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THE ANALYSIS OF THE CHANGES IN INTEGRATION OF NATURE OF SCIENCE INTO TURKISH HIGH SCHOOL CHEMISTRY TEXTBOOKS: IS THERE ANY DEVELOPMENT?

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To attain the goal of scientific literacy, nature of Science (NOS) is one of the areas that should be addressed. In many countries, to train scientifically literate generations is fundamental aim of science education, which results in emphasizing NOS in science curriculum and curricular materials. The textbooks prepared in the light of curriculum should incorporate NOS aspects into the all grades. In Turkey, secondary science curricula were reformed in 2013. In this document analysis, NOS aspects included, approach adopted for integrating NOS aspects (i.e., explicit-reflective, implicit, and historical), and content-embeddedness of integration were analyzed in the reform-based and old high school chemistry textbooks that are published and provided by National Ministry of Education. Results revealed that from 9th to 12th grade, the number of the NOS aspects mentioned in the textbooks decreased. The most frequently cited aspects were tentative nature of scientific knowledge, empirical bases of science, the difference between observation and inference. However, models in science, creativity and imagination were the NOS aspects that were overlooked. Regarding the approach, contrary to the suggestion of the literature, implicit approach was employed frequently. Finally, NOS aspects were provided in a content-embedded way in 9th and 10th grades whereas they were presented mostly in a content-generic way in 12th grade. Only 9th grade textbook provided two NOS activities for teaching NOS. Although some changes have been made regarding teaching NOS, some important parts are missing.. In light of the results, we suggest that all NOS aspects should be integrated into the textbooks in an explicit-reflective and way. Additionally, for teaching NOS, explicit-reflective activities should be offered in textbooks.

Introduction

What is science? There is no single right answer to this question. Different scholars have described science by highlighting its different aspects (e.g., scientific inquiry, scientists' characteristics, and nature of scientific knowledge). Regarding science, 'nature of science' (NOS) is an important concept that should be addressed. McComas, Clough, and Almazroa (1998) viewed NOS as an amalgam of sociology, history, psychology, and philosophy of science. NOS is about features of scientific knowledge, how scientists accumulate scientific knowledge, the methods scientists use, and the relationship between science, technology, and society.

In all around the world (e.g., Great Britain, The Netherlands, the United States, Turkey, Chile, and South Africa) scientific literacy has been a targeted outcome of science education (Cofré et al., 2014; Dillon, 2009). Although there is no single definition of the scientific literacy construct, it can described as "the knowledge and understanding of scientific concepts and processes required for personal decision making, participation in civic and cultural affairs, and economic productivity." (National Research Council [NRC], 1996, p. 22) In daily life, people hear news about nuclear energy, genetically modified foods, green house effect, and acid rains. In order to be a scientifically literate citizen, one should have adequate knowledge about NOS and scientific knowledge (Bartos & Lederman, 2014; Cofré et al., 2014; McComas, 1998). Hence, NOS has been focused as an important aspect of science curricula in many countries (e.g., in the USA; American Association for the Advancement of Science [AAAS], 1993; NRC, 1996, 2011; in Turkey National Ministry of Education, [NME], 2013 (a), in Chile Cofré et al., 2014, etc.). In this qualitative research paper, we focused on how NOS integration into the high school chemistry textbooks (from 9th to 12th grades) in Turkey. Additionally, in the second year of the reform in secondary science curricula, how recently written textbooks integrated NOS was also aimed in this study.

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Literature Review

NOS and Teaching NOS

There have been different ideas about the aspects of NOS and which aspects of NOS should be taught in science courses in the related literature (Irzik & Nola, 2011; Lederman, Abd-El-Khalick, Bell, & Schwartz, 2002; McComas, 1998). However, the aspects of NOS accepted in general are; tentative nature of scientific knowledge, empirical bases of science, inferential/theoretical nature of scientific knowledge, scientific method, subjectivity in science, the role of creativity and imagination of scientists in scientific inquiry, the relationship between theory and law, the socio-cultural embeddedness of science, science is amoral, interdisciplinary nature of science, the difference between observation and inference, the relation between science and technology, the use of models in science, and science is a solitary pursuit. The detailed explanation of the aspects was provided in Table 1.

Table 1. The NOS aspects and their explanation

NOS Aspects	Explanation
Scientific method	There is no single method that all scientists use. It may change according the field and the research questions focused on.
Empirical bases of science	Scientific knowledge is accumulated through the data collection. Scientists support their claims with data collected.
Inferential/theoretical	The developments in science occur owing to the data collected (i.e., through observations and experiments conducted). Additionally, interpretation of the theoretical knowledge and the inferences made are sources of the developments.
Tentative nature of scientific knowledge	Scientific knowledge may be replaced with the new one in light of the new data collected or the re-interpretation of the existent data (e.g., changes in the Atomic models from Dalton to Modern Atomic Theory).
Subjectivity	Complete objectivity may not be possible in deciding which type of the data will be collected, how the data will be collected, which part of the data will be used, and how the data will be interpreted
Creativity and imagination in science	The creativity and imagination of the scientists are important in all steps of the scientific inquiry (e.g., Kekule' s imagination of the Benzene ring).
Theories/laws	Theories and laws have different nature. Theories do not turn into laws with adequate evidence. Theories have an explanatory nature whereas laws have a descriptive nature that describes what happens under certain circumstances.
Socio-cultural embeddness	Culture in which scientist live, ethnicity, beliefs that they have may influence scientists' interpretation.
Observation and inference	Observation and inference are different concepts. Observation is the description of the observed phenomenon or the event whereas the inference includes interpretation of the observed things.
Science and technology	Science and technology are different fields. Science aims at understanding the nature whereas technology focuses on application and making life easier.
The use of models in science	Models are utilized in science to make understanding and interpretation easier. Models do not represent the real structure.
Science is a solitary pursuit	Scientists generally study together while forming research questions, collecting and analyzing data.
Science is a human endeavor	When scientists make an investigation, they share the study with the public. In this process, peers review their investigation. Different scientists take part in this process.
Moral aspect of science	Science is neutral. It does not focus on the use of the scientific information regarding moral issues (e.g., genetically modified foods vs. treatment of genetic disease and producing nuclear energy vs. atomic bomb)
Interdisciplinary nature of science	There are no clear-cut compartments of science. Fields are related to each other.

