen, 2009; Ryan & Aikenhead, 1992; Sandoval & Morrison, 2003; Sormunen & Koksal, 2011; Tsai, 2006). The reasons of their misunderstandings were studied and the researchers showed textbooks, teachers and the media were the resources of frequently determined misunderstandings in literature (McComas, 2003; Irez, 2008). But, motivational preparedness (degree of interest and importance values in NOS learning at the beginning of teaching on NOS) of students or their perception regarding NOS knowledge as a school subject was not considered as a resource. Hence, there is a need to consider students as active learners, doing research on their motivational status. Learning NOS might contribute to understanding possible resources of NOS misunderstandings.

High school science lessons are important for learning about NOS aspects, because they are composed of subjects referring to NOS aspects and students meet scientific disciplines with their separate titles (Biology, Chemistry etc.) for the first time in high school years. But high school lessons do not include only teaching NOS, they also include teaching of other knowledge types such as health, physics, chemistry, biology and social sciences. Sometimes, NOS teaching might be a limited part of a teaching of another type of knowledge (biology, chemistry, physics) in a certain time interval. Relative place of learning NOS knowledge and other knowledge types in terms of motivational perceptions of students in high school years might be an effective factor on tendency to do an activity or choosing activities (choice), giving more time on one type than the other (persistence) and reading more on some types of knowledge (performance) than the others. Therefore, the motivational status of high school students to learn NOS knowledge might be an important explanatory resource for NOS misunderstandings, the status might also explain the place of NOS knowledge among science or social science content knowledge.

In high schools, students differ in terms of their achievement and ability. Some of them present ordinary achievement and ability while the others represent advanced success and ability in science or social sciences. The advanced students can be defined as individuals who are good at content knowledge in science and social sciences, and have higher motivation and more positive attitudes toward learning science or social science subjects, and need to improve their learning in their own field of study (Koksal & Sormunen, 2009; Koksal & Sormunen, 2011). Advanced students are important for studying on misunderstandings regarding NOS aspects. Since advanced students are more active in terms of learning tasks and more aware of the importance of getting knowledge about any discipline, they also represent different behaviors more than ordinary students when they are learning science. Park and Oliver (2009) studied on in-class behaviors of advanced students, they pointed out that in science classes they frequently represented behaviors including "being impatient with the pace of other students" (p.339), "having perfectionist traits" (p.339), "asking challenging questions" (p.339), "disliking routine and busy work" (p.339), "being critical of others" (p.339) and "being aware of being different" (p.339). By taking into account their advanced features, they should be investigated separately from the other groups of students in high schools; since their experiences in the knowledge gain process are more effective than of ordinary students and they experience more individual learning opportunity on school-related subjects.

In addition to their individual advanced features, advanced students are also members of our society which should make informed decisions on daily life subjects, socio-political issues, democracy and science. For advanced students, knowing about science and its aspects (knowing about NOS) is as important as knowing about science or social science content for being scientifically literate (Damastes & Wandersee, 1992; Uno & Bybee, 1994). In other words, advanced students need to make their knowledge meaningful and systematic by combining their content knowledge and knowledge about nature of science during their decision making processes. As a starting point, their initial understandings on the NOS aspects and motivational status to learn the NOS aspects should be determined to teach NOS aspects to them effectively.

By considering importance and interest as the effective motivational factors on the components of task value, this study purposed to examine the motivational status of advanced students regarding importance and interest about NOS knowledge among the other types of knowledge as school subjects. In addition, NOS understandings of advanced students are also purposed to determine.

