AN ANALYSIS OF THE EARTH SCIENCE CHAPTER IN THE OFFICIAL TURKISH FIFTH GRADE SCIENCE TEXTBOOK REVISED IN 2013

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Abstract

Muhammet Emin Mısır, “An Analysis of the Earth Science Chapter in the Official Turkish Fifth Grade Science Textbook Revised in 2013”

Earth science education aims not only improvement of scientific literacy but also teaching domain specific characters of earth science. Textbooks have important roles in earth science education. The purpose of the study was to analyze the earth science chapter of the 5th grade science textbook in Turkey in terms of earth science literacy (ESL) and science literacy (SL). In this study, quantitative analysis method was used. SL framework consists of four main themes; science as a body of knowledge, science as a way of investigating, science as a way of thinking and the interaction among science, technology, and society”. Moreover, ESL framework involves six themes which are geological time, spatial thinking, holistic system thinking, fieldwork, knowledge of earth science and earth science, technology and society. The SL framework was retrieved from the science education literature. The ESL framework was developed by the researcher based on the earth science literature. The data analyzed in accordance with frameworks of SL and ESL by two independent researchers. The results showed that the “fieldwork” theme of ESL was most emphasized in the earth science chapter. Moreover, it was found that some of the domain characteristics of earth science education such as geological time, spatial thinking, holistic system thinking were inadequately emphasized. The results also indicated that “science as a body of knowledge” theme was the most emphasized whereas the “scientific thinking” theme was not emphasized adequately. This study will be one of the guides about science textbooks for textbook preparation commission, science educators and teachers.

Tez Özeti

Muhammet Emin Mısır, "An Analysis of the Earth Science Chapter in the Official Turkish Fifth Grade Science Textbook Revised in 2013"

Dünya'yı anlamak ve sınırlı kaynaklarının etkili kullanımını sağlamak için yerbilimi eğitimi önem arz etmektedir. Bu sebeple, yerbilimi okuryazarı olan bir toplum oluşturmak gerekmektedir. Yerbilimi eğitiminde kitaplar önemli bir yere sahiptir. Bu çalışmada 5. Sınıf Fen Bilimleri Ders Kitabı'nın yerbilimleriyle ilgili konuları işlediği ünitesinin fen okuryazarlığı ve yerbilimi okuryazarlığı açısından incelemesi yapılmıştır. Ünitede bilim okuryazarlığı için 4 ana tema olan "bilimsel bilgi, araştırma yöntemi olarak bilim, bilimsel düşünme ve bilim, teknoloji ve toplum arası etkileşim" analiz edildi. Ünitedeki yerbilimi okuryazarlığı için de 6 ana tema olan "jeolojik zaman, uzamsal düşünme, bütüncül sistem düşünme, alan çalışması, yerbilim bilgisi ve yerbilim, teknoloji ve toplum ilişkisi" analiz edildi. Bu çalışmada nicel araştırma yöntemi kullanılmıştır. Bilim okuryazarlığı için fen eğitimi literatüründen bir çerçeve elde edilmiştir. Yerbilimi okuryazarlığı içinse yerbilimi literatürüne bağlı kalarak araştırmacı tarafından çerçeve oluşturulmuştur. Veriler bu çerçeveler ışında iki farklı araştırmacı tarafından toplanmıştır. Sonuç olarak görülmektedir ki, bu ünitede yerbilimi okuryazarlığı temaları arasında en çok öne çıkan "alan çalışması" olmuştur. Bunun yanında, yerbilimi alanına özgü olan "jeolojik zaman, uzamsal düşünme ve bütüncül sistem düşünme temaları çok fazla vurgulanmamıştır. Bilim okuryazarlığı temaları arasında ise "bilimsel bilgi" teması en yüksek vurguya sahiptir. Bilimsel düşünme teması ise en az vurgulanan olmuştur. Bu araştırma sonuçlarıyla kitap hazırlama komitesine, fen eğitimi öğretim görevlilerine ve fen öğretmenlerine ışık tutacaktır.

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CONTENTS

CHAPTER 1

INTRODUCTION

The importance of earth science education is increasing in science education in several countries such as USA, Israel, Germany and UK (King, 2010). It is indicated that our lives and future depend on the understanding and appreciation of home planet. Earth science education is the only way that students understand and appreciate the complex systems of earth (American Geosciences Institute [AGI], 2004). Since earth science literacy is essential for "the ability of civilization to make decisions, is a source of culture, is of high utility in developing fundamental human skills" (Kastens & Manduca, 2012, p. 207), it should have a fundamental place in curriculum and so in textbooks.

Earth science education is part of science education in many countries (National Curriculum for Science in England, 2013; Next Generation Science Standards, 2013). In Turkey, it is also covered under the life science and science education curriculum in elementary (1st to 4th grades) and middle school years (5th to 8th grades). In each grade, there is at least one objective related to earth science education. In 5th, 6th, 7th and 8th grades, there is a specific chapter in science textbooks to teach earth science objectives. Thus, topics of earth science education such as "earth's crust", "earth, moon and the sun", "solar system", and "earthquakes and weather and climate events" have been taught at the primary and middle school years (Ministry of National Education [MoNE], 2013a, p. 11). In Turkey, the whole science education curriculum has been reformed in 2013. With this reform movement, MoNE has started to revise the content of science education. As a part of the reform movement, new textbooks has been started to be prepared for each grade. In this regard, 5th grade science education textbook which includes an earth science chapter has been changed in 2013-2014. The earth science chapter of 5th grade science textbook is crucial in terms of its content, emphasis and allocated time. It involves basic concepts and core subjects of earth science such as formation of earth's crust, events occurring on earth's crust and soil, water and air pollution. Moreover, the percentage of the earth science related objectives is the highest in this grade comparing to other grades in primary and middle school curriculum. Similarly the allocated time for earth science chapter is the highest in this grade. Considering the allocated time, number and the content of objectives, it is argued that 5th grade earth science chapter forms an important part of earth science and science education in middle school years.

Earth science chapters being part of science textbooks should support one of the main aims of science education; that is science literacy. Science literacy is mainly related to "scientific knowledge, attitudes, and skills that an individual needs in order to function effectively in our present-day world" (Chiappetta, Fillman & Sethna, 2004, p. 2.). Köseoğlu, Budak and Tümay (2003) states in the improvement of science literacy, textbooks are indispensable because they are expected to lead to efficient, prominent and long-lasting learning of science. Başlantı (2000) also emphasizes that the quality of science textbook shapes up the science instruction in class. Moreover, the contents of science textbook affect perceptions of students and teachers about science (Chiappetta, Fillman & Sethna, 2004). Irez (2008) states that science textbooks are thought to be used as a mine of nearly all information.

Another aim of earth science chapters in science textbooks is to teach earth science literacy. Earth science literacy involves understanding of core knowledge of earth science and domain specific characters of earth science such as geological time, spatial thinking, holistic system thinking and fieldwork studies. There are limited studies about the representation of the domain specific characters and concepts of earth science in textbooks. For instance, Decker, Summers and Barrow (2007) made a textbook analysis about one of earth science literacy themes i.e. geological time in biology textbooks. As a result, they found that all the texts refer geological time as “order of major geological events” or “length of a geological event” (p. 404). In another study, King (2010) examined the earth science misconceptions in secondary science textbooks. In the result of the study, more than 500 examples of misconceptions, which are very high, were determined in the earth science texts in the textbooks. For instance, misconceptions about the dating of the formation of the Earth and the formation of life are common. In Turkey, it could not be found any single study focusing directly upon reviewing themes of earth science in textbooks.

In this study earth science chapter of 5th grade science textbook was analyzed in terms of earth science literacy and science literacy. For this reason, earth science education literature, representations of science literacy and earth science literacy in science education textbooks were reviewed.

Purpose of the Study

The purpose of the study is to analyze the earth science chapter of 5th grade science textbooks in terms of earth science literacy and science literacy. Hence, how science literacy and earth science literacy are represented in the earth science chapter of 5th grade textbooks is described and discussed in the light of related literature.

In order to analyze science literacy in earth science chapter, an analytical framework developed by Chiappetta, Fillman and Sethna (2004, p. 2) was used. In this framework, there are four main themes "(a) science as a body of knowledge, (b) science as a way of investigating, (c) science as a way of thinking and (d) the interaction among science, technology, and society". The framework is commonly used in textbook analysis in the literature nationally and internationally (e.g., Başlantı, 2000; Chabalengula and Mumba, 2008; Erdoğan & Köseoğlu, 2012; Udeani, 2013; Vesterinen, Aksela & Lavonen, 2013). For the analysis, each complete paragraph, question, figure and table with caption in the earth science chapter of the 5th grade science textbook was chosen as unit of analysis and coded as suggested in manuscript of Chiappetta, Fillman and Sethna (2004).