There have been many ideas stated about science, scientists, and

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scientific knowledge on the news, newspapers, social media, and in the science textbooks. Research has revealed that the information provided by textbooks and other media included many misconceptions about what science is, how scientists work, and what NOS is (Abd-El-Khalick, Waters & Le, 2008; Irez, 2009). Not only the people who write about science and scientific processes in the newspapers or textbooks, but also science teachers, college professors, and pre-service teachers do have misconceptions about those as well (Lederman, 2007). Therefore, it is assumed that if NOS, its aspects, and features of science are taught to students from early stages of science education, students would have a better understanding of science, scientists, and their work.

Approaches for teaching NOS

Regarding how teaching NOS, there are three different approaches for teaching NOS, namely, *explicit-reflective*, *implicit*, and *historical* approaches. Explicit-reflective approach assumes that learners learn about NOS by participating into scientific activities through which learners design, collect data, analyze and interpret, and share the results with peers. After the activity, teachers should discuss the NOS aspects included in the activity explicitly through the participation of learners (Abd-El-Khalick & Lederman, 2000) Different than the first approach, the implicit one assumes that learners learn about NOS by participating in inquiry activities. In other words, an explicit discussion on the aspects of NOS, nature of scientific inquiry, and how scientists work is not used in the implicit approach. Finally, in the historical approach, NOS is addressed by the use of interesting cases happened in the history of science, the story of the discoveries, and the inventions discovered by coincidence. In order to teach NOS through historical approach, teachers need to be knowledgeable about historical of science (HOS) and the interesting stories of discoveries (Abd-El-Khalick & Lederman, 2000). Research on teaching NOS has revealed that explicit-reflective approach results in better understanding of NOS than implicit one (Khishfe & Abd-El-Khalick, 2002; Lederman, 2007).

Content relation of NOS

Another important aspect of teaching NOS that deserves attention is the content relation of NOS aspects. There are two ways of teaching NOS regarding the content relation, namely, content-embedded and content generic (Lederman, 2007). The former is teaching NOS aspects by integrating the aspects into the topic taught. For instance, to teach tentative nature of scientific knowledge, Atomic Models topic (i.e., stressing the tentative nature of scientific knowledge with modifications and changes from Dalton's Theory to Modern Atomic Theory) is very suitable. Therefore, to emphasize tentative nature of scientific knowledge, it can be integrated into the Atomic Theories topic (i.e., the content from chemistry curriculum) that forms a basis for teaching about scientific knowledge can be changed or modified by the use of new knowledge or by the re-interpretation of the existent one. Second, the content-generic way is teaching NOS aspects without integrating them into the topic taught. There are many content-genetic activities in the literature (e.g., *Tricky Tracks* by Lederman & Abd-El-Khalick, 1998; *The Great Fossil Find* by Randak & Kimmel, 1999), which is used for teaching NOS with content-free activities. Literature has stated that both ways are effective in teaching NOS (Lederman, 2007).

In order for teachers to teach NOS and its aspects by the use of the approaches summarized above, teachers should be proficient in using them. Teachers have to be equipped with knowledge about NOS, how to teach it, and learners' difficulties and misconceptions about NOS. However, studies have clearly shown that science teachers do not have required knowledge for teaching NOS (Cofré et al., 2014; Hanuscin, Lee, & Akerson, 2011). It is clear that teachers should be encouraged to teach NOS by supporting their NOS knowledge and pedagogy for teaching NOS through pre-service teacher education and in-service training activities in which explicit-reflective teaching approach is emphasized (Lederman, 2007). Even if teachers are trained for teaching NOS, research revealed that teachers still have obstacles in teaching NOS (Abd-El- Khalick, et al., 1998; Hanuscin et al., 2011). To minimize the obstacles teachers face with; NOS aspects, teaching NOS, and useful strategies and historical cases should be provided in science curriculum documents and science textbooks explicitly. In this way, science teachers would have instances to see how to integrate NOS into their science classes, and have activities to apply in the class, which have a potential to increase teachers' NOS integration into teaching. Additionally, not only teacher education and professional development activities but also written documents (i.e., science curriculum documents and textbooks) should pay attention to integrate NOS and give examples of NOS activities and HOS cases (Aydin, Demirdogen, Muslu, & Hanuscin, 2013; Lederman, 2007). From this point in mind, this research focused on analyzing high schools chemistry textbooks (from grade 9th to 12th, four books in total) regarding NOS teaching. Textbooks have two types of influence on learners: direct and indirect influence (Irez, 2009). The former is the case when learners use the textbook on his/her own. The indirect influence occurs when teachers utilize textbooks to organize their teaching. Likewise, textbooks are essential sources for teachers in designing their teaching. Therefore, textbooks should be equipped with essential aspects and examples for teaching and learning NOS in order to raise scientifically literate citizens.

Research on NOS Integration into Textbooks and Curriculum Documents

There have been some studies on teacher training for integrating NOS into science courses in the USA (e.g., Akerson, Cullen, & Hanson, 2009; Akerson, Hanson, & Cullen, 2007; Hanuscin, et al., 2011). However, in the countries where much less money is invested on teacher education professional development project, the curriculum materials and textbooks are vital sources for teachers who need support for integrating NOS into their teaching. Therefore, the quality of those materials and textbooks plays important role in determining the quality of science teaching and learning. In this part of the literature review, research focusing on the NOS in the curriculum materials and textbooks were presented.

