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Views of Nature of Scientific Inquiry of Students in Different High Schools

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Abstract

The purpose of this qualitative study was to explore different high school students' views of Nature of Scientific Inquiry (NOSI). Eleventh grade students in Science High School (SHS, 69 students), Teacher High School (THS, 99 students), and Anatolian High School (AHS, 99 students) were participated in the study. Views about Scientific Inquiry (VASI) questionnaire was applied at their classroom and some of them were interviewed just after filling out the questionnaire. Analysis of the data was done by establishing a profile for each student by assigning naïve, mixed, and informed codes for each NOSI aspect. Then, frequency of each code was determined and tabulated. Two researchers' coding agreement of the questionnaires was 85%. The results of the study revealed that SHS students demonstrated more informed views than other two high schools on three NOSI aspects which were 'scientific investigations all begin with a question and do not necessarily test a hypothesis', 'there is no single set of steps followed in all investigations', and 'inquiry procedures are guided by the question asked'. SHS students and THS students were close to each other and had more informed views than AHS students in two NOSI aspect of 'data are not the same as evidence' and 'explanations are derived from data and what is already known' aspects. On the other hand, AHS students provided less informed view on two aspects ('same procedures may not get the same results' and 'procedures influence results'), but had also least naïve views on both aspects which means that they have more merit to develop these aspects. The NOSI aspect of 'conclusions must be consistent with data' was the aspect that most of high school students in each school had informed views. SHS had the more science courses than

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THS and AHS. Based on the results of this study, it seems that more science courses and more previous science experience help developing more informed NOSI views, but it should be researched more before making a clear conclusion.

Introduction

Scientific inquiry was stated to be the main way of teaching science in Turkey at middle school science curriculum (Ministry of National Education [MoNE], 2014). It is also emphasized in high school physics and chemistry curricula as one of the aims. For example, in the chemistry curriculum, it is stated as '*students collect data by doing experiments, infer, interpret, and conclude from these data*' (MoNE, 2017a, p. 18). Similarly, it is emphasized as '*students produce knowledge by applying scientific process skills, solve problems, and share knowledge*' (MoNE, 2017b, p.17) in physics curriculum. On the other hand, in biology curriculum, it is not emphasized in the aims of the curriculum. Furthermore, in the learning outcomes of first unit of 9th grade is the introduction of biology science and one of learning outcomes in this chapter states that '*students apply steps of the scientific method for solving a problem in biology*' (MoNE, 2017c, p. 21) which sounds as teaching of traditional one method of science. Although biology curriculum contradicts with physics and chemistry curricula, such improvements in science teaching was valuable, since inquiry as a science teaching method was found to have positive impacts of some level of inquiry science instruction on student content learning and retention in the majority of the studies (Minner, Levy, & Century, 2010). Some of the schools would have difficulty in applying inquiry in science teaching, but if they can apply inquiry, it is being mostly applied for teaching science concepts. In this way, the students learn science concepts through inquiry and they also learn how to do inquiry. There are other aspects of scientific inquiry that would be easily pointed out through their inquiry process and these aspects help them to form a more comprehensive understanding of scientific inquiry. These aspects define the distinctive properties of scientific inquiry and are called Nature of Scientific Inquiry (NOSI). In other words, scientific inquiry is about doing inquiry, but nature of scientific inquiry (NOSI) refers to understanding about inquiry (Lederman et al., 2014). The NOSI aspects suitable for teaching K-12 grades are listed by Lederman et al. (2014) as;

1. Scientific investigations all begin with a question and do not necessarily test a hypothesis,
2. There is no single set of steps followed in all investigations (no single scientific method),
3. Inquiry procedures are guided by the question asked,
4. All scientists performing the same procedures may not get the same results,
5. Inquiry procedures can influence results,
6. Research conclusions must be consistent with the data collected,
7. Scientific data are not the same as scientific evidence,
8. Explanations are developed from a combination of collected data and what is already known.

As you can see, these NOSI aspects define some of the principles and hidden properties of scientific inquiry and knowing them would help students apply inquiry more consciously and be aware of what they are doing. Nature of Science (NOS) aspects are included in all high school science curricula (MoNE, 2017a, 2017b, 2017c) since NOS is being searched in Turkey in recent years. Since NOSI aspects are somewhat newer than NOS, NOSI aspects are not included in the biology and chemistry curriculum, but there was an aim in physics curriculum stating that '*students understand the nature of scientific inquiry*' (MoNE, 2017b, p.17). An important point is that there are research evidence that the students having science education through inquiry programs do not develop these NOSI aspects (Lederman et al., 2014; Metz, 2004) or Nature of Science (NOS) aspects which are very similar to NOSI aspects, but related to the nature of scientific knowledge (Khishfe & Abd-El Khalick, 2002; Meichtry, 1993). Similar findings were reported by other researchers. For example, Aydeniz, Baksa, and Skinner (2011) enrolled high school students in scientific laboratories and analyzed the change in their views about NOS and scientific inquiry. They found out that students learned the process of inquiry, but did not learn hidden aspects of scientific inquiry. They also suggested making these aspects explicit. Bell, Blair, Crawford, and Lederman (2003) followed a small sample of high school students' understanding about scientific inquiry who were enrolled in an eight-week apprenticeship program. In such programs, students work in science laboratories with real scientists on their scientific work. Their results revealed that students understood the process of inquiry, but not that of formulating questions since they worked on already started and ongoing research. But their understanding of some aspects related to NOSI aspects such as scientists use varied methods, scientists test ideas, scientists use current knowledge, and investigations may lead to more questions was less than their understanding of process of scientific inquiry. They also suggested explicit teaching of NOSI aspects. From these research results, we should learn that teaching only the process of inquiry to teach science concepts will not develop a comprehensive understanding of NOSI aspects. Without these understandings, they would not learn science and scientific inquiry to a degree to form scientific literate individuals. Because one should differentiate science from non-science, a scientific inquiry from a pseudo-inquiry that sometimes shown on advertisements. Such understandings would be sustained through teaching NOS and NOSI aspects explicitly throughout science curricula at each level. For this reason, it is important to know what students' know about NOSI aspects and start from there to develop their NOSI views. This research study was designed to determine what their ideas are about NOSI aspects and inform science teachers and policy makers. Thus, the purpose of the study was to explore different high school students' understandings of NOSI and compare them to find out similarities and differences among schools.