Moreover, earth science chapter was analyzed in terms of earth science literacy. In order to do this analysis, a framework was developed by the researcher based on the earth science literature and the framework of Chiappetta, Fillman and Sethna (2004). The framework involved the themes which are (a) geological time (Chaochen, Hoare & Ravn, 1991; Decker, Summers and Borrow, 2007; Dodick & Orion, 2003; King, 2008), (b) spatial thinking (Manduca & Mogk, 2006; Reynold et al., 2005; King, 2010), (c) holistic system thinking (Assaraf & Orion, 2005; Kastens & Manduca, 2012; King, 2008; Orion, 2002), (d) fieldwork (Edelson, Salierno & Sherin, 2006; King, 2008), (e) body of earth science knowledge (Dal, 2009; King, 2008, 2010) and (f) the interaction among earth science, society and technology (Assaraf & Orion, 2005; Kastens & Manduca, 2012). For the analysis, each complete paragraph, question, figure and table with caption in the earth science chapter of the

5th grade science was selected as unit of analysis again. As suggested in the framework of Chiappetta, Fillman and Sethna (2004), the frequencies in each theme was detected to be interpreted by two different researchers. Then, inter-rater analysis was calculated to test the reliability of the analysis.

Research Questions

Specifically, the following research questions drove the study:

1. To what extent does the earth science chapter of the 5th grade science textbook in Turkey represent the science literacy themes?
2. To what extent earth science literacy does earth science chapter of 5th grade science textbook in Turkey represent the earth science literacy themes?

Significance of the Study

This study is about the representations of science literacy and earth science literacy in earth science chapter of the 5th grade science education textbook in Turkey. In this section, first, the importance of earth science literacy and science literacy is presented. Second, significance of textbook analysis is discussed. Third, the significance of 5th grade earth science chapter in earth science education is explained.

Lewis and Baker (2010) claims that ESL helps understanding of environmental issues, disaster preparedness, and sensible resource use. Bralower, Feiss, and Manduca (2008) also states that earth science is indispensable to understand crucial global threats in the coming century: “shortages of water (potable and otherwise), declining availability of fossil fuels, coastal inundation, the literal collapse of ecosystems, and of course, global warming—to name the obvious" (p. 20). There are many difficult decisions that governments have to make concerning earth science related complex issues such as dwindling energy, mineral resources, water shortages and changing global climate. We need citizens and governments that are earth science literate to create policies that appropriately value the importance of resource conservation, use, and sustainability (Earth Science Literacy Initiative, 2010, p. 1). That is to say, although earth science studies seem to be within the borders of interest and expertise of geoscientists, ESL is also a public necessity (Wysession & Rowan, 2013). ESL emphasizes taking action of citizens about the treats for earth. Manduca and Kastens (2012) moot the importance of teaching earth science and creating public awareness about it. They remark that earth science learning and taking action about earth are crucial in sustainability of life and humanity (Kastens & Manduca, 2012). At schools, it must be priority to teach students earth system, its components and relationship between them, which seems possible only with developing ESL (Manduca & Mogk, 2006).

In many countries, earth science education is a part of science education. Therefore, earth science chapters in science textbooks also aim SL. It is vitally important to help students appreciate SL (Özgelen, 2010). In previous PISA frameworks (OECD, 1999, 2003, 2006), it is emphasized that SL is important at both national and international level in order to make the best decisions for ourselves, our community and earth. United Nations Environment Programme also states in the 2012 Annual Report that problems threatening humanity and world such as insufficient water and food, diseases, insufficient energy, climate change are possible to be handled with teaching SL (as cited in OECD 2015 Framework, 2013, p.3).

Science education community members put forth that a better public understanding of science depends upon the number of scientifically literate people in a society (Özgelen, Yılmaz-Tüzün & Hanuscin, 2013).

ESL and SL are important for citizens and societies. For improvement of ESL and SL, textbooks are indispensable because they are expected to lead efficient, prominent and long-lasting learning of science (Köseoğlu, Budak & Tümay, 2003). That is why; the efficiency of textbooks is important. Başlantı (2000) emphasizes that the quality of science textbook shapes up the science instruction in class. The most important way of deciding quality of textbooks is textbook analysis. Alamri (2008) describes the textbook analysis as systematic analysis of the text materials. Textbook analysis is especially important in countries like Turkey where the compulsory and main source of education is textbooks (Özkan, 2013). "A textbook should be kept under close review as to its physical appearance, design and illustration, objectives, content, flexibility, teachability, teaching methods, practicing and testing" (Alamri, 2008, p. 2). Moreover, textbook analysis can determine whether a textbook meets learning goals of science and earth science education. Alongside with these, each chapter is supposed to have certain pedagogic characteristics (Kontozi, 2013). For instance, Ladue (2013) claims that earth science chapters in a textbook require more visuals, images, schemas and other kinds of organizational components like letter sizes and type fonts. With the help of textbook analysis, researchers reveal whether pedagogical characteristics exist.

King (2008) suggested that earth science component in science textbooks should be under regular review by researchers. These reviews make pressure on commission of textbook preparation towards improving the quality and content of earth science units in textbooks. In other words, the experts who decide upon the changes on textbooks can see deficits of textbooks and make their policy according to the textbook analysis. Additionally, textbook analysis helps science educators compensate their knowledge deficits and makes them realize the significance of components in units. This realization guides teachers about the relations between the subjects, establishment of cognitive maps within the issues, and causes of misconceptions about the topics.

Since there are very few studies conducted on analysis of earth science in textbooks in the literature; conducting a study on this subject helps to fill in the research gap. In Turkey, general science textbooks have been analyzed from various aspects such as gender (Özdoğru et al. 2004, Özkan, 2013), science literacy and nature of science (Kahveci, 2009), physical structure and linguistic (Aycan, Kaynar, Türkoğuz & Arı, 2002), content, analogy (Dikmenli & Kıray, 2007). However, no study has been found focusing directly upon themes of earth science in textbooks in Turkey. The concern about the gap of earth science issues studies is not limited to Turkey. Lewis and Baker (2009) also stated that they could not find "any studies that directly related to the issue of advancing geoscience education as part of scientific literacy" (p. 122). Even Chris King who is really dedicated to expand our earth science literacy and regarded as one of the first chief researchers in the field of earth science, he has not examined how earth science literacy are covered in textbooks. The textbook aspect of earth science has been underestimated or ignored and put on one side after all other crucial things.

In this study, the recently (in 2013) published 5th grade science textbook has been examined in terms of the domain specific characteristics of earth science. The reason for choosing 5th grade science textbook is the significance of 5th grade curriculum in earth science education. 5th grade science curriculum has the highest percentage of earth science objectives compared to other grades in elementary and middle years. Moreover, the highest amount of time is allocated to earth science chapter at this grade. Briefly, students deal with earth science subject in 5th grade more than any other grades in middle school in terms of amount of time and number of objectives. This creates opportunity to get familiar with earth science issues at this level of education. High number of objectives included in the curriculum requires that students are expected to reach more learning outcomes in terms of knowledge, skills and competences related to earth science.

5th grade is the stage where students seriously start to compose and build an understanding of earth science. Basic concepts and core subjects of earth science are taught at 5th grade such as formation of earth's crust, events occurring on earth's crust and soil, water and air pollution. At this stage they learn about earth science concepts, materials and terms. They also internally develop an appreciation of earth science when they start to understand the events which occur around their surroundings and affect their daily life. Table 1 shows the learning objectives determined by MoNE (2013a) for the 5th grade earth science education.

Table 1. Learning Goals of Earth Science Unit in 5th Grade Science Curriculum

5.7.1.1	Students know that the earth's crust is made up of rocks.
5.7.1.2	Students make an association between rocks and mines and discuss the importance of mines as a technological raw material.
5.7.1.3	Students investigate and present the formation of fossils and its types.
5.7.1.4	Students understand that the study of fossils is a discipline and they know what experts of this area are called.
5.7.1.5	Students give examples of natural monuments and they discuss their importance as a cultural heritage.
5.7.1.6	Students make offerings for protecting and transferring natural monuments to next generation.
5.7.2.1	Students explain the difference between erosion and land slip and they predict the possible consequences of erosion in the future.
5.7.2.2	Students offer solutions for protecting the land from adverse effects of erosion.
5.7.3.1	Students give examples of surface and grand water and they explain their area of usage.
5.7.4.1	Students discuss the reasons of air, water and soil pollution, the adverse effects they will lead and possible precautions to be taken.