Abd-El-Khalick and his colleagues (2008) stated that one of the main reasons of inadequate NOS understanding of learners and teachers is poor quality science textbooks. "In the case of NOS, the impact of textbooks gains significance because very few, if any, commercially viable science textbooks have been recently designed specifically to help pre-college students develop

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informed NOS conceptions as emphasized in current science education reform documents." (p.836) Therefore, examining how and to what extend NOS is integrated into the science textbooks would make a pressure both on authors and publishers regarding paying more attention to NOS (Abd-El-Khalick, et al., 2008). To fill this gap in the literature, Abd-el-Khalick and his colleagues analyzed 14 high school chemistry textbooks used frequently in the US (i.e., five of them had series between one decade to four decades). In this study, the researchers analyzed the 'Scientific Method', 'The Structure of the Atom and Atomic Models', and 'The Kinetic Molecular Theory' parts of the textbooks rather than analyzing the whole book. Results revealed that textbooks characterized scientific method, theories and laws, and the role of creativity and imagination not in accord with recent NOS related research in science education. Additionally, 12 of the analyzed books did not mention socio-cultural embeddness of science at all. Another noticeable result was that there was no clear development regarding NOS integration in the last 40 years.

Similar to Abd-El-Khalick and his colleagues (2008), Niaz and Maza (2011) examined 75 General Chemistry textbooks' introductory chapter regarding nine NOS aspects (e.g., tentative nature of scientific knowledge, theory-law relation, there is no single scientific method, role of imagination and creativity in science, etc.) Results showed that textbooks did not pay necessary attention to NOS. For instance, almost 95 % of the books analyzed did not mention that theories and laws have different nature, and that with more evidence theories do not become laws. Likewise, 85% of the books did not provide any information regarding scientists might interpret the same data in different ways. The NOS aspects presented satisfactorily were the tentative nature of scientific knowledge (17%) and the role of creativity and imagination in science (16%). The tentative nature of scientific knowledge aspect of NOS was the most frequently mentioned one with 39%. Given the fact that this study analyzed only the introductory chapter of the textbooks, the results do not provide any information about how and to what extend the rest of the books addressed NOS aspects.

In another study, Irez (2009) examined five 10th grade Turkish high school biology textbooks. In all the textbooks analyzed, scientists were represented as objective, curious, and good observers. 'Science is a solitary pursuit' was mentioned in only one of the books analyzed. Furthermore, none of the book stated the tentative nature of scientific knowledge and socio-cultural embeddness of science. However, all of the books mentioned that science is empirical. Another noteworthy result was that all of the books stated that 'there is a single scientific method that scientists follow step by step' and 'theories become law with adequate evidence', which are not consistent with informed NOS understanding. Irez (2009) discussed that those misconceptions detected in the textbooks are one of the main reasons of misconceptions that teachers and learners have about NOS. Finally, the researcher emphasized that NOS was not integrated into the all chapters rather it was mentioned in some parts of the textbooks.

Finally, in addition to textbooks in some of the studies researchers focused on professional journals regarding representation of NOS and its aspects. Aydin et al. (2013) studied on the papers published in *The Science Teacher* journal (i.e., NSTA journal for high school teachers). 65 papers published from 1995 and 2010, were examined regarding the NOS aspects, the content-embeddness of them, and the approaches used (e.g., explicit-reflective). The most frequently mentioned NOS aspect was 'science as a human endeavor' (27 articles out of 65). 'Tentative nature of science' (24 articles) and 'socio-cultural embeddness of science' (24 articles) were also included more than other aspects (e.g., science and technology relation, the difference between observation and inference, and the relation between theory and law). 28 of the articles mentioned NOS explicit-reflective way. History of science (HOS) was used in 19 of the papers. Regarding the content-embeddness, in 27 of the articles focused on embedded NOS aspects into a topic whereas 38 of them mentioned NOS in a content-generic way. Researchers stated that less frequently mentioned NOS aspects would be problematic for teachers to integrate them into their teaching.

The Significance of the Study

Textbooks are cheap and most-readily available sources for both learners and teachers (Abd-El-Khalick, et al., 2008; Irez, 2009).

> [A]mong others, as resulting in classroom practices that oftentimes closely mirrored the sequences and structures in textbooks or preparatory coursework. For NOS and SI [scientific inquiry], no such referent or document exists. Having subject matter experts, or even those charged with informing the inclusion of NOS and SI in reform documents and curricula, explicate their own knowledge structures might also prove efficacious in helping develop coherent conceptions in teachers, and hopefully, their students. (Barton & Lederman, 2014, p.1178)

Previous research has examined how NOS was integrated into the some chapters (i.e., 'Scientific Method', 'The Structure of the Atom and Atomic Models', and 'The Kinetic Molecular Theory') of the high schools chemistry books (Abd-El-Khalick, et al., 2008), introductory chapter of college general chemistry textbooks (Niaz & Maza, 2011), 10th grade high school biology textbooks (Irez, 2009). However, none of them analyzed the all chapters of the books, which makes generalization of the results to the all books impossible. Furthermore, McComas and Olson (1998) stated that analysis of the curriculum documents "in languages other than English and particularly from non-Western cultures" (p.51) should be done. To fill this gap, we focused on high school chemistry textbooks (from 9th to 12th grades) and analyzed them regarding NOS aspects mentioned, the approaches used for addressing them (i.e., explicit, implicit, and historical), and the content relation of them (i.e., content-embedded and content-generic) in the whole books used all around the country. We think that, with this study we will be able to address McComas and Olson's (1998) call. Finally, this study provides valuable data about the big picture of the NOS integration into all chapters of high school chemistry textbooks from 9th to 12th grades.

In Turkey, a national curriculum is used in all around the country for all courses in K-12 in order to provide the same opportunities for all learners in the country. National Ministry of Education (NME) is responsible for preparing the national curriculum. NME also provides the textbooks for all learners free for all courses. In

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the textbook writing and publishing process, first, NME calls for writing textbooks. Then, some science educators write them and submit it to textbook writing commission in which many experts (i.e., including science teachers and experts from measurement in education, etc.) working for NME examine the textbooks submitted. After a thorough examination, the textbooks received the highest scores for each grade is distributed to learners in all around Turkey for free. All learners and teachers utilize the textbooks distributed by NME. Therefore, the textbooks used by all learners should reflect NOS appropriately and necessarily. As in the other countries in the world, raising scientifically literate citizens is major goal of science education in Turkey, which makes NOS integration into the books obligatory.