Literature search was resulted with a few VASI studies in different countries. Two studies were summer camps for developing middle school students' NOSI views (Leblebicioglu et al., 2017, 2019) and application of creative drama (Sarısan-Tungac, Yaman, & Bal-Incebacak, 2018). All three intervention studies reported positive development in the students' NOSI views from naïve views at the begining to more informed views at the end of the intervention. Senler (2015) study applied VOSI-E questionnaire which was one of previous NOSI questionnaires to compare Turkish and American middle school students in their views of scientific inquiry. VOSI-E (Lederman & Ko, 2003) included four NOSI aspects which are 'all investigations begin with a question', 'there is no single scientific method', 'scientists collect empirical data to answer their questions', and 'data and prior knowledge are used to answer questions'. She reported that there was a significant difference between Turkish and American students' NOSI views. American students demonstrated more contemporary views on the aspects of all investigations begin with a question, scientists collect empirical data to answer their questions, and data and prior knowledge are used to answer questions, while the Turkish sample demonstrated more contemporary views on the aspect of there is no single scientific method.

An international study (Lederman et al., 2017) reported that middle school students in different countries demonstrated naïve views. A similar study in Brazil produced similar results (Bologna Soares de Andrade & Levoratob, 2017). Yang, Park, Shin, and Lim's (2017) study produced better results. Middle school students in their study demonstrated more informed views about NOSI aspects of 'all scientists performing the same procedures may not get the same results', 'inquiry procedures are guided by the question asked', and 'research conclusions must be consistent with the data collected'. On the other hand, they had naïve views about other NOSI aspects such as 'there is no single set of steps followed in all investigations', 'explanations are developed from a combination of collected data and what is already known', and 'scientific data are not the same as scientific evidence'. Another study in South Africa (Gaigher, Lederman, & Lederman, 2014) reported very positive results. The students revealed mixed or informed views on all NOSI aspects except the aspect of 'there is no single set of steps followed in all investigations'.

As it was evidenced in previous studies, students learning science would not understand the nature of scientific inquiry. This study was conducted in order to determine the situation in our country. Detailed information about the purpose and method of the research is given below.

Purpose of the Study

The purpose of this qualitative study is to explore the students' NOSI views in different high schools. Results of the study would also inform teachers and administrators. Thus, it is also expected to give guidance to the researchers in the field of nature of scientific inquiry in Turkey.

Method

The study is a qualitative exploration of the similarities and differences in students' NOSI views in three different high schools. The high schools were a Science High School (SCH), a Teacher High School (THS), and an Anatolian High School (AHS) in a suburban city in the region of Western Black Sea in Turkey. This study is a qualitative study which does not aim at generalizing its results and schools were not chosen to form a sample. The study was applied in all high schools in the city center in 2016. Eleventh grade students in each high school participated in the study. The reason for choosing 11th graders was that being more adapted to high school grades than 9th and 10th graders and not having stress of university placement exam as much as 12th graders.

Open-ended questionnaires were applied in classrooms in each school. When the questionnaires were completed, the students were asked if they want to make an interview on the questionnaire. The volunteered students were interviewed in a quiet place like library. The data were analyzed by qualitative techniques and results were interpreted. More detailed information about the process was presented in the following subsections.

Participants

Most of the students in all of the 11th grade classes participated in the study. Number of participants in each school is presented in Table 1.

Table 1. Number of Participants

Schools	Total	Girls	Boys
SHS	69	40	29
THS	99	62	37
ATS	99	59	40

In SHS, the questionnaires were applied in three classes and all classes were on science track. In THS, the questionnaires were applied in three classes on science track and one class on Turkish-mathematics track. In ATS, the questionnaires were applied in two classes on science track and two classes on Turkish-mathematics track. General information about the school types is the following.

SHSs have only science track and have a concentrated science course teaching of chemistry, physics, biology, and mathematics. The students in these schools have six hours of mathematics at every grade from 9th to 12th grade. Other science courses (physics, chemistry, and biology) are two hours per week at 9th and 10th grades, four hours per week at 11th and 12th grades. At least 60% of their course schedule at each grade should be consisted of science courses. The students are projected to science, engineering, and health professions in the universities. They have also have to provide an individual or group science project in one of the science courses every term.

THSs were converted to Social Science high schools, but the students participated in this study were the last students in 2016 and continuing through their THS program. THS students have general education including science courses at 9th grade. At the 10th grade, the students choose different tracks such as science and Turkish-mathematics tracks. Students in science tracks continue to take all of the science courses; three hours of physics, chemistry, biology, and four hours of mathematics. But, the students in Turkish-mathematics track only take mathematics course, no other science courses.

AHSs are the schools which have more tracks such as science, Turkish-mathematics, literacy, and language education. The students have six hours of mathematics, two hours of physic and chemistry, and three hours of biology at 9th and 10th grades. They choose one of four tracks at 11th grade which were science, Turkish-mathematics, literacy, and language education. Their courses will differ at each track. Science track continues to have all science courses which are six hours of mathematics, four hours of physics and chemistry, and three hours of biology. On the other hand, the students in Turkish-mathematics track only take mathematics course, no other science courses. We applied questionnaires in Science and Turkish-mathematics tracks, because there were only eight students in the language track.

Instrument

Views about Scientific Inquiry (VASI) questionnaire (Lederman et al., 2014) was applied in the study. The reason for using this questionnaire was being the only instrument at the moment to assess students' views of scientific inquiry. It was a newer version of Views of Scientific Inquiry (VOSI) questionnaire (Schwartz, Lederman, & Lederman, 2008). VASI consisted of seven open-ended questions which aimed at emerging students' ideas about eight aspects of NOSI presented in introduction section. The questions were asking the description of science, whether a given investigation is an experiment or not, if investigations start with a question, which of two experiments would answer a question, etc. It was translated to Turkish and validated by a team (Han Tosunoglu & Yalaki, 2017). It was applied in all classes of the high schools by the first and second researcher. Participation was voluntary, but most of the existent students accepted to fill out the questionnaire. Volunteer students were also interviewed just after filling out the questionnaire by again first and second researcher at a quiet place in the schools such as conference room and library. They were asked to clarify unclear issues in the questionnaires or provide examples for their responses. The purpose of the interview was to enrich data and understand their reasoning better. They were less volunteer to do the interviews and only ten students in SHS, twelve students in THS, ten students in AHS were interviewed.

Data Analysis

Analysis of VASI questionnaires were done as holistic analysis of a student's responses to all questions and deciding the category of the student's understanding as unclear, naïve, mixed, and informed. Instructions of coding VASI was explained in Lederman et al. (2014) and it was used in assigning students' responses into these categories. Informed responses are the ideas that were aligned with NOSI literature and consistent throughout the questionnaire. Mixed responses are the ideas aligned with NOSI literature, but are not consistent throughout the questionnaire. There may be novice responses in some of the questions. Novice responses are the responses that are not aligned with NOSI literature or not reasonable responses and consistent throughout the questionnaire. A profile for each student was investigated at the end of coding. Then codes from all students were summarized in a table and interpreted.

Data analysis was completed in a short time (two weeks) by the first and second researcher to increase the reliability of the qualitative codes. In order to sustain validity of coding process, randomly-selected five questionnaires from each school were independently coded by the first and second researcher. Since, they both have previous experience in coding VASI, it was thought that they could reach a coding agreement easily. If not, they had planned to code more questionnaires together. Coding agreement was 85% (same codes/total codes x 100) and found acceptable. First and second researcher coded the data school by school. They shared questionnaires and coded the data independently, but they met regularly in a few days to compare their codes and discuss the situations that they could not decide. Interview data were used to clarify unclear issues in the questionnaires.