## Methodology of Research

### *General Background of Research*

In this study, descriptive cross-sectional research method was preferred to determine the perceptions and the understandings of the participants. One hundred eighty six ninth grade advanced students enrolled in one science (n=99, female=44, male=55) and one social sciences (n=87, female=48, male=39) high schools participated in the study. Ninety two female and 94 male students were included in the study. The majority of them (n=175) had not taken any course or seminar on the nature of science and had not participated in any program regarding NOS. In Turkish educational system, social sciences and science high schools were established for advanced students and these schools are located at only centers of provinces in the whole country. Science and Social Sciences high schools allocate more time and dense content for science courses than ordinary high schools; 6 lessons per week for the ninth grade, 12 lessons per week for the tenth, eleventh and twelfth grades. Ordinary schools allocate 6 lessons per week for the ninth and tenth grades, 9 lessons per week for the eleventh and twelfth grades. The teachers and students are selected to the schools via applying selection rules determined by the Ministry of Education. For the students, selection process includes taking high nation-wide examination score and having high background Grade Point Average (GPA). In the sample of this study, the participants were among top scorers (5% of all test takers) in nation-wide examination including multiple choice items.

*Instrument, Procedures and Data Analysis*

To collect data on advanced students' NOS understandings and their motivational status to learn NOS as a school subject, two different instruments were utilized. The first one was a ranking questionnaire developed by the researchers. The questionnaire included 17 knowledge type names as knowledges given in the schools. For example, math knowledge, science knowledge, history knowledge and nature of science knowledge were put into the questionnaire as knowledge type names. In the questionnaire, the students were asked to rank the knowledge types by scoring "17" for the most important and interesting and 1 for the least important and interesting. They could give the same ranking to two or more different types of knowledge. The instrument was administrered to the students by the researchers. The analysis of the answers to the questionnaire was done by counting frequencies of the participants giving a number (1-17) for a subject. In other words, researchers counted the participants scoring each number from 1 to 17 for a knowledge type. In the analysis, 9 was accepted as transitional point due to its location at the mid-point, then frequencies regarding to lower and higher points were calculated as negative and positive perception evidence.

The second instrument was a modified version of views of nature of science (VNOS) questionnaire including 11 open-ended questions. The modified VNOS instrument was applied to randomly selected participants (N=46 (SHS=25, SSHS=21) from the sample of this study. The answers to the VNOS instrument were analyzed by using profiling sheets structured by considering the literature (McComas, 1998; Lederman et al., 2002; Abd-El-Khalick, 1998). The profiling (E=expert, N=Naïve, T=Transitional, NA=Not Applicable) was made by two different researchers who have four-year experience on nature of science studies. The inter-coder agreement was calculated and found as 75%. After discussion on the disagreements, the final profiling was done with consensus.

## Results of Research

The findings of this study will be introduced by two different sections; "NOS understandings", "Importance perception" and "Interest perception". In the first section the answers to the VNOS questions are presented as profiles of the participants in table 1 and table 2.

**Table 1. Nature of science understandings of the advanced students in SHS**

| Misunderstandings on NOS Aspects | Participant Codes (SHS) | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Pt1 | Pt2 | Pt3 | Pt4 | Pt5 | Pt6 | Pt7 | Pt8 | Pt9 | Pt10 | Pt11 | Pt12 | Pt13 |
| Use of only one method myth in science | N | T | N | N | N | T | T | E | N | N | N | N | N |
| Hierarchy between theory and law | N | N | N | NA | NA | N | N | N | NA | NA | N | N | N |
| Sameness between observation and inference | T | E | E | N | T | N | N | N | N | N | N | NA | N |
| Objectivity | E | E | NA | T | T | N | E | NA | N | N | E | T | T |
| No place for imagination and creativity in science | T | E | N | T | N | T | T | E | E | E | N | E | N |

| Misunderstandings on NOS Aspects | Participant Codes (SHS) | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Pt1 | Pt2 | Pt3 | Pt4 | Pt5 | Pt6 | Pt7 | Pt8 | Pt9 | Pt10 | Pt11 | Pt12 | Pt13 |
| Absolute and fixed scientific knowledge | N | N | N | N | N | E | E | N | N | N | E | E | N |
| No emphasis for observation and evidence in science | N | E | NA | E | T | NA | T | NA | T | N | E | N | N |