It is also important to point out that this study also aims to find out to what extent the science literacy represented in the 5th grade science textbook prepared in accordance with the new curriculum (MoNE, 2013b). The MoNE has made a recent reform on educational programs at primary, middle and high school levels. This reform includes the revision of science education curriculum from third to eight grades. Although the curriculum change starts at the science programs of all levels from third to eight, only fifth grade science textbook has been prepared and used in 2013-2014 education year. Thus, the analysis of 5th grade science textbook is also important to discuss the outcomes of the last reform in science education.

When considering aforementioned reasons, it clearly appears that analysis of 5th grade science textbooks in terms of science and earth science (geoscience) literacy is valuable and necessary in order to discuss earth science education in Turkey. This study is one of the first studies in Turkey which focuses on significance of earth science education and earth science literacy. Moreover, it is immediate to reveal how the new published textbook conveys the message about science and earth science literacy after the 2013-2014 reform movement. It also creates awareness on the neglected aspects of science and earth science literacy. In other words, this study also aims to guide science teachers for being aware of earth science themes which have been determined by geoscience researchers in order to teach in their science courses. It is expected that this study may attract the attention of policy-makers, science educators and teachers to take action about preparation of earth science textbooks. This study is one of the first studies in Turkey which focuses on significance of earth science education and earth science literacy.

CHAPTER 2

REVIEW OF THE LITERATURE

This chapter first presents the literature related to earth science education. It involves definition of earth science, earth science education, changes and revisions in earth science education, position of earth science education in Turkey and worldwide. Second part focuses on the textbook analysis in science and earth science education. It also emphases two main aims of earth science education namely science literacy and earth science literacy. Moreover, it presents the research related to textbook analysis in terms of science and earth science literacy.

Definition of Earth Science

This section makes a general description of earth science, its content and its role in our understanding of earth. In the literature, there exist various definitions of earth science, which emphasize on different aspects of it. Basically, earth science can be defined as building an understanding of what the earth is, how its systems work, and how it evolved to its current state (Adams & Lambert, 2006; Dal, 2009). McLelland (2011) also describes Earth science as “the study of the physical Earth, from the outer reaches of the atmosphere to the center of the planet, including all the interrelationships between atmosphere, water, and rock” (p.6).

Earth science also addresses complex real-world problems (Bralower, Feiss, and Manduca, 2008; Michigan State Board of Education, 2006) such as "crucial global threats in the coming century: shortages of water, declining availability of fossil fuels, coastal inundation, the literal collapse of ecosystems and global warming" (Manduca, 2008, p. 20). Moreover, production, availability, and potential depletion of natural resources which directly affect economy, security, and the safety and sustainability of the environment are the other problems which are addressed by earth science (The Geological Society of America, 2011). AGI (2011) states that earth science allows global thinking and local acting. This principle refers to the idea of protecting the health of entire planet while taking actions in own local community. This is the principle which should lead our attitude towards the issues of earth and environment. To promote deeper understanding of earth, global threats and events should be within our interest and also we should put into practice global thinking by acting locally in our society.

Earth scientists like Engelhardt & Zimmermann (1988), King (2008), Bralower, et al. (2008), and Heenan, Nowlan and Clinton (2010) refrain from defining earth science; they rather point to interdisciplinary aspects of earth science. To make it clear, many disciplines such as mathematics, computer science, chemistry, and physical sciences (such as forces, energy and magnetism)have been utilized together in order to understand the size, age, composition, structure and behavior of the earth. Likewise, it is possible to claim that life sciences are partially born from earth since earth is the only planet which has biological activities and a proper understanding of earth requires the knowledge of life sciences. In addition, geography is another branch of science dealing with earth surface (National Research Council, 2012) and it helps the formation of knowledge of earth. In other words, earth science is an interdisciplinary area which requires the utilization of biology, chemistry, mathematics, computer science, physics and geography. However, the earth science incorporates certain components and contents unique to itself which differentiate this discipline from others. Engelhardt and Zimmerman (1988) exemplify these components and contents as “earth, its components, its historical development, the history of life upon it, as well as all these in relation to other planetary bodies” (p. 1). Additionally, National Research Council (2012, p. 171) claims that following issues showed in the Table 2 are included within earth science content.

Table 2. Earth Science Content in National Research Council Framework (2012)

Earth’s Place in the Universe	Structure, composition, and history of the universe, the forces and processes by which the solar system operates. Earth’s planetary history
Earth’s Systems	The processes that drive Earth’s conditions and its continual evolution (i.e., change over time), The planet’s large-scale structure and composition, describes its individual systems, and explains how they are interrelated. Mechanisms driving Earth’s internal motions and vital role that water plays in all of the planet’s systems and surface processes.
Earth and Human Activity	Society’s interactions with the planet. How Earth’s processes affect people through natural resources and natural hazards, Humanity in turn affects Earth’s processes.

In order to illustrate earth science, it is a requirement to determine what kind of attributes and characteristics earth science has, what identifies it and what it is most commonly referred with. King (2008) stated that earth science should make use of a wide range of methodologies, develop holistic systems thinking involving consideration of major Earth systems. For instance exploring the components of the water cycle provides the students with an understanding of the interrelationships between the earth systems and man (Assaraf& Orion, 2005).Moreover, it should require high level spatial (three dimensional) ability thinking. He also claims that "earth science should develop time perspective (geological time) and incorporate the strategies and methodologies ranging from particular observational and recording skills to the high level analysis and synthesis skills" (p. 189).

Another study by Kastens and Manduca (2012) came up with four central themes of earth science which are geologic time, spatial thinking, teaching in the field and complex interacting systems. In spite of the "critical importance of geological time, there is relatively little attention given to it by researchers in the field of cognition or science education" (Dodick & Orion, 2003, p. 7). Geologic time is "understanding earth's geological event as a sequential series" (Karahan, Nam, Roehrig & Moore, 2012, p. 3159). According to Trend (1998), geologic time provides framework into which geological events and other phenomena can be located. Understanding earth system and its events require geologic time, for example understanding of geologic time is the key point to decide upon the important climate change debate whether the global climate change is due to human effect or natural cycle (Karahan, Nam, Roehrig and Moore, 2012). However, in some studies it is found that students do not have necessary knowledge of absolute time of earth geologic events (Libarkin & Anderson, 2005; Trend, 2001).

Spatial thinking appears to be the second theme of earth science. National Research Council (2006) defines spatial thinking as a thinking which attempts to find meaning in the shape, size, orientation, location, direction or trajectory, of objects, processes or phenomena, or the relative positions in space of multiple objects, processes or phenomena. Kastens and Ishikawa (2006) emphasizes that both learners and instructors need to have the extensive spatial thinking skills in order to grasp the meaning of earth science. Kastens and Manduca's (2012) concept of spatial thinking refers to the same meaning as the concept of three dimensional thinking in studies of Gaspersz (1999) and Orion, Ben-Chaim and Kall (1997).

The third theme of earth science is claimed as teaching in the field. Marques, Praia & Marques, Praia and Kempa (2003) states that fieldwork in earth science is just as important as laboratory work in the context of education in the physical sciences. Earth science demands teaching in the field for understanding of earth science. King (2008) claims that geoscience fieldwork has its own distinctive attributes which requires the development of particular skills and techniques. These skills and techniques are possible to be attained via teaching in the field and explained as in the following:

- developing intellectual skills and abilities,
- developing practical skills and abilities,
- mastering practical techniques,
- developing interests and attitudes. (Thompson, 1982, as cited in King, 2008, p. 201)

Teaching in the field requires setting clear learning objectives and carefully planning and selecting the experiences students should have. Practitioners in the field should take into account educational aims, time available, distance, student readiness, and availability of localities and resources (Lonergan & Andresen, 2006).

On the other hand there is a disagreement between scientists to place earth science whether into social studies (geography) or natural science (Heenan, Nowlan & Clinton, 2010). This situation also affects teaching of the earth science issues. For instance, in Turkish primary and elementary schools the earth science issues are placed in science courses. In high school schools, they are taught in geography classes. However, in universities separate earth science courses are taught by geological engineers or instructors from social sciences departments.

Earth Science Education

The Geological Society of America (2011) pays great attention to the importance of teaching earth science because the production, availability, and potential depletion of natural resources directly affect economy, security, and the safety and sustainability of the environment. Therefore, there is a great need to understand the reasons and potential societal results of natural Earth processes (The Geological Society of America Report, 2011). Only through earth science education can students understand complex interacting systems of the planet (Kastens & Manduca, 2012). Bralower, Feiss and Manduca (2008) also stated that earth science education is "vital to understanding crucial global threats in the coming century: shortages of water (potable and otherwise), declining availability of fossil fuels, coastal inundation, the literal collapse of ecosystems, and of course, global warming—to name the obvious" (p. 20).