In the comparisons, the schools were considered as a whole which means that the data was not separated into subcategories according to tracks, because the participants were at 11th grades and separation into different tracks at 10th or 11th grade. Before these grades, their courses were the same in each school.

Results and Interpretation

The percentage of all types of high school students having informed, transitional, and naïve views of the eight aspects of NOSI were given in Table 2 and the schools were compared on each NOSI aspect in separate sections for each NOSI aspect. Student names are pseudonyms.

Table 2. Percentages of Students Categorized as Holding Naïve, Transitional, and Informed Views across Eight NOSI Aspects

%of students	Begins with a question			Multiple methods			Same pro. may not get the same conclusions			Procedures influence results		
	SHS	THS	AHS	SHS	THS	AHS	SHS	THS	AHS	SHS	THS	AHS
No response	1	5	4	13	24	14	6	3	5	17	8	15
Naïve	1	7	7	12	14	21	48	35	32	30	26	14
Transitional	68	79	82	41	52	58	14	18	33	22	38	48
Informed	29	9	7	35	10	7	32	44	29	30	28	22
N	69	99	99	69	99	99	69	99	99	69	99	99
%of students	Procedures are guided by the ques. asked			Data are not the same as evidence			Explanations are dev. from data and what is al. known			Conclusions consistent with data collected		
	SHS	THS	AHS	SHS	THS	AHS	SHS	THS	AHS	SHS	THS	AHS
No response	1	1	10	4	3	6	3	3	10	3	1	6
Naïve	29	46	47	4	7	12	0	7	14	16	15	21
Transitional	10	17	25	68	73	74	38	28	42	4	2	2
Informed	59	36	17	23	17	8	59	62	33	77	82	71
N	69	99	99	69	99	99	69	99	99	69	99	99

Scientific Investigations All Begin with a Question and Do Not Necessarily Test a Hypothesis

The students did not have a naïve understanding like all scientific investigations should start with a hypothesis and designed to test a hypothesis in all three high schools. Some of the students stated that they were taught a sequence of scientific investigation which is observation, hypothesis, experiment to test the hypothesis, evaluation of the hypothesis, change the hypothesis if it was not proved and start all over again, if it was proven it becomes a theory. Although they were taught hypothesis testing, none of them stated that scientific investigations start with a hypothesis. Even though they wrote about hypothesis testing sequence in the first question, they accepted that all scientific investigations start with a question in the following question. Naïve conception (1% in SCH, 7% in THS, and 7% in AHS) in this study was different from this conception. One of the students from SHS stating that;

I agree with the students saying no, because the important thing in a scientific inquiry is the applying logical method. There is nothing related to question. (Onur-SHS).

Onur considers method as the most important part of a scientific inquiry. He does not even consider a question as a part of inquiry. That's why his idea was categorized as naïve. On the other hand, most of the students (68% of SHS, 79% of THS, and 82% of AHS students) in all types of high schools accepted that all scientific investigations start with a scientific question, which coded for transitional category. SHS students demonstrated less transitional views, but more informed views than other two high schools in this aspect. There were also some differences in SHS students' responses. In SHS, most of the students explained their reasoning in short such as '*question is required to decide what to search for*', but they could not give an example. Some of these students in this category indicated contradictory views in different questions regarding this NOSI aspect. For example, Enes was a student showing both. He accepted bird observation as *'scientific, because it has a hypothesis and s/he does inquiry toward this hypothesis'* in question 1a. This is clearly a naïve conception. But, in the second question he agrees that '*yes, (all scientific investigation starts with a question), because if you do not ask a question, you cannot know what to search for*'. He does not give an example. This was a clear informed conception exampled in Lederman et al. (2014). The same student swings between two opposite conceptions in two questions. This would be interpretation from a western point of view. But, the reality is that this student does not contradict the two views; rather he combines both of them as asking a research question at first and developing hypothesis next as it is evident in additional question at the front page of VASI. He defines science as '*inquiry which is done to answer a scientific question*' and explains how scientific inquiry is done as '*by proving a hypothesis for a question or changing the hypothesis if it is not proven*'. He clearly states that scientific investigations begin with a question, but at the same time he also states that there would be a hypothesis for the question under investigation. Such a mixed conception was the most common conception in SHS students and categorized as transitional. Such conception rarely emerged in other high school students' responses.

Another idea emerged in all high school students' responses was that not all scientific investigations start with a question, because it would also start with observation, curiosity, or by chance. Meral is one of them and explained her reasoning as follows;

> *No, it does not have to. Because, a scientific investigation would start as a result of long observation. You form a hypothesis for this event. If your idea (she means hypothesis) is wrong, you may change it. For example: Color of butter changes in summer and winter. This example is not a question, a knowledge reached by observation. (Meral-SHS).*

Meral disagrees with the idea that all scientific investigations start with a question, but did not either demonstrate a naïve conception of all scientific investigations start with a hypothesis. She had hypothesis idea but not as an initial step, as a following step after observing an event. She was taught a sequence of scientific inquiry starting with an observation, then hypothesizing. On the other hand, she did not indicate a hypothesis after observing butter; she stated that they reached this knowledge about the color of butter by observation. Such students did not have naïve conception that all scientific investigations start with hypothesis, but they did not also have a clearly informed conception of there would be a question to search for. Hypothesis testing is reliable in some fields, but not even applicable in some other fields and thus could not be a necessity in all scientific investigations.

Gurol is one of the students claimed that curiosity triggered the scientific investigations rather than scientific investigations start with a scientific question, as follows;

> *Yes, but that question was asked from curiosity rather than scientific because science has risen from curiosity and necessity at the beginning. For instance, if Newton did not be curious about the apple falling dawn on his head, the gravity would have been found too late, thus other scientific studies would have disrupted indirectly. (Gurol-AHS).*

Gurol did not oppose to asking questions in scientific investigations. He thought that scientific investigations could start with a question, but this question was asked from sense of curiosity. He implied that curiosity is the starter of a scientific investigation instead of a scientific question, as he stated the falling down the apple on Newton's head. Therefore, his thoughts were not accepted as a naïve conception. Some of the students accepted that scientific investigations generally starts with a question like Gurol, but not always; it would done based on curiosity or observed non-purposefully. They did not agree the words 'always' and 'scientific question' in the question.

There were also other interesting views among transitional views in this NOSI aspect. Some of the students in transitional category accepted that scientific investigations start with a question, but the question would not be scientific; it would be from daily life, personal, simple, or ordinary questions, etc. They did not consider simple daily life questions as scientific.