| Misunderstandings on NOS Aspects | Participant Codes (SHS) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Pt14 | Pt15 | Pt16 | Pt17 | Pt18 | Pt19 | Pt20 | Pt21 | Pt22 | Pt23 | Pt24 | Pt25 |
| Use of only one method myth in science | N | N | T | N | T | T | N | T | T | N | NA | T |
| Hierarchy between theory and law | NA | N | N | NA | N | NA | NA | N | N | N | N | N |
| Sameness between observation and inference | N | T | N | NA | N | N | N | E | N | N | N | N |
| Objectivity | T | E | E | T | T | E | N | T | NA | E | E | T |
| No place for imagination and creativity in science | T | T | T | E | E | E | T | E | E | E | E | E |
| Absolute and fixed scientific knowledge | N | N | N | N | N | N | E | N | N | E | N | N |
| No emphasis for observation and evidence in science | N | T | E | T | E | N | E | N | E | E | N | N |

Table 1 shows misunderstandings of the advanced science students on "*use of only one method in science*", "*hierarchy between laws and theories*", "*difference between observation and inference*" and "*existence of absolute and fixed scientific knowledge*". In the table, it is also seen that nearly half of the participants in SHS have expert understandings on "*no place for imagination and creativity in science*". For the remained aspects; "*objectivity*" and "*no emphasis for observation and evidence in science*", the participants represent different understandings including expert, naïve and transitional without showing a tendency. The naïve understandings of the participants in science high schools can be represented in the following quotations;

> *"Experiments are the processes of finding something by experiencing. In development of scientific knowledge, experiments are a requirement so we must evaluate scientific knowledge based on experiment results" (Existence of one method in science, Science High School, Female, VNOS-C Questionnaire, Question 2)*

> *"Theories result from existent experimental results, laws are advanced form of theories" (Hierarchy between theories and laws, Science High School, Male, VNOS-C Questionnaire, Question 5)*

> *"Difference between observation and inference is ignorable so they are similar" (Difference between observation and inference, Science High School, Male, VNOS-C Questionnaire, Question 8)*

> *"Theories can change but laws are fixed, for example atom theory of Dalton changed but gravitation law of Newton did not change, there is no way to change laws" (Tentativeness, Science High School, Male, VNOS-C Questionnaire, Question 4)*

For the aspects of place of creativity and imagination in science, one of the female participants rep-

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resented an example of an expert view by writing that "*scientists use their creativity and imagination, e.g., in planning stage of scientific research, everything we have now, includes creativity and imagination*" (*Place of imagination and creativity in science*, *Science High School, Female, VNOS-C Questionnaire, Question 11).*

**Table 2. Nature of science understandings of the advanced students in SSHS**

| Misunderstandings on NOS Aspects | Participant Codes (SSHS) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Pt1 | Pt2 | Pt3 | Pt4 | Pt5 | Pt6 | Pt7 | Pt8 | Pt9 | Pt10 | Pt11 |
| Use of only one method myth in science | N | N | NA | N | NA | T | N | N | NA | N | NA |
| Hierarchy between theory and law | N | N | N | N | N | N | NA | N | N | N | NA |
| Sameness between observation and inference | N | N | N | N | N | N | NA | N | N | N | NA |
| Objectivity | T | T | E | T | E | T | NA | N | T | T | E |
| No place for imagination and creativity in science | E | T | NA | E | E | E | E | E | E | NA | E |
| Absolute and fixed scientific knowledge | N | E | E | N | N | N | E | N | N | N | E |
| No emphasis for observation and evidence in science | N | N | N | E | E | E | N | E | E | N | E |

| Misunderstandings on NOS Aspects | Participant Codes (SSHS) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Pt12 | Pt13 | Pt14 | Pt15 | Pt16 | Pt17 | Pt18 | Pt19 | Pt20 | Pt21 |
| Use of only one method myth in science | NA | T | N | N | E | N | N | N | N | N |
| Hierarchy between theory and law | N | NA | N | N | N | N | N | N | N | N |
| Sameness between observation and inference | NA | N | N | N | NA | N | N | N | N | N |
| Objectivity | E | NA | N | T | T | T | T | E | T | T |
| No place for imagination and creativity in science | NA | NA | E | E | E | E | E | E | E | E |
| Absolute and fixed scientific knowledge | N | N | N | N | N | N | E | N | N | N |
| No emphasis for observation and evidence in science | N | NA | E | N | T | N | N | T | N | N |