Barstow et al. (2001) point to the significance of earth science education with its establishing a relationship between earth and students. They claim that earth science is closely related to the students' natural surroundings, which means that students are always in touch with the earth. This point also is emphasized by LaDue and Clark (2012).It offers students subject matter which has direct application to their lives. Earth science education also develops skills that help students become better problem solvers. Problem solving includes three-dimensional analysis and comprehension of time and scale (AGI, 2011, King, 2008).

Earth science deals with crucial concepts like geological time and vastness of space which are mostly neglected in curriculum of other science disciplines. Geological time is "vast amount of time available for geological events and the sequencing of events" (King, 2008) and understanding of it is important in order to understand humans' effect on earth and earth's to humans (Earth Science Literacy Initiative, 2010). Civilization relies on utilization of earth's energy, mineral, and human resources and civilization requires awareness of natural phenomena such as floods, tornadoes, hurricanes, volcanoes, and earthquakes which make earth science education highly significant for today and future.

Earth Science Education Worldwide

In the history of science, a series of revolutions which have greatly influenced people's understanding of universe has been done such as Copernican-Galilean redefinition of earth and universe and Darwinian revolution (Dodick & Orion, 2003). AGI (2004) suggests that earth science education should "be included in science curriculum at all grades, be offered as a core credit science course for high school graduation, and be assessed through state-mandated science tests and exit exams" (p. 1).

However, earth science has been seen as a minor and neglected science (Hoffman & Barstow, 2007). Schumm (1991) states that the main reason for this neglect is about the fact that geology has often been depicted as a derivative science since its methodology and logic were provided by the physical sciences (Schumm, 1991). With respect to school curriculum, earth science still seems to be neglected as it is covered in a very narrow sense (Lewis & Baker, 2010). The root of bringing the Earth science to the curriculum of formal school education lay in the 1950-1960 reform movement in USA. To make it clear, there existed a curriculum reform movement of the 1950's and 60's in America, one of the reason for that was Soviet launch of Sputnik- beat America in the space race (DeBoer, 1991). After surprise launch of Sputnik, USA government revised especially science curriculum and then the number of Ph.D.s in science including earth sciences doubled every 6.2 years during this period (Kaiser, 2002). That is to say; the space shuttle drove the physical science and earth and space science forward. After revealing importance of earth science, earth science education immediately took its place on the agenda by the education policy makers and researchers.

Earth science has been part of science curriculum in schools for more than 100 years without getting attention it deserves. There is a common view among people which assumes that science education comprises of only biology, chemistry, and physics disciplines (AGI, 2004). Lately the view of earth science as a neglected discipline is changing. In other words, earth science education has made a big proceed recently and undergone a remarkable transformation (AGI, 2010) by some initiatives such as Blueprint for Change: Report from the National Conference on the Revolution on Earth and Space Science Education, and the Benchmarks for Scientific Literacy (Lewis & Baker, 2010). Also learners' poor achievement in earth science tests in the Trends in International Mathematics and Science Study (TIMSS) and the Programme for International Student Assessment (PISA) leads to discomfort and trouble about science education in society among science educators. This low achievement draws the attention of policy makers to take action about earth science (Lewis & Baker, 2010). In order to improve TIMSS and PISA results, the policy-makers attempt to come up with solutions to national educational issues and promote their international test results (Riley, 2003). These international tests also draw their attention to the fact that the science education is comprised of distinct disciplines and each component of science education should be taken into consideration. TIMSS makes a category of main components of science education as: “Life Science, Physical Science and Earth Science” for 4^{th} grade and “Biology, Chemistry, Physics and Earth Science” for 8^{th} science (OECD 2015 Framework, 2013).In PISA science framework (2012), subjects of science are physics, chemistry, biology and earth science.

Other impulses to the changes in curricula of earth science have been driven by externally by organizations such as the American Geosciences Institute, the National Science Foundation and the U.S. Department of Education (Lewis & Baker, 2010) and lastly Next Generation Science Standards. Besides that, change in the curricula lead to a change in general goal of science education internally. To make it clear, science education aims the main goal of “Science for All” in the last decades all over the world. During this period the goal has shifted from preparing future scientists toward educating our future citizens, that shift and science literacy required the earth science literate citizens (Assaraf & Orion, 2005).

Earth science has grasped wide attention in many countries because it is understood that our lives and future depend on the depth of our understanding of our home planet. It is now very pleasing that many countries are revising their earth science standards and curricula (Hoffman & Barstow, 2007). King (2010) also summarized the current status of geoscience education at schools worldwide.

According to this summary, geoscience is taught either as a compulsory (e.g., UK, Japan, and Korea) or as an optional course (e.g., Brazil, Portugal, and Taiwan). Moreover, mostly it is part of a national science curriculum or national geography curriculum whereas in African countries, it can be taught under any field. Earth science education is gaining increasing prominence within school science curriculum worldwide (King, 2010). On the other hand, as stated in TIMSS Science Framework (2011), there exists no standard and universally applicable earth science curriculum. For instance, in science curriculum of United States, it is up to the decision of Next Generation Science Standards [NGSS] (2013) to determine what subjects earth science education should cover. For the 5th grades, the content of earth science should consist of the themes "earth materials and systems: plate tectonics and large-scale system interactions, the roles of water in earth's surface processes, weather and climate, natural resources, natural hazards, human impacts on earth systems, global climate change." (NGSS, 2013, p. 8)

In England, National Curriculum for Science in England (2013) suggests that the earth science related topics should cover "the sun, earth and moon and shape of earth, movement of earth, plate tectonic interactive and dynamic rock cycle" (p. 170). In Turkey, earth science in curriculum of 5th grade comprises of following topics which constitutes the content of earth science education: "classification of igneous rock, minerals and technology, fossils reflecting history of earth, soil types and erosion, surface and ground waters, natural monuments of earth's crust" (MoNE, 2013a, p. 20). So, the content of earth science education for a specific grade may have differences in different countries. In other words, there is no common practice determined for each level in earth science education.

Earth Science Education in Turkey

Like in all grades and courses in pre-higher education in Turkey, selection and provision of textbooks is within the authority of MoNE. In middle schools of Turkey, curriculum has been developed according to broad-fields curriculum design which combines two or more related disciplines into a single broad field of study and stresses important generalizations (Nyagah, 2010).Physics, Biology, Chemistry and Earth Science are all combined into a single science textbook (Irez, 2008), which is the same as U.K. (King, 2010). However, in Turkey when students start high school education, all other subjects are regarded and taught as separate disciplines except for Earth science. This situation unfortunately justifies the view of Schumm (1991) that students might form an opinion that earth science is a neglected discipline. In each grade of middle school, there is one chapter focusing on earth science topics. In order to have a qualified earth science education, this chapter should be well-organized, coherent and include relevant scientific knowledge.

In Turkey, earth science education begins at the elementary 1st grade. However, in this process the lesson is not called as earth science. At 1st and 2nd grade classes, earth science issues are studied in Life Sciences (Hayat Bilgisi) courses. In first grade Life Sciences textbook, there are only 5 objectives related to earth science out of a total 86 objectives in all units. In the second grade Life Sciences textbooks, 4 out of 95 objectives are related to earth science subjects. In 3rd grade, the course is called as science education. 3rd grade science textbook has 3 out of 32 objectives for the earth science. In 4th grade science education curriculum, there exists just 1 out of 46 objectives related to earth science. The frequencies and percentage of earth science objectives are shown in Table 3. There is very limited number of earth science objectives in elementary school. A comprehensive teaching of earth science is not taking place in elementary school.

Table 3. Grades, Total Number of Objectives, Number and Percentage of Earth Science Objectives

Grade	Number of Earth Science Objectives	Total Number of Objectives	Percentage
1	5	86	5.81
2	4	95	4.21
3	3	32	9.37
4	1	46	2.17

Earth science issues are taught under the course of science education in middle school from 5th grade to 8th grade. In science education textbook of 5th grade, 10 objectives belong to earth science issues out of 44 objectives. 4 out of 52 objectives in 6th grade, 9 out of 78 objectives in 7th grade and 16 out of 78 objectives in 8th grade belong to earth science unit. The frequencies and percentage of earth science objectives are shown in Table 4.

Table 4. Grades, Number and Percentage of Earth Science Objectives and Allocated Time for Earth Science Unit

Grade	Number of Earth Science related Objectives	Total Number of Objectives	Percentage of the Objectives	Allocated Time for the Objectives (Lesson hour)
5	10	44	22.7	24
6	4	52	7.69	16
7	9	78	11.5	16
8	16	78	20.5	18

Table 4 shows that the highest percentage of earth science objectives and allocated time for earth science topics are at grade 5 and 8. In grade 5, basic concepts and core subjects of earth science such as formation of earth's crust, events occurring on earth's crust and soil, water and air pollution are taught. In 8th grade, earthquakes, weather and climate events, and formation of seasons are covered as topics of earth science. MoNE (2013a) has made a recent reform in science education curriculum. With this reform movement, textbook of 5th grade science education has changed and newly published. On the other hand, 8th grade science textbook has not been published yet. Thus, it appears more beneficial to analyze 5th grade science education textbook.