In 2013, NME made some alterations in the high school science curricula which highlighted developing science process skills and scientific literacy. Teachers started to utilize the new curricula in the 2013-2014 academic year (i.e., fall semester) for 9th grade. Then the next year, in 2014-2015 academic year, they started to utilize 10th grade curriculum and new textbooks. It was the second year of the reform. Next year in 2016, 11th grade curriculum and the textbook will be utilized in the schools. In 2017, all grades will be using the new curricula and the new textbooks. In other words, the reform is in stages. To check to what extend the reform addresses the scientific literacy regarding NOS, it would be worthy to compare the new (i.e., 9th and 10th grade textbooks) and the old ones (i.e., 11th and 12th grade textbooks) in terms of NOS aspects issued, the approaches used, and to what extend the aspects were mentioned.

The research questions guiding the study were:

1. Which aspects of NOS were emphasized in high school chemistry textbooks in Turkey?
2. Which approaches were utilized to integrate NOS aspects into the Turkish chemistry textbooks?
3. How NOS aspects presented in the Turkish textbooks regarding the content embeddedness?
4. How do chemistry textbooks prepared in light of the reform-based and old curricula differ addressing NOS?

Methodology

Research Design

This study is qualitative in nature and a content analysis of Turkish high school chemistry textbooks (Merriam, 2009). The high school chemistry textbooks were analyzed regarding NOS integration.

Data Collection and Analysis

First, high school chemistry textbooks for 9th to 12th grades were obtained from high school. Then, we started the analysis of the textbooks received. When we confronted with a NOS aspect addressed in the textbook, we coded that part regarding four dimensions, namely; (1) the NOS aspects, (2) approach, (3) content-embeddedness, and (4) the degree to which textbook mention the NOS aspect. By this way, we collected the raw data. Then, by the use of the raw data, we formed tables, calculated percentages, and drew graphs to better interpret the results. In other words, data analysis of the study included four parts, namely, the aspects of NOS addressed (see Table 1 in the literature review part and Table 2), the content-embeddedness (i.e., content embedded vs. content generic) (Table 3), the approaches used for addressing NOS aspects (i.e., explicit-reflective, implicit, and historical), and the comprehensiveness of addressing NOS aspects in the chemistry textbooks. The details regarding the coding were provided in the following paragraphs.

First, to code the textbooks, we utilized the NOS aspects stated in *National Science Teacher Association* (NSTA, 2000) document and additional aspects of NOS (Aydin et al., 2013). All aspects used for coding were provided in Table 2.

Table 2. NOS aspects used in the analysis of the textbooks

Aspects from NSTA Document	Additional aspects
Tentative nature of scientific knowledge	Observation-inference
Scientific method	Science and technology relation
Creativity and imagination in science	Model use in science
Theories and laws	Science is a solitary pursuit
Socio-cultural embeddedness of science	Moral aspect of science
Empirical bases of science	Interdisciplinary nature of science
Subjectivity	
Inferential/theoretical	Science is a human endeavor

Second, we coded the NOS aspects mentioned in the books regarding the content embeddedness (Table 3)

Table 3. The content-embeddedness NOS aspects

Content-embeddedness	Explanation
Content-embedded	NOS aspect is embedded into the topic covered. For instance, tentative NOS can be addressed well in the Atomic Theories from Dalton to Modern Atomic Theory by the use of cases showing that scientific knowledge can be changed by the use of new knowledge or re-interpretation of the existent one.
Content- generic	Addressing NOS aspects without using the content taught. For instance, using 'old or young lady' picture to teach subjectivity in science aspect of NOS.

Third, the parts addressing NOS aspects were also coded regarding the approach used (Table 4).

Table 4. Approaches used for addressing the NOS aspects

Approaches	Explanation
Explicit-reflective	For teaching NOS, activities and/or scientific inquiry are used. After that, a whole class discussion about the NOS aspects addressed in the activity are discussed explicitly rather than assuming that learners simply understand the aspects focused in the activity.
Implicit	It assumes that learners learn NOS aspects by participating scientific processes such as observation, data collection, and analysis of the data. Teacher neither provides explicit explanation nor holds a whole class discussion on the aspects.
Historical	The use of interesting cases that occurred in the history of science. For instance, Rutherford's Gold Foil Experiment is a good example of the difference between observation (i.e., very low percent of the

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	alpha particles scattered) and inference (i.e., there should be a small and dense nucleus with positive charge in the atom)

As seen from Table 4, in explicit-reflective approach, there should be activities for teaching NOS aspects and then NOS aspects should be discussed explicitly through the participation of learners. However, when we analyzed the textbooks, we realized that there are only two activities provided in the 9th grade textbook. The other authors did not present any activities; rather, they provided some examples from HOS or examples with some information about the NOS aspects. Therefore, when we used explicit-reflective approach in this study, we had to modify its meaning. When we used explicit-reflective approach, the reader should understand that the textbook authors explicitly mention the NOS aspect, provided explanation, and example for addressing that aspect. Similarly, when implicit approach is used, it means that NOS aspect(s) was mentioned implicitly without stating the NOS aspect clearly and explicitly. Those were required modifications due to the lack of activities in Turkish chemistry textbooks focused on.

Regarding the approaches mentioned in the textbooks, when we started the analysis, we realized the existence of the hybrid approaches in the textbooks (e.g., explicit-reflective and historical approach or implicit and historical one). Therefore, we added them into our codings.

Finally, the data were coded regarding the comprehensiveness of addressing NOS aspects, which is related to what extend textbooks provide information about the NOS aspects. With help of the rubric Abd-El-Khalick and his colleagues (2008); we coded the data (Table 5). Abd-El-Khalick et al. (2008) used negative scores for the textbook parts that make learners develop alternative conceptions about NOS in textbooks. However, due to the fact that we did not detect any part that may cause alternative conceptions about NOS in the textbooks analyzed, there is no negative score in the rubric we utilized.