According to table 2, the majority of the participants in SSHS are experts on "*no place for imagination and creativity in science*" aspect while the majority of them are naïve in terms of "*use of only one method in science*", "*hierarchy between laws and theories*", "*difference between observation and inference*" and "*existence of absolute and fixed scientific knowledge*". They also represented expert, naïve and transitional understandings on "*no emphasis for observation and evidence in science*". The participants are transitional in terms of "*objectivity*" aspect in general. The naïve understandings of the participants in social sciences high schools are represented in the following quotations;

> *"For doing science, there is a universal way: determining problem, establishing hypotheses, making experiments and observations, establishing theories and laws" (Existence of one method in science, Social Sciences High School, Female, VNOS-C Questionnaire, Question 3)*

> *"If a scientific theory is accepted by everybody, it becomes a law" (Hierarchy between theories and laws, Social Sciences High School, Male, VNOS-C Questionnaire, Question 5)*

*"There is no difference between observation and inference" (Difference between observation and inference, Social Sciences High School, Female, VNOS-C Questionnaire, Question 8)*

*"Theories might be refuted by anti-theses but laws are fixed and absolute" (Tentativeness, Social Sciences High School, Female, VNOS-C Questionnaire, Question 5)*

In addition to these misunderstandings, one of the participants in social sciences high school represented an expert view that "*scientists use creativity and imagination in all stages of a scientific research*" (*Place of imagination and creativity in science*, *Social Sciences High School, Male, VNOS-C Questionnaire, Question 11)*.

In the second section we present the findings concerning the perception of the participants regarding the importance of NOS knowledge as a school subject. The findings are presented in table 3.

**Table 3. Frequencies regarding the perceptions of the advanced students on nature of science as a school subject in terms of "importance".**

| Subjects | Missing | Categories | | |
|---|---|---|---|---|
| | | 1,2,3,4,5,6,7,8 | 9 | 10,11,12,13,14,15,16,17 |
| | | Negative Perception Frequency | Transitional Perception Frequency | Positive Perception Frequency |
| Language and Expression | 3 | 48(SSHS=7, SHS=41) | 7 | 128 (SSHS=75, SHS=53) |
| Turkish Language | 5 | 46(SSHS=11, SHS=35) | 4 | 131 (SSHS=71, SHS=60) |
| Religion Knowledge | 8 | 63**(SSHS=31, SHS=32) | 4 | 111 (SSHS=48, SHS=63) |
| History | 3 | 29(SSHS=8, SHS=21) | 7 | 147(SSHS=75, SHS=72) |
| Mathematics | 4 | 11 (SSHS=8, SHS=3) | 1 | 170 (SSHS=74, SHS=96) |
| Nature of Science | 15 | 66**(SSHS=46, SHS=20) | 8 | 97(SSHS=32, SHS=65) |
| Geography | 3 | 33 (SSHS=11, SHS=22) | 11 | 139(SSHS=69, SHS=70) |
| Geometry | 3 | 8 (SSHS=7, SHS=1) | 8 | 167(SSHS=73, SHS=94) |
| Physics | 3 | 27(SSHS=22, SHS=5) | 5 | 151(SSHS=66, SHS=85) |
| Chemistry | 2 | 45(SSHS=33, SHS=12) | 8 | 131(SSHS=37, SHS=94) |
| Biology | 6 | 26(SSHS=21, SHS=5) | 9 | 145(SSHS=56, SHS=89) |
| Health Knowledge | 7 | 74**(SSHS=34, SHS=40) | 10 | 95(SSHS=43, SHS=52) |
| Foreign Language | 7 | 15(SSHS=10, SHS=5) | 1 | 163(SSHS=74, SHS=89) |
| Second Foreign Language | 9 | 56(SSHS=21, SHS=35) | 5 | 116(SSHS=60, SHS=56) |
| Physical Education | 3 | 83**(SSHS=49, SHS=34) | 8 | 92(SSHS=35, SHS=57) |
| Visiual Arts | 5 | 137**(SSHS=67, SHS=70) | 3 | 41(SSHS=20, SHS=21) |
| Music | 4 | 131**(SSHS=63, SHS=68) | 7 | 44(SSHS=18, SHS=26) |