At high schools in Turkey, disciplines of science are taught as separate courses like physics, chemistry and biology; however limited number of earth science is taught under the course of geography and physics in an isolated way. That is; there is no systematic teaching of earth science in high schools.

In science teacher education, geoscience still stays as an ignored and underestimated area. As in the USA, the current picture of geoscience courses in Turkey does not seem promising. Although science teachers are responsible to teach earth science chapters in science education curriculum, pre-service teachers take at most one course of earth science. Moreover, there is no standard procedure about course's being elective or must. Also, there is no agreement on which field of expertise is eligible for this course. The Turkish Council of Higher Education (CoHE) promulgated the content of teacher education programs for universities in 2007. Earth science course was signed as one main course for science education teachers. However, in practice there is no common approach. For instance, earth science is a course given by geological engineers in both Hacettepe and Mersin University. In Hacettepe university, it is an elective course; however, in Mersin University, it is a must course. In Uludağ University and Giresun University, the earth science course is given as a must course by instructors from the department of

Social Science. In Boğaziçi University, Middle East Technical University and Yıldız Technical University, for science education students there is no must course called as "Earth Science".

In spite of these differences between universities about department and status of course, the content of these courses generally include the following content since the Turkish CoHE (2007, p. 57) promulgated:

1. Structure of the earth and types of rocks
2. The knowledge related with minerals
3. The importance of external processes on the rock cycle
4. Geologic time and the relationship between geologic events and time
5. The conditions for the formation of rocks and their deformation processes
6. The fact of earthquake.

It is very unfortunate that earth science did not get attention it deserves in Turkey. It is very important that education of earth science should be emphasized more. Government should take necessary steps to develop geoscience educators in order to dissociate earth science and save it from living in the shadows of other disciplines. Geoscience educators have not been a profession in Turkey yet and it is a very novel area most people are still unfamiliar with. Earth science should have its own instructors, teaching methods, journals etc. In order to exemplify, when reviewed the journals in Turkey about earth science issues, it is clearly noticeable that there exists only journals of geological engineering departments. However, studies should be conducted on teaching of geoscience and education faculties should address the issue of geoscience in their academic publishing more. In fact, it is better if faculty of education becomes responsible and eligible for earth science teaching because education of a special subject also requires pedagogical knowledge of it (GSI, 2011).

Textbook Analysis in Science and Earth Science Education

Textbooks are the most referred teaching materials in education process at schools (Elgar, 2004; Kılıç & Seven, 2011; Özkan, 2013). Textbooks' importance is due to their multiple functional aspects for various components of teaching process such as learners, teachers and learning material. These aspects are their being primary knowledge source for learners (Lemmer, Edwards & Rapule, 2008), teaching methods and techniques for instructors (Kavaz, 2006) and content of instruction as learning material (Gök, 2012). For instance, Ünver (2009) states that students use textbooks as a primary sources in order to study and solve homework problems; therefore, information given in each textbook is absolutely significant to students' understanding of the concepts. Slough, McTigue, Kim, &Jennings (2010) claim that middle school teachers mostly teach their curricula heavily dependent on textbooks while there are multiple resources available to them.

Textbooks are irreplaceable with anything else as a source of knowledge from generation to generation in education process (Kavaz, 2006). Despite the wide use of technology based teaching materials, textbooks continue to play a very important role in education process, with their influence on teaching strategies that teachers employ in class and with their function of shaping teaching and learning activities (Sunar, 2011; DiGiuseppe, 2014). Textbooks are still most preferred for various reasons. Wilson (1997) lists these reasons as portability of textbook, the chance to have random access to contents of textbooks, textbook as a multimedia object due to its inclusion of text, but also graphics, drawings and photo-reproductions, its accessibility with no other expense such as an additional application or tool. McKenzie (1997) adds more reasons such as simplifying and condensing knowledge, organizing subject-matter in a clear way and synthesizing what science has cumulated so far. Additionally, Wellington (2001) describes multiple reasons for preference of textbooks over internet and multi-media like CD-ROM and online texts, which are easiness to read, portability, and less eye strain, and Chiappetta and Fillman (2007) also point to the aspect of textbooks which supplies proper organization of subject-matter at all levels of schooling. With guidance of a good textbook, teachers can keep ahead of most of their students and learn as they go (Hubisz, 2003). Especially in countries like Turkey where the compulsory and main source of education is textbooks, textbooks have very important place in learning and teaching process (Özkan, 2013). Both teachers and students spend a great deal of their preparation, class and homework time working with textbook materials (Lemmer, Edwards & Rapule, 2008).

Ünsal and Güneş (2002) stated that the quality of textbooks used in schools affect directly the quality of education given in schools. Until today, importance of textbooks has never decreased and they still the primary information source of teachers, students and parents (Aybek, Çetin & Başarır, 2014). Textbooks are indispensable teaching materials which serve the curricula subject methodically and direct the students to the goals of the course (Ünsal & Güneş, 2002).

From the science education perspective, textbooks have central role in teaching and learning science and earth science (Lemmer, Edwards & Rapule, 2008). Science teachers are heavily dependent to assigned textbooks to organize science courses and teach science knowledge (Chiappetta, Fillman & Sethna, 2004; Hubisz, 2003; Love & Pimm, 1996). Chiappetta, Fillman and Sethna (2004) also add that "in many instances, the science textbook forms a major part of a science course" (p. 2). The knowledge to be taught in class, homework assigned to students, graphics and tables, examples, experiments, evaluation and chapter assessment tests are all available in textbooks, which take most of the time in a science course. In England, the Government Council for Science and Technology conducted a general survey of 576 high school science teachers and it was found that 89% of them used science textbooks often (King, 2001).

The amount of textbook analysis research itself is a manifestation of the importance of textbooks as well (Elgar, 2004). Alamri (2008) states that textbook analysis is defined as systematic analysis of the text materials and a textbook should be kept under close review as to its appearance, designation and illustration, aims, content, teachability, teaching methods, practicing and evaluation. Cunningsworth (1995) claims that textbook analysis requires careful selection of materials examining whether they reflect the needs of the learners. Also he states that textbook analysis should examine the aims, methods and values of a specific teaching program. Okeffe (2013) also states that textbook analysis is highly valuable and indispensable tool for the promotion of school curricula. Kontozi (2013) asserts that textbook analysis has three major advantages: "it helps choosing the most suitable book for a specific context, it promotes teachers' awareness on the actual contents of a book and thirdly it facilitates policy makers to make necessary adaptations in textbook" (p. 1).

In literature, it is very common to find textbook analysis and evaluations in different fields. Previous studies reveal that there are wide variety of textbook studies in different areas such as mathematics teaching (Orton, 2004; Özgeldi & Esen, 2010), English language teaching (Lawrence, 2011), geography (Biilman, 1997), science (Dimopoulos, Koulaidis and Sklaveniti, 2005; Horris, 2014), biology

(Chiappetta & Fillman, 2007; Irez, 2009), physics (Rodriguez & Niaz, 2004; Park & Lavonen, 2013) and earth science (Decker, Summers & Barrow, 2007; King, 2013).

Moreover science textbooks are analyzed with respect to various variables such as general science textbooks have been analyzed from various aspects such as gender (Elgar, 2004), science literacy and nature of science (Chiappetta & Fillman, 2007), science vocabulary (Groves, 1995), content (Hubisz, 2003) and analogy (Dikmenli & Kıray, 2007).

In this study, science textbook analysis was done with respect to science literacy and earth science literacy.

Textbook Analysis in terms of Science Literacy

This part of the study focuses on a deeper understanding and explanation of science literacy and textbook analysis related to it.

Science literacy is a term which has popped out recently and gained value within a few decades. There have been many attempts among science education society in order to make a definition of science literacy in order to fully understand what it means (Holbrook & Rannikmae, 2009). Unfortunately, there exists no consensus about definition of scientific literacy (Hodson, 2008; Roberts, 2007). Even if there is not a consensus about definition, science education community agrees that scientific literacy should be an important outcome of schooling (Roth & Lee, 2005). As a term in science education, it has been in use since four decades and different meanings have been attributed to it by various members of science community (Holbrook & Rannikmae, 2009). This part of the study will attempt to collect the definitions and basic characteristic elements of science literacy in literature of science education.