Table 5. Scoring rubric for comprehensiveness of the NOS aspects

Scores	Category	Explanation
1 point	Mentioned	NOS aspects were described but not supported with an example from chemistry, and/or history of chemistry
2 points	Satisfactory	NOS aspects were described and the explanation was enriched with the necessary examples from chemistry and /or from history of chemistry

Before coding independently, researchers formed the tables for all dimensions and discussed their meanings. Both researchers coded the textbooks independently by the use of the descriptions of the aspects, approaches, content-relations, and completeness for one chapter in the 9th grade chemistry textbook. After coding the data for a unit independently, they compared and contrasted the codings. The interrater reliability was .84 (Miles & Huberman, 1994). Small differences were discussed. Then, both researchers coded another chapter independently and compared the coding. The comparison of the coding showed that they coded almost in the same way. The interrater reliability was calculated as .96 (Miles & Huberman, 1994). Very little minor issues discussed again. Yet another chapter was coded independently and comparison was done. In the third cycle, the coding was identical for aspects, approaches, and content-relation, and completeness. Then, the second author coded the rest of the 10th, 11th, and 12th grade textbooks. All of the data received were used to form tables. To help readers to follow the data coding, details for the procedure were summarized in Table 6 for all dimensions focused on.

Table 6. Examples of codings for aspects, approaches, content-relation (embeddedness), and completeness

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Aspects	Approaches	Content-relation		Short excerpt from the textbooks
Tentativeness	Explicit-reflective	Content-Embedded	2	"Sometimes, it is necessary to change knowledge or model due to accumulation of the new knowledge. In this topic, you will learn how the knowledge about atom has changed in light of the new information accumulated." (Altun & Tümay, 2013, 9th grade, p. 55)
Science is a solitary pursuit	Explicit-reflective	Content-Embedded	2	"As you may remember, J. J. Thomson stated that atoms have spherical shape and have particles with negative charge surrounded by particles with positive charge. Is that real structure of the atom? A research group leaded by one of Thomson's student Ernest Rutherford studied on the structure of the atom. " (Altun & Tümay, 2013, 9th grade, p. 75)
Empirical	Explicit-reflective	Content-Generic	1	"The difference between Dalton's and Democritus' s theory is that Democritus' s idea is a philosophical view and non-empirical one whereas Dalton's idea is a hypothesis based on scientific evidence and necessitates empirical evidence…." (Dursun, Gülbay, Çetin, Tek, Özkoç ve Güntut, 2013, 10th grade, p.17).
Science-technology	Implicit	Content-Generic	1	"The discovery of steam engine, also known as industrial revolution, resulted in changes in people's way of living (from agriculture to industry). The discovery happened owing to the development in the thermodynamic field of science. Hence, science influenced technology and the society…" (Kavak, 2013, 11th grade, p. 44)
Empirical	Implicit	Content-Embedded	2	"The plane of polarization is turned by optically active compounds, cannot be determined by the examination of the structure of the substance, rather experimentally. Most of the biological molecules have enantiomeric structure. For instance, glucose and galactose have enantiomeric structure." (NME, 2013 (b), 12th grade, p.151)
Aspects	Approaches	Content-relation		Short excerpt from the textbooks
Observation and inference	Implicit-historical	Content-Embedded	1	"If the galaxy moves away, the wavelength of the light decreases, the frequency of the light increases, and the spectral lines move to red side. Russian Meteorologist and mathematician Alexander Friedmann realized the expansion of the universe in 1922." (NME, 2013 (b), 12th grade, p.17)
Theories/ laws	Explicit-historical	Content-Embedded	2	"How does Dalton's Atomic Theory explain Law od conservation of Mass and Law of conservation of Mass? … As you can understand the information presented above, scientific theories and laws are different regarding both their meaning and function. They do not have hierarchical relations. They do not turn into other. Laws are the descriptions of the events observed in the nature. Theories, on the other hand, are the explanation how those events occur… (Altun & Tümay, 2013, 9th grade, p. 68
Inferential/Theoretical	Implicit	Content-embedded	1	"The existence of the charged particles in the atom, likewise the experiments and observations that show the existence of the atom, was understood by the use of evidence gathered through indirect ways." (Altun & Tümay, 2013, 9th grade, p. 70
Interdisciplinary & human endeavor	Implicit	Content-embedded	1	"In 1803, by conducting research, British Chemists and teacher John Dalton used atom concept after Democritus. In 1869, Russian chemist Dmitri Mendeleev developed a periodic table for the elements known…. In 1911, Physicist Ernest Rutherford discovered nucleus model of atom." (Altun & Tümay, 2013, 9th grade, p. 52)
Use of Models	Explicit, historical	Content-embedded	2	"As you can understand from the Dalton, Thompson, Rutherford, Bohr, and Modern Atomic models that represent the atom, those models help us understand scientists'' theories about the atom. Models play an important role in science just as theories do. Models developed in chemistry are useful especially in understanding what happens in the sub-microscopic level." (Altun & Tümay, 2013, 9th grade, p. 96)

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Creativity and imagination	Implicit	Content-embedded	1	" Alfred Werner explained the structure of the of the compounds that transition metals form with neutral molecules and ions when bond concept had not been known well. He received Nobel Prize owing to that research." (Kavak, 2013, 11th grade, p. 181)
Human endeavor	Implicit	Content-embedded	1	"Kinetic Theory that explains the behaviour of the gases was firstly proposed by Bernoulli. Then Clausius, Maxwell, Boltzmann, and Van der Walls developed it. " (Altun & Tümay, 2013, 9th grade, p. 242)
Subjectivity	Implicit	Content-embedded	1	"His interest in hot air balloons directed Charles to examine the effect of temperature on the volume of a gas." (Dursun, Gülbay, Çetin, Tek, Özkoç ve Güntut, 2013, 10th grade, p. 193)

In this way, all of the chapters in the chemistry textbooks were analyzed and presented in the results part of the study.

Results

In this part of the study, the results of the analysis focusing on how NOS was integrated into the high school chemistry textbooks were presented regarding the aspects of NOS (i.e., research question 1) (i.e., creativity and imagination in science) an the quality of the integration, the approaches (i.e., explicit-reflective, implicit, and historical) used to integrate NOS (i.e., research question 2, the content relation of NOS (i.e., research question 3) (i.e., content-embedded and content generic). For the 4th research question focusing on the differences between the new textbooks (for 9th and 10th grades) prepared in light of the reform-based and old textbooks (for 11th and 12th grades) differ addressing NOS, the results were presented under the results for the first three research questions. After presenting the results for aspects integrated, the comparisons for new and old textbooks were provided.