No (scientific investigations do not start with a scientific question), because a problem in daily life would cause a scientific inquiry. For example, how waste disposal on Earth would be prevented? By providing energy from waste... (Selin-SHS).

Selin is trying to explain that waste disposal which is a problem in daily life would affect scientists for asking a question about how it would be prevented and result in a solution such as providing energy from waste so that waste does not stay on Earth. She does not accept this question as scientific, because it is about daily life. She might have been conceptualized that scientific questions should be questions studied in a laboratory.

Burcu exampled such students' thinking that scientific investigations would start with non-scientific questions including our personal ideas;

No (scientific investigations do not start with a scientific question), because it would start with questions which included our personal ideas. (Burcu-SHS). (She did not provide an example).

She might have been irritated by the word '*scientific*', and thought that questions which include personal ideas are non-scientific and scientific investigation would also start with non-scientific questions. She did not give an example. But, there were other students who stated this point more clearly. For example, Gulsun stated that;

'I agree with the student saying no (all scientific investigations do not start with a scientific question), because it is not necessary to ask a scientific question to start a scientific investigation. For instance, someone's questioning about why the pencil is hard is not a scientific question. This person could determine that his/her pencil is hard, because of the less distance between the atoms by making observations and experiments. He/she could explain why this pencil is hard scientifically, but his/her question is not scientific at the beginning. (Gulsun-THS).

Gulsun did not consider simple questions as scientific, but thinks that scientific investigations would start with such simple questions and get more complicated and scientific afterwards.

On the other hand, there were a small number of THS students (9%) and AHS students (7%) having informed view about this aspect whereas 29% of SHS students had informed views. SHS students provided more detailed explanation regarding the role of question in a scientific investigation and considered as informed as in the case of the following quotes:

Yes. One can search nothing without knowing what s/he is questioning. Determination of problem/question/subject of an inquiry both shows the researcher his/her aim and narrow downs the framework of the research. (Gamze-SHS).

An example for informed views fromTHS students is given below;

I agree with the student saying yes, because a scientific investigation should start with a scientific question. It is followed a way, made experiments, and gathered data by that question. For instance, in order to conclude whether pine trees are more in this city or not, it is asked the question: Are there more pine trees in this city? (Derin-THS).

There is No Single Set of Steps Followed in All Investigations

There were some naïve views (12% of the SHS, 14% of the THS, and 21% of the AHS) about this NOSI aspect in all type of schools' students. The students generally expressed the notion that only one method should be implemented and a sequence of scientific inquiry should be followed in inquiry process in this category. Although the students of SHS were taught a sequence of scientific inquiry in their school curriculum, only 12% of students developed the idea of it is the only method of doing science (naïve conception). One exemplary quote is the following:

1a. Yes, (bird investigation is scientific). Because, s/he first observed. Then s/he formed the hypothesis. This shows that s/he follows steps of the scientific inquiry.

1b. Yes, (it is an experiment). Because, s/he did observation and inquiry which are required for experiment.

1c. No. (Scientific investigations cannot follow more than one method). There is only one method in scientific investigations. Because, this method is established step by step and gives the right result. (Murat-SHS).

Murat saw steps of scientific inquiry in bird investigation which was based on observation and there was a hypothesis (indeed there is no hypothesis stated in the question). He accepts it as scientific, because it follows its steps. He also clearly stated that he found these steps of scientific inquiry as the only reliable method of science, because it serves well for finding the truth. But, even this student accepts that all scientific investigations start with a question. He does not contradict hypothesis with question.

Some students showed better performance on distinguishing observation and experiment in the question of 1b. However, they did not reflect this discrimination to the question of 1c which asked whether multiple methods could be used or not in a scientific investigation. Thus, the students had this view stated the only one method should be used in scientific investigations presented different justifications. In THS, Yavuz answered;

1b. I think, the researcher did observation rather than making experiment because existent event was examined, there were not experimental groups, and they did not implement any test.

1c. No (scientific investigations cannot follow more than one method). The steps necessary for a research to be scientific is not flexible. (Yavuz-THS).

Yavuz differentiated observation and experiment clearly in question 1b, but he did not state observation and experiment as a scientific method in question 1c. He implies that scientific investigations should follow a sequence of scientific research, thus he accepts these steps as an only scientific method in scientific investigations.

Some of the students in naïve category claimed that scientific investigations should follow only one method of scientific inquiry in order to decrease subjectivity, reach accurate results, and prove something.

On the other hand, almost half of the students (41% of SHS, 52% of THS, and 58% of AHS) held transitional views of this aspect of NOSI in every type of schools. The students did not develop the idea that the sequence that they were taught is the only method of scientific investigation and found bird observation investigation in the question as scientific. When it is directly asked if there would be more than one method of a scientific investigation, most of them answered yes and differed in their explanations. The students in transitional category made general explanations such as it would be better to work with more than one method and they generally propose research from documents and experiment and/or observation as methods of scientific investigation. Meral is one of these students. She accepts bird investigation as scientific, because there is a process started with a problem and then concluded based on observation. She also considers bird investigation as an experiment, because laboratory is not necessary for experiments. One cannot take living things to a closed place (she means laboratory) with their environment. The researcher could reach a right conclusion if s/he investigates a living organism within its habitat. She also accepts that scientific investigations would follow more than one method. She explains her reason as;

> *Time and conditions change. That's why you can only search historical events on documents. That's why, you skip experiment/observation step (in the sequence of steps of a scientific investigation). But, a chemical reaction can be replicated everywhere in suitable conditions by experiment/observation. Both are scientific. (Meral-SHS).*

She cannot differentiate observation and experiment; she accepts them as parts of the same method and uses them hand in hand like experiment/observation. She also calls them as steps, because they were taught a sequence of scientific inquiry and experiment and observation are steps there. She also accepts documentary research as another method of research and thus she thinks that there would be more than one method of scientific investigations.

Most of other students provided transitional views like Meral. They cannot separate observation and experiment and they accept multiple methods of science without thinking there would be observation or experiment depending on field of study. They rather propose other types of methods that would be used in other areas of science such as documentary search in history, knowledge search from different sources like books, questionnaires, interviews, statistics, and social experiments, etc.