*Note: SSHS: Social Sciences High School, SHS: Science High School*

The findings on the perceptions regarding "importance" of NOS knowledge show insufficiency in giving importance to NOS knowledge as a learning subject in high schools of advanced students. When looked at the positive perception frequency, it is seen that importance of NOS knowledge is 13$^{th}$ important knowledge type for learning in school. Hence, importance of NOS knowledge is not perceived as high as of the knowledge regarding social science and science subjects. Moreover, school types (social sciences high school vs. science high school) also contribute to the difference in importance percep-

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tion among advanced students. Social science high school students have less positive perceptions on importance of NOS knowledge (frequency of negatives=46, frequency of positives=32) than science high school students (frequency of negatives =20, frequency of positives=65).

In the second part of the second section, we present the findings on "interest" perception of the participants in relation to NOS knowledge as a school subject. The findings are presented in table 4.

**Table 4. Frequencies regarding the perceptions of the advanced students on nature of science as a school subject in terms of "interest".**

| Subjects | Missing | Categories: 1,2,3,4,5,6,7,8 — Negative Perception Frequency | 9 — Transitional Perception Frequency | 10,11,12,13,14,15,16,17 — Positive Perception Frequency |
|---|---|---|---|---|
| Language and Expression | 1 | 78 (SSHS=37, SHS=41) | 6 | 101 (SSHS=48, SHS=53) |
| Turkish Language | 2 | 64 (SSHS=29, SHS=35) | 5 | 115 (SSHS=55, SHS=60) |
| Religion Knowledge | 1 | 82**(SSHS=50, SHS=32) | 4 | 99 (SSHS=37, SHS=62) |
| History | 2 | 39 (SSHS=18, SHS=21) | 12 | 133 (SSHS=61, SHS=72) |
| Mathematics | 2 | 21(SSHS=18 , SHS=3) | 1 | 162 (SSHS=66, SHS=96) |
| Nature of Science | 14 | 82** (SSHS=62, SHS=20) | 7 | 83 (SSHS=18, SHS=65) |
| Geography | 2 | 46 (SSHS=24, SHS=22) | 9 | 129 (SSHS=59, SHS=70) |
| Geometry | 3 | 24 (SSHS=19, SHS=5) | 5 | 154 (SSHS=60, SHS=94) |
| Physics | 4 | 50 (SSHS=45, SHS=5) | 7 | 125 (SSHS=31, SHS=94) |
| Chemistry | 5 | 56 (SSHS=44, SHS=12) | 10 | 115 (SSHS=31, SHS=84) |
| Biology | 5 | 31 (SSHS=26, SHS=5) | 10 | 140 (SSHS=51, SHS=89) |
| Health Knowledge | 7 | 89** (SSHS=49, SHS=40) | 9 | 81 (SSHS=29, SHS=52) |
| Foreign Language | 5 | 28 (SSHS=23, SHS=5) | 10 | 143 (SSHS=54, SHS=89) |
| Second Foreign Language | 5 | 74(SSHS=29, SHS=35) | 6 | 101 (SSHS=45, SHS=56) |
| Physical Education | 3 | 76 (SSHS=42, SHS=34) | 2 | 105 (SSHS=48, SHS=57) |
| Visual Arts | 3 | 120** (SSHS=50, SHS=70) | 3 | 60 (SSHS=36, SHS=24) |
| Music | 3 | 116** (SSHS=48, SHS=68) | 5 | 62 (SSHS=40, SHS=22) |