National Research Council (1996) claims that scientific literacy means:

> that a person can ask, find, or determine answers to questions derived from curiosity about everyday experiences, that a person has the ability to describe, explain, and predict natural phenomena, the ability to read with understanding articles about science in the popular press and to engage in social conversation about the validity of the conclusions, that a person can identify scientific issues underlying national and local decisions and express positions that are scientifically and technologically informed. (p. 15)

According to the Council (2007), a literate citizen should be able to evaluate the quality of scientific data on the basis of its resource and the methods used to construct it. The Council also states that science literacy refers the capacity to find and evaluate arguments based on evidence and apply conclusions from scientific arguments appropriately. Chiappetta, Fillman and Sethna (2004) define science literacy "as the scientific knowledge, attitudes, and skills that an individual needs in order to function effectively in our present-day world" (p. 2). Kavaz (2006) asserts that a scientifically literate individual comprehends the relationship and interactions between science and technology, nature of science, scientific concepts, principles, laws and theories.

The Programme for International Student Assessment (PISA) defines scientific literacy as:

> An individual's scientific knowledge and use of that knowledge to identify questions, to acquire new knowledge, to explain scientific phenomena, and to draw evidence-based conclusions about science-related issues, understanding of the characteristic features of science as a form of human knowledge and enquiry, awareness of how science and technology shape our material, intellectual, and cultural environments, and willingness to engage in science-related issues, and with the issues of science, as a reflective citizen. (OECD, 2009, p.14)

In previous PISA frameworks (OECD, 1999; OECD, 2003 & OECD, 2006), it is always emphasized that science literacy is vital at both national and international level in order to make the best decisions for ourselves, our families, our community and environment. United Nations Environment Programme states in the 2012 Annual Report that problems threatening humanity and world such as insufficient water and food, diseases, insufficient energy, climate change are possible to be handled with teaching science literacy (as cited in OECD 2015 Framework, 2013, p.3). Science education community members put forth that a better public understanding of science depends upon the number of scientifically literate people in a society (Özgelen, Yılmaz-Tüzün & Hanuscin, 2013). Therefore it is vitally important to help students appreciate science literacy (Özgelen, 2010) and in Turkey, the science course aims to teach "NOS and technology, science concepts, science process skills, relation of STS, and environment, the values constructing the essence of science, and attitude and values toward science" in order to develop their science literacy". (MoNEa, 2013, p. 6)

In OECD 2015 Framework (2013), scientific literacy is defined as "the ability to engage with science-related issues, and with the ideas of science, as a reflective citizen" (p. 7). According to the Framework, "a scientifically literate person is willing to engage in informed discourse about science and technology which requires the competencies to explain phenomena scientifically, evaluate and design scientific enquiry, interpret data and evidence scientifically" (p. 8).

Science literacy has its own characteristic elements. Miller (2004) comes up with three elements in order to explain scientific literacy:

1. Vocabulary of science (science content): The vocabulary of basic scientific constructs needed to read and understand competing views from a popular science news source (e.g., The New York Times Tuesday Science Section).
2. Understanding of scientific inquiry (nature of science): The process or nature of scientific inquiry.
3. Attitudes towards organized science and knowledge (attitudes towards science): The social impact of science on the individual and society. (p. 273)

Norris and Philips (2003) propose a larger list of elements which constitute the term of scientific literacy as in the following:

1. Knowledge of the substantive content of science and the ability to distinguish from non-science;
2. Understanding science and its applications;
3. Knowledge of what counts as science;
4. Independence in learning science;
5. Ability to think scientifically;
6. Ability to use scientific knowledge in problem solving;
7. Knowledge needed for intelligent participation in science-based issues;
8. Understanding the nature of science, including its relationship with culture;
9. Appreciation of and comfort with science, including its wonder and curiosity;
10. Knowledge of the risks and benefits of science; and
11. Ability to think critically about science and to deal with scientific expertise. (p. 275)

Science is a very essential subject that majority of students will use throughout their life and educators need to prepare them for their future lives and careers through an effective science education (Özgelen, 2010). Quantity of scientifically literate people in a society ensures wide spreading understanding of science (Driver, Leach, Millar, & Scott, 1996). To grow knowledgeable citizens, science education should achieve scientific literacy, that includes public understanding of science (Bezzi, 1998). To achieve that, “educational researchers play a vital role by providing teachers, teacher educators, administrators, and policy makers with information about the creation of a curriculum that supports scientific literacy”

(Glynn & Muth, 1994, p. 1057). Textbooks play very important role in order that teachers and students should have informed views of science (DiGiuseppe, 2014). Therefore, there are a number of textbook analysis researches about science/science literacy.

As a part of scientific literacy, nature of science has become a popular topic in textbook analysis (Vesterinen, Aksela and Lavonen, 2013). Chiappetta and Fillman (2007) examined five high school biology textbooks in order to determine the inclusion of four aspects of the nature of science, which are science as a body of knowledge, science as a way of investigating, science as a way of thinking, and science and its interactions with technology and society. Same chapters or sections of each textbook were examined using an analysis procedure. The procedure used to analyze the five biology textbooks is described in a 27-page booklet entitled Procedures for Conducting Content Analysis of Science Textbooks (Chiappetta, Fillman & Sethna, 2004).The researchers rated the unit of analysis independently. They compared their coding and the reliability was high. They also made a comparison with the research done with previously-used textbooks before and stated that the current textbooks had a better representing of nature of science in terms of the criteria stated in the booklet. That shows the textbook analysis studies have effect on revising curriculum materials.

A similar textbook analysis about inclusion of nature of science was surveyed by Irez (2008) in Turkey. He evaluated 5 most frequently used high school biology textbooks in Turkey. After carefully reading the textbooks, statements about nature of science were determined and each of them supposed as one theme. Therefore, 11 themes of nature of science were generated, which results in means of cognitive maps to research. The study disclosed a various problems with the representation of nature of science in textbooks. Science was represented as collection of facts and also scientific processes and descriptions were not explained well enough, which causes teachers and students understand of science inappropriately. It is also a message textbooks convey to teachers and students that science is a body of knowledge not a dynamic process (Chiappetta, Fillman & Sethna, 2004). Furthermore, Irez (2008) claimed that some important aspects of science were neglected by textbooks such as that there is no single scientific method and there is no hierarchical relationship between theories and laws. He also stressed that the authors of the textbooks often appeared not to understand the processes well enough to explain them to students and therefore presented various misleading and inadequate descriptions regarding scientific enterprise, similar to those revealed by research on science teachers' and students' understandings of science.

Yamak (2009) examined 6^{th}, $7^{th}$and 8^{th}middle school science textbooks according to some criteria in terms of science literacy. A total of three middle school science textbooks in grade and two biology units were analyzed in each textbook. In the 6^{th} grade science textbooks, "Reproduction, Development and Growth in Living Beings" and "Systems in Our Body" units, in the 7^{th}grade science textbook, "Systems in Our Body" and "Human and Environment" units, in the 8^{th}grade science textbook, "Cell Division and Heredity" and "Livings and Energy Relationships" units were analyzed by using "Nature of Science Criteria", adapted from a study from the literature. The instrument consists of 3 categories, 9 criteria and 28 indicators. The categories are: "Science as Authoritative Knowledge", "Science as Understanding Phenomena" and "Science as the Social Construction of Knowledge". A qualitative oriented approach was performed and content analysis method was used to assess the science textbooks. Data were analyzed by percentage and frequency analysis. Reliability was calculated by Cohen's Kappa and the value 0.71 which was found is reliable. The results of this study revealed that the three science textbooks inadequately presented the nature of science categories. It was also found that the percentages of almost all the indicators were fewer than fifty. The textbooks presented the "science as authoritative knowledge" category relatively higher than the other two categories. The "science as the sociocultural construction of knowledge" category was portrayed less than the other two categories.

Stressing the importance of textbook analysis with respect to nature of science, Niaz and Maza (2011) also surveyed 75 general chemistry textbooks. Nine criteria of the NOS were search for in the textbooks. Those criteria are (1) tentative nature of scientific theories, (2) laws and theories serve different roles, (3) there is no universal step-by-step scientific method, (4) observations are theory-laden, (5) scientific knowledge relies heavily, not entirely, on observation, experimental evidence, rational arguments, creativity and skepticism, (6) scientific progress is characterized by competition between rival theories, (7) scientists can interpret, the same experimental data differently, (8) development of scientific theories, at times is based on inconsistent foundations, (9) scientific ideas are affected by their social and historic milieu. Those criteria were collected from the literature including the studies of Chiappetta et al (1991), Rodriguez and Niaz (2002), and Niaz et al. (2010). The authors analyzed three textbooks (selected randomly) on all nine criteria. After the inter-rating agreement, they analyzed the other three textbooks. Results from this study revealed that high school chemistry textbooks fared poorly in their representation of NOS.