The distribution of NOS aspects through the grades

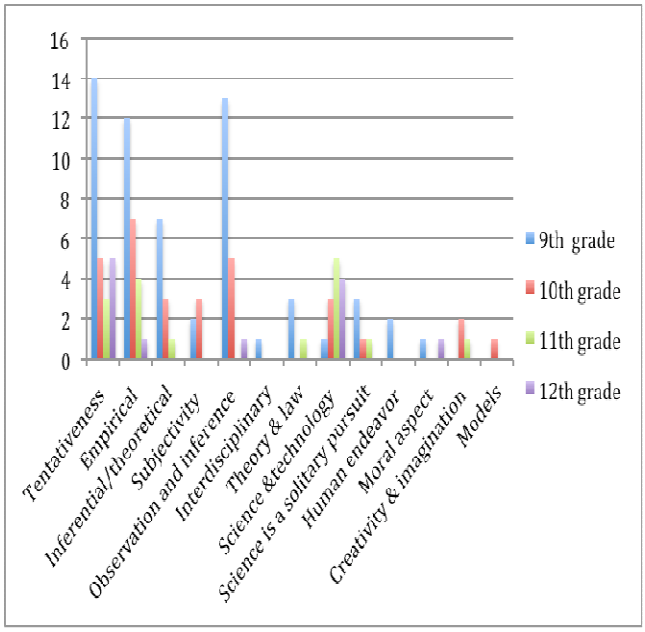
The results of the analysis were presented in Table 7.

Table 7. The aspects addressed in each grade

Grade	The number of the aspects addressed	The frequency of the NOS aspects addressed
9	11	59
10	9	30
11	7	16
12	5	12

As the table shows, the number of the NOS aspects issued in the textbooks decreases from 9th to 12th grade. Regarding the number of aspects addressed, 9th grade textbook integrated 11 different aspects of NOS (i.e., out of 15 aspects provided in table 1 and 2) whereas 12th grade textbook did only 5. Regarding the frequency of the aspects stated in the textbooks, a similar tendency was observed. The frequency of the NOS aspect issued decreased from 59 to 12 through 9th grade to 12th grade. A detailed further analysis was done for the determining the which aspects addressed in different grades (Graph 1)

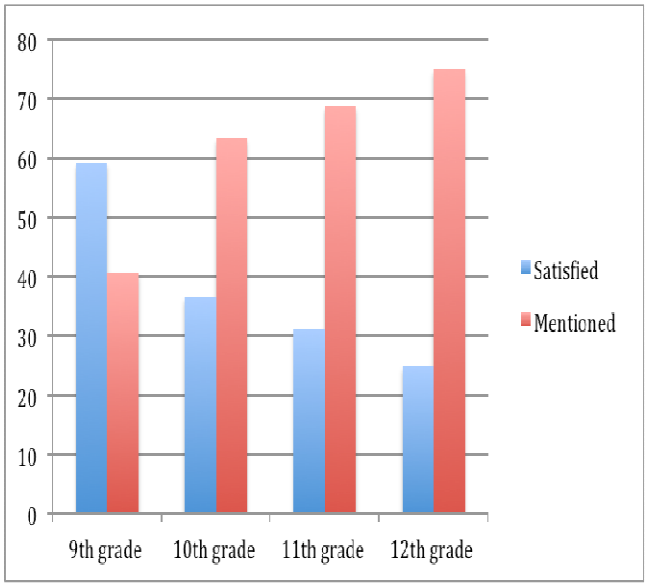
Graph 1. The NOS aspects integrated into the chemistry textbooks



As graph 1 shows, some of the aspects of NOS, for instance, tentativeness of scientific knowledges, empirical NOS, the difference between observation and inference were stressed mostly. However, models used in science, moral aspect of science, creativity and imagination in science aspects were the ones that were mentioned in very few part of the textbooks analysed.

Regarding the aspects of NOS integrated into the textbooks, we also interested in seeing the quality of the integration (Graph 2)

Graph 2. The quality of integration of NOS aspects (%)



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As Graph 2 shows, only 9th grade textbook included more parts that addressed NOS issues satisfactory than the parts just mentioning NOS aspects. In the other grades, for instance, the 12th grade textbook issued NOS aspects in 12 times. However, nine of them only mentioned the aspect rather than providing detailed explanations or example from science and history of science. In the three cases, the authors specified the NOS aspect and provided examples related to teaching the aspect, which was coded as 'satisfied'.

Examination of the approaches to address NOS aspects in Textbooks

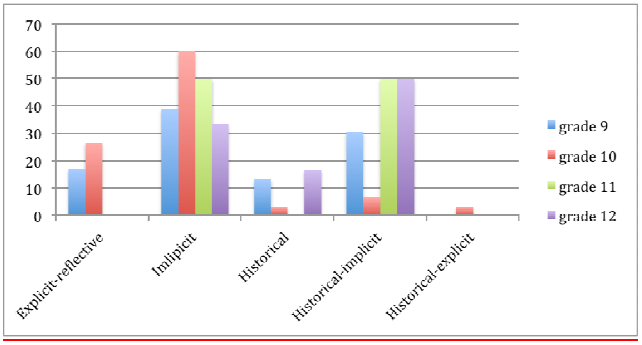
In the literature review part of the study, it was stated that NOS aspects are presented in three different ways, namely, explicit-reflective, implicit, and historical approaches. The analysis of the approaches used to integrate NOS aspects into the chemistry textbooks was presented in Table 8.

Table 8. The approaches used in the textbooks fro grade 9th to 12th

Approaches	9th grade	10th grade	11th grade	12th grade
Explicit-reflective	10	8	0	0
Implicit	23	18	8	4
Historical	8	1	0	2
Historical- Implicit	18	2	8	6
Historical- Explicit-reflective	0	1	0	0
Total	59	30	16	12

To understand the analysis better, the data were calculated in percentage. In Graph 3, the same data were presented in percentage.