*Note: SSHS: Social Sciences High School, SHS: Science High School*

The findings on "interest" factor of motivation indicate existence of insufficient number of the participants who find NOS knowledge interesting to learn at school. Frequencies of negative interest perceptions show that NOS knowledge is seen as 14$^{th}$ interesting subject to learn in high school. Positive interest perception frequencies also represent the same order of NOS knowledge among other types of knowledge taught in schools for advanced students. Moreover, the findings based on school type difference show that advanced students in social sciences high schools see NOS knowledge less interesting than social sciences and science knowledge by expressing more negative perception on interest aspect of motivation in learning NOS knowledge (frequency of negatives=62, frequency of positives=18). However, science high school students have more positive interest perceptions regarding NOS knowledge than social science students in spite of insufficient number of the participants accepting NOS knowledge as interesting as social sciences and science subject knowledge (frequency of negatives= 20, frequency of positives=65).

**Discussion**

The findings of this study have shown misunderstandings of the advanced students in both SHS and SSHS on different NOS aspects; "*use of only one method in science*", "*hierarchy between laws and theories*", "*difference between observation and inference*" and "*existence of absolute and fixed scientific knowledge*". Although the participants in the groups have misunderstandings on four aspects of NOS, they are experts on "*no place for imagination and creativity in science*" aspect and have transitional understandings on "*objectivity*" aspect. Similar misunderstandings have also been represented by previous studies (Koksal & Sormunen, 2009; Koksal & Sormunen, 2011). Koksal and Sormunen (2011) by studying with 39 Finnish advanced science students have found that VNOS-C answers of the participants are naive in terms of "*tentativeness*". In the literature, there is a conflicting study; in this study Liu and Lederman (2002) focused on NOS understandings of 29 Taiwanese advanced students in junior high school level. As a result of this study, the authors reported that the majority of students have basic understanding on tentative and empirical NOS. This finding is not in line with the result of this study, but as reported by the authors the study has internal validity threat. Hence it can be said, that advanced science students represented misunderstandings on various NOS aspects in spite of their advanced content knowledge and high achievement. These findings are contradictory with the findings of Schwartz and Lederman (2002). They showed that the students having more comprehensive science background knowledge were better able to learn and to apply NOS knowledge into science content than the students with weak science background. The confliction with the findings of this study might be caused by sample and cultural difference because Schwartz and Lederman (2002) studied with beginning secondary science teachers in USA context.

Resources of NOS misunderstandings are explained as teachers, textbooks and the media (Abd-El-Khalick, Waters and Lee, 2008; Irez, 2008; McComas, 2003; Tsai, 2006), but teaching to overcome misunderstandings requires having appropriate affective preparedness of students for changing their conceptions regarding NOS aspects (Duit and Treagust 1998; Lee and Brophy 1996, Pintrich et al. 1993). Motivational status is a dominant affective characteristics to initiate and follow a performance due to the fact that motivation is correlated to various cognitive and affective variables (Koksal & Tasdelen, 2007; Osborne, Simon, & Collins, 2003). Especially, task value component of motivation is associated with the use of effective learning strategies, self-efficacy, intrinsic and extrinsic motivation (Bong, 2001; Douglas, 2006; Koksal &Tasdelen, 2009; Yumuşak, Sungur, & Çakıroğlu, 2007). But the results of the present study showed insufficiencies in having appropriate levels of "importance" and "interest" perceptions as components of task value on NOS knowledge. The participants do not see NOS knowledge as important as social science and science subject knowledge while they also do not find NOS knowledge as interesting as social science and science subject knowledge. Bong (2001) indicated that "value of the task" is directly related to learn a type of knowledge correctly by effecting enrollment and performance. As previously stated, having insufficient "importance" and "interest" perception is a disadvantage to learn NOS aspects and might contribute to the formation of misunderstandings on NOS aspects. By giving more value to science and social science subject knowledge, the participants might read more about science and social science subjects than those for NOS knowledge. The difference in reading actions rooted from the difference in task value perceptions might be a reason for acceptance science and social science knowledge more believable than NOS knowledge by advanced students. Moreover, reading more about these knowledge types is problematic because of insufficiencies in textbooks and resources. Abd-El-Khalick, Waters and Lee (2008) studied on chemistry textbooks by focusing on representation of NOS aspects; they found that the textbooks represented NOS aspects poorly. Similarly, Irez (2008) analyzed five most frequently used biology textbooks in Turkey and the author found that the textbooks represented various NOS aspects inappropriately; even some of them did not include important aspects of NOS. In addition to reading more about science and social science subject knowledge, having less level of task value for NOS learning, might also cause to follow more media representation (periodicals, news, movies etc.), regarding science and social science subject knowledge than NOS knowledge. This situation can be speculated, that motivational insufficiencies (giving low value to learn NOS aspects) of the participants might be another contributor of misunderstandings on NOS aspects. Because this insufficiency might