Regarding the representation of nature of science in science textbooks, Vesterinen, Aksela and Lavonen (2013) carried out a textbooks analysis study on

Finnish and Swedish upper high school chemistry textbooks. The dimensions of NOS were analyzed from five popular chemistry textbook series. The study provided a quantitative method for analysis of representations of NOS in chemistry textbooks informed by domain-specific research on the philosophy of chemistry and chemical education. The selection of sections analyzed was based on the four themes of scientific literacy: knowledge of science, investigate nature of science, science as a way of thinking, and interaction of science, technology and society. This was done using an analytical framework described and validated by Chiappetta, Fillman and Sethna (1991). For the second round of analysis the theme of science as a way of thinking was chosen for a closer inspection. The units of analysis in this theme were analyzed using seven domain specific dimensions of NOS: tentative, empirical, model-based, inferential, technological products, instrumentation, and social and societal dimensions. The dimensions are determined especially from the studies of Osborne et al. (2003), Lederman et al. (2002), Abd-El-Khalick et al. (2008) and Vesterinen et al. (2009).Based on the inter-rater agreement, the procedure and frameworks of analysis presented in this study was a reliable way of assessing the emphasis given to the domain specific aspects of NOS. Consequently, they found that there is a positive change in representation of NOS in textbooks; however, it is not enough.

Textbook Analysis in terms of Earth Science Literacy

This part of the study focuses on a deeper understanding and explanation of geosciences literacy and textbook analysis related to it. ‘Geoscience’ is a relatively new term for the Earth sciences (King, 2008). Geoscience and earth science terms are used interchangeably in this study.

The Earth Science Literacy Initiative (2010) states that “science is an ongoing process of discovery of natural world and earth science is part of this process” since the foremost concern of Earth science is to discover the natural world. Therefore science literacy and earth science literacy are interconnected and related to each other which are necessary together to continually expand our knowledge of the earth. The common issues of interest connecting science literacy and geosciences literacy are especially about problems threatening humanity and world as stated in the 2012 annual report of Nations Environment Programme such as insufficient water and food, diseases, insufficient energy, climate (as cited in OECD 2015 Framework, 2013, p.3).

“Understanding earth’s workings, deciphering the history of it and predicting the future of this active planet” has been the center of interest for earth scientists for a long time. They are eager to find ways to “understand how Earth’s internal processes shape the planet’s surface and how geological, biological, atmospheric, and oceanic processes interact” (National Academy of Science, 2008). Understanding how earth systems work and what earth science means is possible with earth science literacy (Manduca & Kastens, 2012). According to AGI (2008), earth science literacy is an appreciation of the planet’s effects on humans and of humans’ effects on it. Studies of earth science literacy do not date back to old time. Dupigny-Giroux (2010) states that the emerge of geoscience literacy within science literacy as a particular area of interest is very recent (over the last decade).

Lewis and Baker (2010) claims that a better geoscience literacy helps the formation of “understanding of environmental issues, disaster preparedness and sensible resource use”. There are many difficult decisions that governments have to make decisions concerning earth science related complex issues such as dwindling energy, mineral resources, water shortages and changing global climate.

Although Earth science studies seem to be within the borders of interest and expertise of geoscientists, earth science literacy is also a public necessity (Wysession & Rowan, 2013). We need earth science literate citizens and governments in order to make policies which assign the significance of resource conservation, use, and sustainability (Earth Science Literacy Initiative, 2010). Bowring (2014) puts importance on necessity of earth science literacy stating that every student and adult, from elementary school through higher education and so on, should have a basic understanding of the ultimate complex system, the Earth. Ensuring earth science literacy within the public is critical for any government to be able to take care of its citizens and national assets (Wysession & Rowan, 2013). In order to develop some understanding of what the future holds, it is needed an enough understanding of how the complex planetary ecosystem fits together (Turney, 2007).

The study of LaDue and Clark (2012) about earth science revealed the main themes of earth science literacy as in the following:

- Public’s decision-making about earth science-related public concerns such as hazard/natural disaster planning, building codes, weather and climate, and impacts the economy,
- Public perception of earth as home,
- Integrative nature of the earth science which means it synthesizes and applies physics, biology, and chemistry.
- Earth’s being easily accessible and concrete,
- Earth science literacy is important for science literacy (p. 375).

Another study by Kastens and Manduca (2012) came up with four central themes of earth science which are “geologic time, spatial thinking, teaching in the field and complex interacting systems”. They should be taught in order to develop science literacy. King (2008) also emphasizes the "geological time, spatial thinking (three dimensional), interacting systems (holistic system thinking), wide range of teaching methodologies and high level analysis and synthesis skills; that is, fieldwork" themes in the way to teach and illustrate earth science.

Geological time is "vast amount of time available for geological events and the sequencing of events" (King, 2008). It is also closely related to understanding of age of earth (Dahl & Libarkin, 2005). In order to develop some understanding of what the future holds, it is needed an enough understanding of how the events occurred in the past (Turney, 2007). Civilization is arguing the reality of climate change; struggling with the challenges of energy and food resources; and is still surprised when hurricanes, tsunamis, volcanoes, earthquakes, or floods strike. Those who do not learn from history are doomed to repeat it (Kastens & Manduca, 2012, p. 207).

King's (2008) components of geologic time are also compatible with Dodick and Orion's (2003) classification of main components of geological time:

1. People should have a perception of deep time which requires making meaningful connections between events and time. Developing reasoning and understanding of deep time are affected by people's making connections between time and event. Absolute time is also important, which is about the duration of the events (Chaochen, Hoare & Ravn, 1991).

2. Using a series of scientific principles, past environments and organisms should be reconstructed for a meaningful understanding of geologic time.

Since its being the period of time covering the physical formation and development of Earth, especially the period prior to human history, understanding of geological time is important to understand humans' effect on earth and earth's on humans (Earth Science Literacy Initiative, 2010).

Spatial thinking consists of components some of which are "spatial concepts, spatial skills, spatial representations and general spatial skills". All components of spatial thinking are described and conceptualized in a map by Kastens and Manduca (2012) as in the Figure 1.

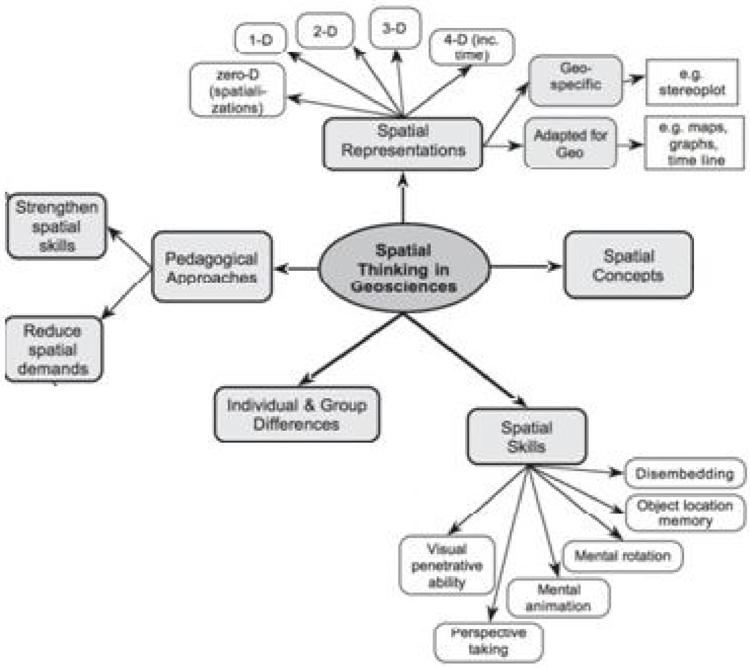

Figure 1. Spatial thinking model adapted by Kastens and Manduca (2012).

The world is viewed as a multi-variate, nonlinear, and sometimes stochastic system (Hays, et al, 1996). Holistic system thinking has its own constructs which are field, interactionism and cyclical view (Choi, Koo &

Choi, 2007). The cyclical model illustrates four Earth systems (hydrosphere, atmosphere, biosphere, and lithosphere) continuously interacting with all others. It is very important for students to understand that it is not possible to consider any part of Earth system being in isolation from any other part. Each Earth-system sphere is connected to the Earth event and all Earth systems are connected to each other (Gagnon & Bradway, 2012). According to Choi, Koo and Choi (2007), interactionism is understanding of "the presence of complex causalities, relationships and interactions between components of Earth" and Field is "the relationship between objects and the field to which those objects belong".

Formal education aims to foster a society constitute by geoscience literate citizens (LaDue & Clark, 2012). If the majority of the society become geoscience literate, good stewardship, sound policy, and international cooperation is promoted (Earth Science Literacy Initiative, 2010).