There were some interesting views in transitional category in which some students stated that they accepted multiple methods in order to reach the accurate results, ensure the reliability, confirm the results, and being skeptical. One of them is given below;

> *In scientific investigations, the process is going to conclusion step by step. The reliability of the investigation could not be possible with only one method. The truest results could be reached by multiple steps and methods. (Selen-AHS).*

On the other hand, SHS students (35%) held more informed views than other two schools (10% of THS and 7% of AHS) with respect to the multiple methods. Informed students clearly stated that there would be more than one method such as observation and experiment and explained their reasoning well. In SHS, Ilayda found bird research in the question as scientific and clearly stated that it is an observation. She also clearly stated that scientific investigations can follow more than one method and explained that;

> *Investigation of species and reaching a conclusion is an observation. It is scientific, because they reach a scientific conclusion based on the results of observation.*
>
> *Formation of water and salt in acid-base reactions would be investigated by experiments. It is scientific because again they reach a scientific conclusion based on the results of experiments. (Ilayda-SHS).*

Another student, Emel considered bird investigation in the question as scientific and did not consider it as an experiment, because there was not any trial, any measurement, and any apparatus. She then proposed the variety of subjects in science for having multiple methods. She explained in detail that;

> *Some subjects are suitable for experimenting (light, formation of compounds, etc.) whereas some other subjects are not suitable for experimenting (history, etc.). There were also social experiments, but the same conditions cannot be sustained again. In these subjects that cannot be experimented, the scientists collect data, do inquiry, and use first hand resources. (Emel-SHS).*

All Scientists Performing the Same Procedures may not Get the Same Results

The most related question for this aspect was directly asking if two scientists asking the same question and performing the same procedure would get the same results. It was interesting that the students in SHS demonstrated highest percentage of naïve responses in this aspect among all eight NOSI aspects. Almost half of them (48%) stated that they would get the same results because they do the same things (naïve). At the same time, approximately one third of students in other schools (35% of THS and 32% of AHS) had naïve understanding about this aspect of NOSI. There were different types of responses under this category. Some of the students demonstrated positivist and objective science view in their responses such as Eylem:

> *To me, they should get the same results. Because, scientific knowledge should be the knowledge that is accepted by everyone. To me, the knowledge that was interpreted or affected by personal views cannot be scientific knowledge. (Eylem-SHS).*

Eylem was very strict in her objective science view. All of her statements were about the scientific knowledge, not the procedure. Some others concentrated on the procedure, but thought that if there is no difference in the procedure, there should not be difference in the results. Ela was one of such students:

> *Yes, (they should get the same results). Because, if there is no difference in the scientific steps procedure, there should not be difference (in the results). At the last, this inquiry does not lead by feelings. (Ela-SHS).*

Some naïve views of the students showed that human error could play an important role in inquiry procedure. A student from AHS stated that;

> *No, (it is not necessary to get the same results). Because they could make an error in this process, thus the results might be different. But they also could not make an error. (Selen-AHS).*

Selen focused on the scientists' error in scientific investigations. According to her, if there was not any error in the process, the scientists reach the same results.

In transitional category of this NOSI aspect, there were 14% of the SHS students, 18% of the THS students, and 33% of the AHS students. These students accepted that they would get different results, but could not explain their thinking clearly (transitional). For example, Ata made a general explanation, nothing related to the procedure or the question and Buket's explanation was short and like a repetition of the statements in the question:

> *Yes, they would get the same results, but this is very difficult. Because, science is very large. (Ata-SHS).*

> *No (they would not get the same results). Because they would get different results from the same procedure. (Buket-SHS).*

On the other side, some students stated that the scientists would get different results because of making variations in the research, but these students did not report the reasons for these differences. One of the quotations from THS was given below:

> *No (they would not get the same results), because everybody has a different research manner (Yasin- THS).*

The students well explained the reasons behind the different results were categorized as informed. These students thought that the scientists would get different results because they interpret the data differently, or they think in different ways, etc. Interestingly, there were more informed students in THS (44%) than SHS (32%). There was the lowest percentage of informed students in AHS (29%). Some of the examples from the informed views were like that;

> *No (they would not get the same results), it might change according to the environment in which the scientist lives and the sources s/he used. (Hasan-THS).*

No (they would not get the same results), because everybody thinks differently. In other words, every person does not think the same thing about a subject and everybody's thinking style is different. One of the important characteristic of the society is that there is a unique thinking style in every person. (Sanem-AHS).

No (they would not get the same results). The same question or the same procedure does not mean the same results. Even if the procedure is the same, there is researcher factor. Researcher's different thinking style, how s/he was raised, and his /her living style affect the results. (Muge-SHS).

Inquiry Procedures can Influence Results

The question which is mostly related to this aspect was a question with a similar wording as the question for previous aspect which asking directly if two scientists asking the same question and performing different procedures would get the same results.

Most unrelated or unclear responses existed in this question (17% of SHS, 8% of THS, and 15% of AHS). Two examples were the followings:

No, But they also can (reach the same results). In short, there is a probability of both here. (Ata-SHS).

No (they would not get the same results). It depends on the results that scientists get from these procedures. (Buket-SHS).

The students with naïve views were 30% in SHS, 26% in THS, and 14% in AHS. They stated that the scientists would get the same results, because the question was the same. Eylem was a good example for this aspect:

To me, they should reach the same answers. Because, there is only one right answer for a scientific question. If they reach more than one right answer, there should be inadequacies in the inquiry or there would be dark points that cannot be explained completely. (Eylem-SHS).

Some students stated that scientific truths do not change from person to person as Suzan:

Yes, they could reach the same results because there are unchanging truths, and everybody gives the same answer. (Suzan-THS).

In transitional category, the students stated that scientists would get different results, but they did not refer to the inquiry process, or mentioned superficially. More AHS students (48%) held transitional views about this NOSI aspect than other two high schools (22% of SHS and 38% of THS).

No, it is not necessary that they would get the same results. Different procedures might cause different results. (Kevser-AHS).

No, it is not necessary that they would get the same results, but it might be said that the scientists make more comprehensive investigations could get close to the true results than other scientists. (Metin-THS).

There were also some students in transitional category indicating that the scientists could reach the same or different results when they follow different methodologies. However they did not elaborate their reasoning. Ela was one of these students:

They could reach the same or different results. Because the same question could deliver to the different results with different procedure. Even though there are different procedures, why could they reach the same results? (Ela-AHS).

On the other hand, the percentages of informed students were close to each other in three high schools (30% of SHS, 28% of THS, and 22% of AHS). These students were on the opposite site with informed conception and stated that they would get different results, because they were applying different procedures. Some exemplary quotations are given below:

There would not be the same results. Because, they would observe different things by following different procedures. (Edesa-SHS).

There would not be the same results. They could get in a common point, but they could also follow different ways. I think it depends on the people's characteristics. A person who is patient and rigorous would reveal more interesting things. (Buse-THS).

The scientist investigated the problem X with experiments and the other scientist investigated the same problem with observations could get different results. Because the second one observed its natural form in its natural environment while the first one manipulated it. (Gulin-AHS).

Inquiry Procedures are Guided by the Question Asked

The most related question for this aspect was asking which of two experiments was better for a given question. Two teams were searching if certain brands of tires are more likely to get flat. One team was testing different brands of tires on the same road wehereas other team was testing the same brand of tire on different roads. Almost one third of the SHS students (29%), half of the THS students (46%), and half of the AHS students (47%) choose the unsuitable experiment without referring to the question under investigation (naïve conception). One exemplary quote for these types of responses was as follows:

Team B's experiment is better. Because, they try three different roads. A more interesting situation. Different conditions were tested. (Ersin-SHS).