Graph 3. The analysis of the approaches for issuing NOS (%)

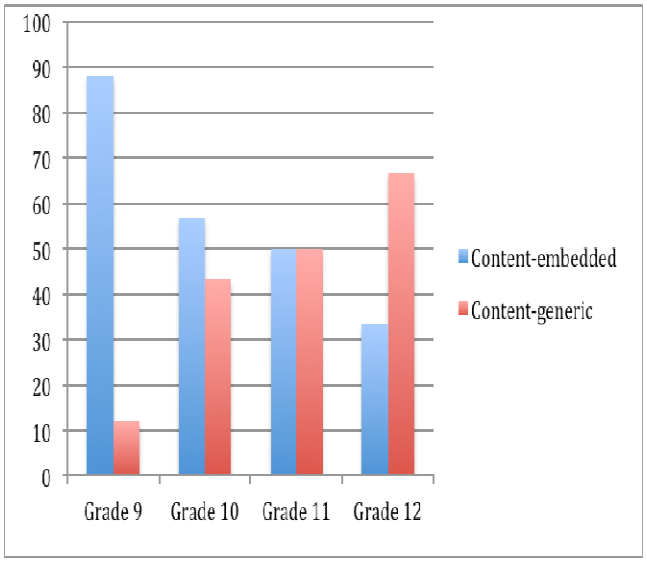


In general, the mostly preferred approach was implicit one. Likewise, historical-implicit approach was utilized frequently. In the 9th and 10th grade books, the explicit-reflective approach was used 17% and 23%, respectively. However, 11th and 12th grade textbooks did not employ explicit-reflective approach. Additionally, the historical approach was not utilized very much.

The analysis of the content relation of NOS aspects in the textbooks

The NOS aspects may be presented either by embedding the aspect into the topic taught (i.e., content-embedded) or without embedding it to the topic taught (i.e., content-generic). The analysis of the textbooks regarding content relations was summarized in Graph 4.

Graph 4. The analysis of integration of NOS aspects regarding content-embeddness



The analysis showed a great variation in relating NOS and the topics taught. In 9th grade textbook, NOS aspects were mostly integrated into the topic covered. On the contrary, NOS aspects were mostly integrated into the textbooks without embedding them into the topic in 12th grade. In the 10th and 11th grade textbooks, the percentages of the content-embedded and content-generic NOS integration are relatively close.

Discussion, Conclusions, and Implications

In this study focusing on the NOS integration into the high school chemistry textbooks revealed that textbooks showed a great variation regarding the number of the NOS aspects mentioned and the way of integrating them (i.e., explicit – implicit and content-generic vs. content-generic). The results presented will be discussed in the sequence of the NOS aspects, the approaches of integrating NOS, and the content relation order.

First, the 9th grade textbook was the one that has the highest number of the NOS aspects integrated (i.e., 11 aspects out of 15). 10th grade textbook included 9 NOS aspects. Through the 12th grade (i.e., 5 aspects out of 15), the number of the NOS aspects appeared in the textbooks decreased. The variation in the attention paid to NOS may be related to the authors' interest in NOS. Those four textbooks were written by different groups of authors who may or may not be interested in NOS. In the study digging into the curricular documents of different countries regarding NOS integration, McComas and Olson (1998) stated that the authors' interests had a large influence on how and to what extend NOS would be emphasized in the curricular materials. Therefore, the differences regarding NOS aspects included and the frequency of integrating NOS aspects may be related to the authors' interest in NOS.

The difference in the number of the NOS aspects issued may also be related to the national curriculum documents. Şardağ, Aydın, Kalender, Tortumlu, Çiftçi, and Perihanoğlu (2014) analyzed the new high school (grade 9 to 12) physics, chemistry, and biology curriculum standard documents regarding NOS integration and revealed that some of the NOS aspects (e.g., inferential-

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theoretical, there is no single scientific method, creativity and imagination in science, and socio-cultural embeddedness of science) were not included in the standard documents at all. However, some of the aspects were emphasized very frequently (e.g., the tentative nature of scientific knowledge). When we compared the results of the both studies, similarities regarding the missing aspects and the aspects cited frequently were noticed. In both studies, the most frequently emphasized NOS aspect was the tentative nature of scientific knowledge. The NOS aspects that were missing both in the curricular documents and textbooks were revealed as the use of models in science, creativity and imagination in science, and moral aspect of science. Similar results were revealed in the analysis of Australian, the US, British, and other countries' science curriculum documents by McComas and Olson (1998). In another study in which the introductory chapter of the General Chemistry textbooks were analysed Niaz and Maza (2011) showed that the difference between theories and laws were only emphasized by four of 75 textbooks analyzed. Additionally, the subjectivity in science aspect was one of the missing aspects in the college textbooks. Finally, they stated that textbooks did not fully address NOS in the college chemistry textbooks.

Regarding the decrease in the numbers from 9th to 12th grade, another possible reason may be the more stress on NOS in the reformed-based chemistry curriculum. As we stated in the significance of the study part, high school chemistry and other science curricula were modified in 2013 in Turkey. At the beginning of the curriculum document for high school chemistry, it was stated that NOS is one of the important aspects of educating scientifically literature citizens (National Ministry of Education, [NME], 2013 (a)). In the document, five objectives were provided for NOS and four objectives for understanding of nature of scientific knowledge (NME, 2013 (a), p.2). Therefore, more explicit NOS stress in the new curricula may make textbooks authors integrate more aspects in the textbooks. However, NOS was not stressed very much in the old curriculum documents, which may explain why the old textbooks include less NOS aspects.

Yet another factor may be the nature and the context of the units covered in the different grades. When we looked at the curricula and the textbooks for the content and the context of the units, we realized that it might be easier for authors to integrate NOS aspects into some units than others. For instance, there are more accessible examples for integrating NOS aspects into The Science of Chemistry (From Alchemy to Chemistry) and Periodic Table unit (in the 9th grade curriculum) than into Equilibrium or Organic chemistry units (in the 11th and 12th grades curricula). The nature and the context of the topic may also be factor explaining the difference as well.