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drive the students to give more time and more value for reading textbooks or other written materials in which NOS is implicitly and inappropriately explained and misunderstandings are in case.

For another finding of this study, it can be said that the advanced science students enrolled in science high schools, have more appropriate "interest" and "importance" perception on NOS knowledge than the advanced students in social sciences high schools, although they do not have high "interest" and "importance" perceptions as for social sciences and science subject knowledge. This finding might be related to the meaning of "science" word in "nature of science" because "science" word calls "natural sciences" in Turkish. Dikmenli (2010) showed that Turkish students see "natural sciences" as scientific while they ignore social sciences as scientific disciplines. Therefore, science high school students might feel more relation with science than the students in social sciences high school.

**Conclusions**

In conclusion, insufficiency in NOS understandings of the advanced students was observed in this study. They are also less motivated (giving less value to learning task) to learn about NOS knowledge than social sciences or science knowledge. Being less motivated to learn about NOS might be another potential resource of the misunderstandings about NOS aspects, due to the fact that giving more value to science and social science subjects and being more interested in science and social science subjects drive learning actions and attentions to these subjects. NOS subject is abstract and needs more time to learn about it than concrete learning subjects such as science and social sciences. In addition, insufficiency of appropriate value given to NOS knowledge should be seen as an important obstacle to implement explicit-reflective NOS teaching in advanced classrooms. As another point, in spite of insufficient value given by science high school students for NOS knowledge, more improved motivational status of science high school students for the value of learning NOS knowledge than of the students in social sciences high school is seen as another significant point showing group differences in teaching NOS in advanced classrooms.

The findings of this study might provide information about beginning motivational status of two different groups of advanced students to instructors for making NOS instruction more comprehensive and effective, and to overcome misunderstandings. Moreover, the need of studying motivational components in explicit-reflective NOS teaching is also shown by the findings of this study. At the same time, the findings on misunderstandings of NOS aspects and motivational status of advanced students who have not frequently studied together might contribute to the literature by speculating possible resource of misunderstandings. As another important implication of this study is the status of NOS knowledge, among other types of knowledge presented in advanced schools is also shown by this study.

The findings of the study give meaningful results on NOS understandings and values given by advanced students on NOS knowledge, but the study has some limitations. The study is limited to 186 advanced students enrolled in two different schools for advanced students (Science High School, Social Sciences High School). At the same time, nature of data collection tools for certain NOS aspects is based on existent NOS frames provided by McComas (1998), Lederman et al. (2002); Abd-El-Khalick (1998), other aspects of science might also have arisen if we had used more open-ended procedure of data collection. When looked at the data collection way on task value components, it is seen that data is collected at ordinal level; this limits us to use inferential statistical methods for investigating task value perceptions of the participants in detail.

Based on these limitations, it can be suggested that open-ended data collection way focusing on examples from social sciences and science contents should be applied to more number of advanced students for determining other important aspects of nature of science. At the same time, follow-up likert type scale application to reach more comparable motivational status of the participants in different schools might be done. Then, inferential statistical methods can also be applied to the data set on motivational status. As a final suggestion, motivational strategies such as goal setting and monitoring should also be incorporated into explicit-reflective NOS teaching and the modified instruction should be tested for effectiveness in changing NOS misunderstandings.

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