A student from THS found both of two experiments deficient:

I think, both of them are deficient. It should be given the scores to the tires according to the brands, type of roads, type of using vehicle, and then evaluated. (Duran-THS).

Ten percent of the SHS, 17% of the THS, and 25% of the AHS students held transitional views in this aspect. The students in this category chose the right experiment, but did not refer to the question under investigation as in the case of Seda and Beril;

Team A's experiment is better. Because, they compare different brands (of tire). Beside, Team B works on only one brand (of tire) and they cannot get enough knowledge. (Seda-SHS).

Team A's experiment is better because testing tires of different brands on the same road is more logical. (Beril-AHS).

The majority of the SHS students (59%) held informed views whereas 36% of the THS and 17% of the AHS students had informed views about this aspect. The students in this category choose the suitable experiment for the question and explained that only this experiment can answer the question, not the other experiment. Belin was best among them:

Team A's experiment is better. Team B's experiment cannot help us in answering the question. The question asked the probability of different brands of tire getting flat on a road. Independent variable: different brands of tires, dependent variable: the situation of the tire, control variable: type of the road. (Belin-SHS).

Belin even analyzed variables in Team A's experiment and clearly explained that only Team A's experiment can answer the question. Another student from AHS answered:

If you seek a good answer, you should make a suitable experiment according to the question. It is only possible in Team A' experiment to compare the possibility of different tire brands getting flat since they tried tires on the same road. (Berrak-THS).

Berrak is aware of the inquiry process is conducted with depending on the question asked in scientific investigations. In addition, she implied comparisons of different brands of tires would only be done if they were tried on the same road.

Scientific Data are not the Same as Scientific Evidence

The most related question was directly asking if data and evidence were the same and explanation for their choice and gave an example for each. Naïve view that data and evidence are the same was very low in all high schools (4% in SHS, 7% in THS, and 12% in AHS). One example from a student in SHS is;

> *In an experiment that was done right, every datum is an evidence and every evidence is a datum. (Hasan-SHS).*

Most of the students in all high schools (68% in SHS, 73% in THS, and 74% in AHS) demonstrated transitional views on these aspects. These students stated that data and evidence are different and tried to explain their difference or define them, but they could not provide qualified explanations. Their explanations were simple explanations such as data are knowledge and evidence is certain knowledge, data are not certain, but evidence is, etc. as in the following example:

> *Data are knowledge related to a subject and we cannot know whether it is right or wrong. Evidence is certain knowledge related to a subject. For example, in a thief case, knowledge reached from finger prints are data, but it is not certain evidence. (Mesut-SHS).*

The ones who considered data and evidence as different and provided acceptable explanations were categorized as informed and their percentage was 23% in SHS, 17% in THS, and 8% in AHS. Informed explanations were more complex and acceptable such as data are the knowledge in an experiment and evidence is a proof of an idea from the data. The following quotations from SHS and THS would be an example:

> *Data are knowledge that was gotten. Evidence is the knowledge which I found to support my conclusion. (Karsu-SHS).*

> *I think they are different. Because, data are all of the knowledge collected in a research about an event. But, evidence is the knowledge that proves the truth of an idea. For example, in a research searching under which color of light a plant make photosynthesis faster, there would be knowledge (means data) about speed of photosynthesis of a plant under each color. Each of these knowledge is data. But, the knowledge showing faster photosynthesis under purple and red light are the evidence of the plant making faster photosynthesis under purple and red light. (Seden-THS).*

Although Seden calls data as knowledge like most of the students do, means it as the results of an experiment. But, differentiate evidence from data as being part of the data that support the conclusion for the question searched.

Explanations are Developed from a Combination of Collected Data and What is Already Known

The most related question was providing two possible dinosaur skeleton and states that most of the scientists agrees on the first skeleton and asking for at least two reasons why you think most of the scientists agree that the animal in skeleton 1 had the best positioning of the bones. It was also asked that thinking about their answer to the question above, what types of information do scientists use to explain their conclusions. There was not any naïve explanation which as simple as since it is big in SHS. There were naïve responses in THS and AHS (7% in THS, 14% in AHS), but they were less than the other views. Most of the students explained while skeleton 1 is better than the other one, but their explanation differed in quality.

The students in transitional category (38% in SHS, 28% in THS, and 42% in AHS) proposed logical explanations such as body would be more balanced in skeleton 1, the legs should be strong to move fast at that age, it is similar to some animals living nowadays, etc., and could not provide considerable explanation for the second question. One example from SHS students is as follows:

a. Because dinosaurs' hereditable properties show that they have big legs. They need strong legs and fast hands for hunting.

b. They tried to get most right conclusion by looking at the data that they have. Data are scientific. (Mete-SHS).

He only indicates the data not the previous scientific knowledge that scientists used such as previous dinosaurs, knowledge from other areas, etc.

On the other hand, informed views demonstrated these explanations. Their percentages were 59% in SHS, 62% in THS, and 33% in AHS. One example of them clearly stated that scientists use scientific knowledge and/or thinks that which is more logical for the conditions at these ages. A student's response from SHS would be an example;

a. A large body mass and volume could stand balanced if the part that was considered as legs should be placed just under the body. They do this regulation according to similar living organisms lived up to date.

b. They explain their conclusions by comparing with the knowledge that they collected up to now and following existent logical rules. (Ahmet-SHS).

a. The hands of the dinosaur in Figure 2 are at the back. The probability of this is low and thus most of the scientists found the skeleton in Figure 1 more reasonable.

b. Scientists conclude according to their results. They searched the dinosaurs in two figures; they decide which one of the probable skeletons is true by using their knowledge about dinosaurs. (Tugba-THS).

The pattern in SHS and THS data was very similar, but that of AHS was a little bit different in this aspect. Transitional views were higher than informed views whereas it was vice versa in SHS and THS.

Research Conclusions must be Consistent with the Data Collected

The most related question was asking for which of three conclusions were suitable for the data given at a table in this NOSI aspect. The data were contradictory to their prior knowledge and they were expected to conclude based on the data in the table (informed conception). If they conclude based on their prior knowledge and/or did not refer the data in the table, they were considered as naïve conception. The data in the table was showing that the more sunlight a plant gets, the less it grows. The three conclusions for these data were;

a. Plants grow taller with more sunlight.
b. Plants grow taller with less sunlight.

or

c. The growth of plants is unrelated to sunlight.

There are a few students who had no response or irrelevant response in this NOSI aspect (3% of SHS, 1% of THS, and 6% of AHS). Only 16% of SHS, 15% of THS, and 21% of AHS conclude according to their prior knowledge and chose option a (naïve) contradicting with the data in the table. Some of the students found the experiment insufficient or wrong as in the case of Gulfin:

(Chose the option c.). The growth of plants is not only related to sunlight. In order to control that, all factors should be controlled. The experiment is wrong. (Gulfin-SHS).