Second, regarding approaches used in integrating NOS into the textbooks, results showed that explicit-reflective approaches were used less than the others. Specifically the old ones (i.e., 11th and 12th grade textbooks) did not utilize explicit-reflective approach at all, which contradicts to the literature's suggestion for NOS teaching. The 9th and 10th grade new textbooks utilized explicit-reflective approach to some extend. Research has revealed that explicit-reflective approach is more useful for developing NOS understanding than implicit approach (Abd-El-Khalick & Lederman, 2000; Khishfe & Abd-El-Khalick, 2002; Lederman, 2007). The results presented in this study are similar to the results revealed by Şardağ et al. (2014) that analyzed the secondary science curriculum documents regarding NOS. Likewise, NOS aspects were not mentioned in the documents explicitly. Curriculum documents play a guide role for textbooks authors in terms of the topics covered, NOS aspects integrated, and objectives focused on. Therefore, implicit NOS emphasis in the curriculum document may result in implicit NOS integration into the science textbooks. Given the fact that teachers' inadequate NOS understanding and teaching NOS repertoire, the use of implicit approach for embedding NOS into the textbooks will not be beneficial for teachers (Lederman, 2007). Similarly, in the study analyzing the paper published in *The Science Teacher* (i.e., a NSTA journal) Aydin et al. (2013) revealed that 43% (i.e., 28 article out of 65) of the analyzed NOS paper used explicit-reflective approach for addressing NOS aspects. In this study, results showed that none of the textbooks provide activities for teaching NOS, which may an important limitation of the teaching NOS in chemistry classes. To support teachers to enrich their instructional strategy repertoire, textbooks should include them. Although the US teachers have a great opportunity to have that repertoire because of NSTA professional journals, teachers who work in different countries may not have that opportunity. Another important result received in this study was the use of hybrid approached in the textbooks. Historical approach was utilized with explicit-reflective and implicit approaches. Lin and Chen (2002) stated that the use of interesting cases occurred in the history of science help learners enrich NOS understanding and provide an opportunity for learners to talk about NOS aspects. Although 9th grade textbook included HOS examples and hybrid use of HOS, 10th grade textbook did not have enough HOS cases. In light of this point, more examples from the history of science should be integrated into the reform-based textbooks for both teachers to use them in their class and for learners who may read them on their own.

Third, regarding the content embeddness of NOS, both methods are useful for teaching and learning NOS (Khishfe & Lederman 2006). In this study, results revealed that in 9th and 10th grade textbooks frequently integrated NOS with a content-embedded way whereas 12th grade textbook presented them in a content-generic way. In 11th grade, both ways were used equally. In the analysis of the articles published in *The Science Teacher,* results showed that authors of the practitioner papers preferred to present NOS aspect in a content-embedded way (%60 of the articles) (Aydin et al., 2013). The analysis of curriculum documents showed that NOS was integrated into the document by integrating the aspects into the topic covered (Şardağ, et al., 2014) Although the literature has suggested using both strategies, we think that embedding NOS aspects into the topic taught may be more helpful for learners and teachers to see the aspects in the context of the science and scientific inquiry. The new textbook authors preferred to integrate NOS aspect by relating them to the topic. Textbooks' integration of NOS is vital because those textbooks are easily accessible and commonly utilized sources for both learners and teachers. Therefore, it is important to integrate NOS into all topics covered in textbooks. We think that when NOS is included in science teaching and learning, learners would be more

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interested in science. Sometimes we, as science educators, witness to the question of "why do we have to learn all of the [atomic] theories rather than learning the correct one?" which indicates inadequate NOS understanding. When the textbooks include NOS aspects satisfactorily, we think that teachers will more probably mention tentative NOS and other aspects of NOS, and learners will stop asking that question and start to appreciate Rutherford's creativity in planning the alpha particle experiment, Bohr calculations, and develop a more positive attitude toward science.

To conclude, new Turkish high school chemistry textbooks showed some good changes regarding the number of NOS aspects issued, the use of explicit-reflective method, and use of HOS examples. However, it still needs some more NOS integration regarding the aspects. Additionally, the new reform-based textbooks should include more NOS activities for teachers to implement in class. Activities that help learners to understand NOS should be part of the textbooks. Given the usefulness of explicit emphasis of NOS in the curricular materials (Hanuscin, Lee, & Akerson, 2011), "curricular materials that model and support the implementation of instruction explicitly emphasizing these dynamic conceptions of NOS and SI [scientific inquiry] may likewise facilitate their [teachers'] translation into practice." (Bartos &Lederman, 2014, p.1178) Moreover, HOS cases should be enriched the textbooks. The real experiences that scientists had in the past would be real and enlightening examples both for learners and teachers. In terms of the approach used, explicit-reflective approach was suggested by the literature. However, new textbooks provided more implicit NOS aspects than the explicit ones. The authors and publishers should be careful about this point and make necessary changes to offer more explicit ones. Finally, regarding the content-embeddness, the authors of new textbooks embedded NOS aspects to the topics covered, which may be useful for learners to see the connection of the aspects and the chemistry topics that they learn. New textbooks have shown very good development but some more work is necessary regarding the quality of integrating NOS into the textbooks as well (i.e., the explicit reflective NOS activities, HOS examples, etc.)

In this research, we studied on the integration of NOS into the high school chemistry textbooks used in Turkey. The results presented are limited to the textbooks analyzed. Therefore, how and to what extend chemistry teachers use them in class is still a question, which is one of the limitations of this study. The enacted curriculum should be focused because teachers are not very enthusiastic to emphasize NOS especially when the education system is dominated by high stake exams. It is not very realistic to reach the goal of educating scientifically literate citizens by only teaching science content. Therefore, teachers' use of the HOS examples and other activities should be examined. Additionally, the difficulties that teachers face with for integrating NOS into their teaching should be focused on.

In the science textbooks, science and the scientists' nature, how science and society influence each other, and science and technology relations should be accurately presented (Koseoglu, et al. 2003). To attain the goal, as Niaz and Maza (2011) and Abd-el-Khalick et al. (2008) stated, not only researchers but also textbook authors and publishers should understand the importance of NOS emphasis. The authors and publishers should be informed about the role of NOS in educating scientifically literature generations. To achieve that, the groups (i.e., researchers, curriculum makers, authors, and publishers) come together and share their ideas and concerns about the topic. Furthermore, to increase the quality of science textbooks, the criteria list should include NOS integration, which increases the probability of attracting authors and publishers' attention on NOS and its integration into the textbooks.

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