Some other students concluded based on their prior knowledge, not the data in the table. Ersin and Eda were two of them:

(Chose option a) If the plant makes more photosynthesis, it grows more. (Ersin-SHS).

(Chose option b) The plants grow faster in dark environments. (Eda-AHS).

On the other hand, all of three high schools (77% in SHS, 82% in THS, and 71% in AHS) showed the highest performance in this NOSI aspect. Most of the students concluded based on the data on the Table and refer to the data in explaining the reason for their choice. But, there was an interesting point in the students' responses. There were 53 students (77%) who conclude either b or c and explained their reasoning by referring the pattern they found in the data. Twenty-one of them chose b and explained their reason based on general pattern in the data which is plant grows less although it gets more sunlight. Karsu was one of them:

(Chose option b.) If one looks at the knowledge (refers to data in the Table) given, as the amount of sunlight increases, plant growth decreases first and then stops. This means that as the plant get less sunlight, it grows more. (Karsu-SHS).

But there was an anomaly in the data; one datum was extraordinary demonstrating an increase in the growth whereas all other data demonstrates a decrease in the growth of the plant as it gets more sunlight. Thirty-two of them chose third conclusion (option c) stating that the growth of plants is unrelated to sunlight because of this anomaly in one data. The single anomaly in the data was more important for these students and they did not consider the general pattern in the data while concluding.

(Chose option c) Option a and b are wrong, because neither more sunlight nor less sunlight demonstrates a proportional increase in the plant growth. (Melek-SHS).

(Chose option c) Because there is not a certain regularity in the table. For example, until fourth week as the amount of sunlight increases, plant growth decreases. But, there is an increase in the plant growth in fifth week. (Ferya-SHS).

Similarly, some of the students just refer to first and last data in the table which shows the plant grows 25 cm when it did not get any sunlight (0 min.) (first datum) and the plant did not grow (0 cm) while it gets the most amount of sunlight (25 min.) (last datum). They just refer to two data among six data in the Table and conclude based on these two data.

(Chose option c) It does not grow as it gets 25 min. of sunlight. It grows 25 cm when it does not get any sunlight. This shows that plant growth is not related to sunlight, but would be related to other factors. (Berkay-SHS).

Both types of responses were considered as informed, because they refer to the data in the table, but they concentrated on different parts of the data and thus their conclusion from the same data were different.

Discussion

The purpose of this study was to explore different high school students' views of NOSI. The results revealed that SHS students outperformed other high schools in three aspects of scientific inquiry. These aspects were 'scientific investigations all begin with a question and do not necessarily test a hypothesis', 'there is no single set of steps followed in all investigations', and 'inquiry procedures are guided by the question asked'. SHS students provided more informed views in these NOSI aspects than other high school students. SHS students had more experience in science courses and had to do a science project in one of the science courses every semester. These experiences would have helped them understand these procedural aspects of scientific inquiry. They were taught a scientific method consisting of series of steps such as observation, hypothesis, experiment, if hypothesis is proven it becomes a theory, if hypothesis is not proven it will be changed and start from the beginning. Irez (2009) analyzed high school biology text-books to find out how NOS was depicted and reported that the scientific method was taught as a series of steps in a chapter. The students' responses in this study revealed that the scientific method is still taught in high school science text-books. But, our data also revealed that although the students were taught the scientific method, they did not recognize it only method of scientific inquiry or all scientific investigations start with a hypothesis. Our explanation for this would be that although they learn the scientific method from the text-books, the only scientific method idea would not have been reinforced as the only method of doing science by teachers in their applications or in their projects. Thus, they did not construct a strict image of the scientific method. Knowing the scientific method did not also cause them to form the idea of 'all scientific investigations start with a hypothesis, if not, it is not scientific'. Our explanation for this would be that the scientific method they were taught starts with observation (Irez, 2009), not with a hypothesis, so they did not get a strict idea that scientific method starts with a hypothesis. They were open to the idea that scientific investigations start with a question or problem and hypothesis was formed later according to the question or the problem under investigation. Some of the students wrote the scientific method as observation, stating the problem, forming an hypothesis, testing the hypothesis by experiment, etc. Their idea of hypothesis did not contradict with the idea of starting with a question. Writing hypothesis at the beginning would not have been reinforced by teachers as a strict rule in their experiences. Being taught steps of the scientific method caused another disadvantage for these students. Since observation is the first step of the scientific method and experiment is the step after the formation of hypothesis, these students recognized observation and experiment as one method. They did not differentiate them as separate methods of scientific inquiry. They used experiment and observation hand in hand and proposed as one method and proposing another method such as documentary research in history as another method used in scientific research when they were asked if there would be more than one method of inquiry. Indeed, observation or experiment would individually be the main and only method in a scientific inquiry. Teaching them as steps of a method prevents such understanding a distinction between observation and experiment. Science textbooks should be corrected in these regards to support contemporary conceptions of NOS and NOSI.

The NOSI aspect of 'conclusions must be consistent with data' is the aspect that all high school students were very good at concluding according to the data given at a table. This type of questions is asked as interpretation questions in multiple choice tests at high-stake exams. Thus, all students experience this type of interpretation of data questions throughout their education at middle and high school grades while getting prepared for these exams.

SHS students and THS students were close to each other and outperformed AHS students in two NOSI aspect of 'data is not the same as evidence' and 'explanations are derived from data and what is already known' aspects. Although most of the students did not have informed views regarding this aspect, percentage of transitional and/or informed views in SHS and THS students were slightly higher than AHS students. In general, SHS students have more science experience than THS and AHS students. Although the students in THS and AHS take almost equal amount of science courses, THS students are generally more motivated toward science professions. In addition, THS students scores higher in science tests on high school placement exams.

On the other hand, SHS students provided more naïve views on two NOSI aspects which were 'same procedures may not get the same results' and 'procedures influence results'. This means that more SHS students thought that scientists doing same experiments would think in the same way and reach the same results which are close to positivist view of science. THS students were the best in this aspect. Similarly, SHS students also thought that there is one correct answer for a question and although the scientists apply different procedures for searching the same research question, they get the same results. This view is also close to positivist view of science. AHS students provided less informed view on these two aspects, but they also had least naïve views on both aspects which means that they have more merit to develop these aspects. There are also similar research results revealing that more science education would result in positivist view of science; for example scientists hold more positivist view of science than science teachers (Pomeroy, 1993).

Another point that needs attention was that the students in SHS and THS demonstrated higher percentages of informed conceptions on three aspects which were 'inquiry procedures are guided by the question asked', 'research conclusions must be consistent with the data collected', and 'explanations are developed from a combination of collected data and what is already known'. These were the only questions which provide options in a context and ask one to choose or explain why one is better than the other. Such questions look like multiple choice test questions, the difference is that they ask an explanation for their choice. Tests are widely used in Turkish schools and all important high-stake exams like high school entrance and university entrance exams. The students in SHS have the highest scores to enroll in these high schools. The next highest scored students enroll in THS. The students in Anatolian high schools have lower scores than both SHS and THS. According to our general observations, the students who aim at enrolling in SHS and THS solve around 200-300 (even more) test questions a day in getting prepared for high school entrance exam. That's why these students are used to recognize the options for a question if it is presented in this format and easily decide on one of them. Thus, they would show better performance in understanding and responding to such questions. Generally, they provide a short explanation for their choice without elaborating their ideas. Second explanation would be that such questions would also be easier to understand and answer than other questions worded in short sentences rather than an explained or pictured situation. Third reason would also be that logical thinking would help in choosing the right option for the situation in these questions, because the right one is indeed the most logical option. After they made the logical choice, they provide a suitable explanation. Their explanations were short, they just write the logic that they used in choosing the option. It would be good to see how these students responds if these NOSI aspects worded similarly to other questions in short sentences and ask directly what they think. We need to do more research to see if which kind of questions were reliably emerge students' ideas about these NOSI aspects. Last explanation for this high performance on these questions would be that these aspects were easy to understand and develop because they were supported by logical thought of an issue. For example, it is logical to conclude based on data, otherwise you are mistaken. It is logical to choose the first experiment is better because it suits well with the question. It is also logical the first skeleton is better, because it fits better with our observations with other animals and our previous observation of dinosaur movies. These aspects were not hidden aspects of scientific investigations.

If we compare the results of this study with South Korean (Yang et al., 2017) and Brezialian (Bologna Soares de Andrade & Levoratob, 2017) VASI study with middle school students, our results will be more compatible to South Korean study. South Korean students as Turkish students in this study provided mixed views on VASI aspects of 'scientific investigations all begin with a question and do not necessarily test a hypothesis' and 'data are not the same with evidence'. The students in both studies had informed views on 'conclusions should be consistent with data' aspect. Turkish students held more informed views on 'inquiry procedures are guided by the question asked', 'there is no single set of steps followed in all investigations', and 'explanations are developed from a combination of collected data and what is already known' aspects whereas South Korean students held more informed views on the aspect of 'same procedures may not get the same results'. On the other hand, results of the Brezilian students in Bologna Soares de Andrade and Levoratob (2017) study are different from both studies; they provided naïve views on all VASI aspects.

We could not compare our results with other research results in Turkish context, because as it was mentioned in introduction section, there was not any study reported about Turkish high school students of NOSI views yet. The only NOSI study (Senler, 2015) was conducted with Turkish and American middle school students by applying VOSI-E (Lederman & Ko, 2003) which included four NOSI aspects; all investigations begin with a question, there is no single scientific method, scientists collect empirical data to answer their questions, and data and prior knowledge are used to answer questions. She mostly compared Turkish and American students to each other. Her results showed that Turkish students demonstrated more informed views about there is no single scientific method. Although our participants were high school students, this aspect (called as multiple methods of science aspect) was one of the aspects that the students demonstrated less naïve views, more transitional and informed views. The participants of our study also did not state that there is only one method of doing science.

If the results of this study is compared to that of Gaigher et al. (2014) study in South Africa, Turkish students in this study demonstrated less informed views than the students in South Africa. The only aspect that Turkish students outperformed South African students is the aspect of 'there is no single set of steps followed in all investigations'.

On the other hand, comparison of the results of this study with international studies in different countries (Bologna Soares de Andrade & Levoratob, 2017; Lederman et al., 2017) reveals that Turkish students in this study have more informed views than the students in these studies. But the students in this study were highschool students whereas the students in other two studies were middle school students.

Conclusion

In conclusion, science education given in SHS shape the students' NOSI views toward positivist view of science, but not to a degree to form a rigid view of scientific inquiry. THS students were closer to SHS students than AHS students in their NOSI views and this is reasonable since, because they were also motivated toward science related professions. Although THS is Teacher High School, the students' motivation toward university is engineering, medicine, and other science related areas as it was the case in SHS. It seems that science courses or their science motivation made a difference in their NOSI views. Science courses introduce different areas of science and the students got the idea what science is and how it is done from their learning in these courses. They learn what it was taught in these courses. They learned the scientific method, because teachers taught them since it was in text-books. If we give up introducing only positivist view of science in science text-books and instead introduce NOS/NOSI contemporarily, they will learn it. It would seem reasonable for someone to teach a positivist view of science in SHS, because they are learning positive sciences. But, positive sciences also underwent philosophical change in recent years and philosophers of science warn us that there is not a universal method of science in a linear and stepwise manner starting from hypothesis to conclusion (Chalmers, 1999). We should develop our science text-books and educate teachers with contemporary philosophies of science as it was suggested by Irez (2009) in 2009. The high school biology textbooks he analyzed included a chapter about science and the scientific method and it was introduced step by step in this chapter. In this way, it was made explicit for the students and most probably it is taught by teachers explicitly at least in this chapter. Furthermore, more science courses mean more reinforcement of this view of science. Slight school differences in our results were explained from this view point.

Recommendations

Following suggestions were made depending on our results and our reasoning on these results.

- The science text-books should not present only the scientific method as only one method of doing science, instead they would explain that there would be many methods of doing science, but the basic methods of study are observation and experiment. Some subjects were suitable for investigating by observation whereas some other subjects would be experimented. Even when experimenting, it is not always necessary to start with a hypothesis, but a research question helps to organize and guide the experiment. Even correlation studies would be introduced to the students at this level. Science is open to creativity in the method of research studies. One could design a methodology for a research question, but s/he should defend it why it should be done in that way. Such more contemporary views of science and scientific inquiry will be presented in science text-books. Only biology curriculum (MoNE, 2017c) mentioned the scientific method whereas physics (MoNE, 2017b) and chemistry (MoNE, 2017a) curricula do not have any mention of it. We hope that writers of chemistry and physics science text-books do not disregard this positive development in these two curricula.
- The students in this study did not propose that data and evidence are the same. They state that they are different, but their reasoning while they were trying to explain their differences came from general sense rather than their experience in science classes. They mostly give example from courts and proofs in mathematics. Thus, science teachers should use data and evidence especially during they were applying inquiry in which they provided data.
- Being taught steps of the scientific method caused another disadvantage for these students. Since observation is the first step of the scientific method and experiment is the step after the formation of hypothesis, these students recognized observation and experiment as one method. They did not differentiate them as separate methods of scientific inquiry. They used experiment and observation hand in hand and proposed as one method and proposing another method such as documentary research in history as another method used in scientific research when they were asked if there would be more than one method of inquiry. Indeed, observation or experiment would individually be the main and only method in a scientific inquiry. Science textbooks should be corrected in these regards to support contemporary conceptions of NOS and NOSI.
- We suggest for future research to investigate science learning experiences in these schools and how NOSI aspects are emphasized.

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