Earth Science Literacy Initiative (2010) also states:

> An earth science literate person understands the fundamental concepts of Earth's many systems, knows how to find and assess scientifically credible information about Earth, communicates about Earth science in a meaningful way, and is able to make informed and responsible decisions regarding Earth and its resources. (p. 2)

The Earth Science Literacy Initiative (ESLI) is an organization funded by National Science Foundation in 2008 in USA. This initiative released a document (2010), representing the current scientific knowledge in Earth science in order to shape decisions of government and industry, and to guide the earth science educator (ESLI, 2010). Unfortunately, no such a document or report about earth science in Turkey has been found by the researcher.

The ESLI document (2010) presents the “Big Ideas” of Earth science that all citizens should know determined by the Earth science research and education communities as in the following:

Big Idea1.Earth scientists use repeatable observations and testable ideas to understand and explain our planet.
Big Idea2. Earth is 4.6 billion years old.
Big Idea3.Earth is a complex system of interacting rock, water, air, and life.
Big Idea4.Earth is continuously changing.
Big Idea5. Earth is the water planet.
Big Idea6. Life evolves on a dynamic Earth and continuously modifies Earth.
Big Idea7. Humans depend on Earth for resources.
Big Idea8. Natural hazards pose risks to humans.
Big Idea9. Humans significantly alter the Earth. (p. 4)

Earth is the only planet where life has been found. It is the centre of life for humanity. It is the only planet in the solar system in which humans can inhabit and enjoy their existence. The resources in earth such as water, minerals and energy resources make life possible for all living beings; therefore it is highly crucial to protect it even from any unnatural changes. Protection and appreciation of earth mostly depends on better earth science literacy (Kastens & Manduca, 2012). Citizens, governments, academicians, students; shortly any group of people from every profession needs to be Earth science literate (King, 2006). At schools it must be priority to teach students to understand earth system, its components and relationship between them, which seems possible only with developing earth science literacy (Kastens & Manduca, 2012). “Only through Earth science education can students understand and appreciate our complex planet” (AGI, 2004). Since broad geoscience literacy is essential for the ability of civilization to make decisions, is a source of culture, is of high utility in developing fundamental human skills (Kastens & Manduca, 2012), it should have a fundamental place in science curriculum and so in textbooks.

In the literature, there are few studies about earth science literacy (Orion, 2002). There some studies carried out about earth science and/or with earth science textbooks. One of the studies about analysis of misconceptions in science textbooks from the earth science perspective was done by King (2010). He surveyed earth science misconceptions and errors among 51 related texts in 29 high school science textbooks in England and Wales. Frequency of already determined earth science misconceptions per page was counted. Science syllabuses and examinations surveyed also showed errors/misconceptions. In the result of the study, more than 500 examples of misconceptions, which are very high, were determined in the earth science texts in the textbooks. Most frequent misconceptions were identified in sedimentary processes/rocks, earthquakes/Earth's structure, and plate tectonics topics. For the 15 most frequent misconceptions, examples of quotes from the textbooks are given, together with the scientific consensus view, a discussion, and an example of a misconception of similar significance in another area of science. The misconceptions identified in the surveys are compared with those described in the literature. This indicates that the misconceptions found in college students and pre-service/practicing science teachers are often also found in published materials, and therefore are likely to reinforce the misconceptions in teachers and their students.

A study about one of earth science literacy theme (geological time) was done by Decker, Summers and Barrow (2007). They selected 11 widely used high school biology textbooks for the study. All of these texts have publication dates of 1998 or later and several represent new or revised editions of earlier versions. Each text was independently examined by two of the authors for its treat-ment of geological time and the scientific study of historical events. They were interested in discussions of the use of inferences in making statements about historical events as well as any mention of geological time spans or specific eras and periods. The earth science related chapter of each textbook was read. At the results, they found that all of the textbooks include a presentation of Earth history and the evolution of life on Earth. In many cases, this material was consolidated in a single chapter, but some texts presented historical material in more than one chapter. All of the texts cover the nature of fossils and most of them include a discussion of the general principles of radiometric dating. The presentation of geological time varies, with some texts including eras and periods in tabular format while others use timelines to show both geological time and biological events. The tables typically focus on Phanerozoic time and identify the approximate dates of geological periods, but geological time before the Paleozoic era is usually identified as “Precambrian.” In some cases, epochs are identified in the Tertiary and Quaternary. All of the tabular presentations emphasize the dates of the time periods and usu-ally do not describe biological features.

Another study was done by Groves (1995) about the science vocabulary load in earth science, chemistry, physics and biology textbooks. The earth science textbook by Silver-Burdett was the most common earth science textbook used in the district of and during the time of the study. Only narrative passages were analyzed. The researcher used the analysis procedure by Yager (1983) which is that the number of science terms was counted in each page. As the result of the study, it was declared that vocabulary load of the textbooks were very high, which might cause that students could view science as a collection of facts and terms to be memorized.

A study about earth (system) science literacy but not textbooks done by LaDue and Clark (2012).They studied with geoscience professors and K–12 Earth Science teachers attending the 2009 Annual Meeting of the Geological Society of

America. The researchers distributed Likert-type and free-response questionnaire to geoscientists and K-12 teachers in order to reveal what they think are important concepts, experiences and difficult to earth (system) science literacy. They designed the Likert-type survey in order to reveal participants' perceptions of challenges and priorities for public earth science literacy and the free-response questionnaire in order to elicit what educators think of important aspects of earth science literacy. While analyzing, inter-rater reliability was used and it and kappa values revealed a substantial agreement between the inter-raters. As a result of the study, they determined the aspects of earth science literacy as in the following:

- Public's decision--making about earth science-related public concerns such as hazard/natural disaster planning, building codes, weather and climate, and impacts the economy,
- Public perception of earth as home,
- Integrative nature of the earth science which means it synthesizes and applies physics, biology, and chemistry.
- Earth's being easily accessible and concrete,
- Earth science literacy is important for science literacy. (p. 375)

CHAPTER 3

METHODOLOGY

This chapter is about methodology of the study. Information about sample, design, analysis frameworks and procedure of the study are given in this chapter.

Sample

The Mystery of Earth Crust/ Earth and Space chapter of the 5th grade science education textbook which covers the subject of earth science is the sample of the study.

Naming of earth science chapter, its sections and content were determined by the 5th grade science education curriculum (MoNE, 2013a). In MoNE 5th grade science textbook, the earth science chapter takes place in pages between 277 and 323 and under four main sections. The first page of chapter (page 277), which is cover page, consists of the name of unit, sections and an explanation about the significance of unit. The following page (p. 278) consists of aim, basic terms and real life questions. The page 279 is only covered with a high quality earth science related photograph. Other information about the sample is given in the Table 5.

Table 5. Total Page Number of Textbook, and Earth Science Chapter and its Percentage

Total Page Number of 5th grade Science Education Textbook	Total Page number of Earth Science Chapter	Percentage of the Earth Science Chapter
332	47	14.15

In the textbook, sections of the earth science chapter are listed as in the following:

1. What exists on earth's crust? (14 pages)
2. The effect of erosion and landslip on earth's crust (10 pages)
3. Surface and ground waters in earth's crust (8 pages)
4. Air, soil and water pollution (15 pages).

In the given chapter, there were 140 units to analyze. 118 of them which fit the criteria determined by Chiappetta, Fillman and Sethna (2004) were analyzed in terms of science literacy and earth science literacy. "Complete paragraphs, questions, figures, tables, pictures with captions, each complete step of a laboratory or hands-on activity" were considered as unit of analysis in this study.

Design of the Study

In the study earth science chapter of 5th grade MoNE science book was analyzed in terms of earth science literacy and science literacy. The content analysis of the earth science chapter is a quantitative study supported with descriptive statistics such as frequencies and percentages. According to Kahveci (2009), producing quantitative data as a result of counting and coding area are important characteristics of content analysis. Quantitative analysis procedures provide a reliable and clear way in the portrayal of "what" is included in the textbooks. The content analysis was carried out by two independent researchers in the light of two analysis frameworks. The analysis frameworks and the analysis procedure were described in the following sections.

Analysis Frameworks

The content analysis of earth science chapter of the textbook was carried out with two frameworks. One of the frameworks was used to analyze the science literacy themes covered in the earth science chapter of 5th grade science textbook. The other framework was used to reveal to what extent the earth science literacy themes reflected by the earth science chapter.

Science Literacy Analysis Framework

In order to analyze science literacy theme in the earth science chapter, an analytical framework, developed by Chiappetta, Fillman and Sethna (2004) was used. This framework was also commonly used in the national and international literature (e.g., Başlantı, 2000; Chabalengula and Mumba, 2008; Erdoğan & Köseoğlu, 2012; Udeani, 2013; Vesterinen, Aksela & Lavonen, 2013; Yamak, 2009). The reason for choosing this framework as an analysis tool for this study is that there is a number of studies done using it in Turkey, and it gives the chance to compare the new textbook with the previously used ones. Another reason is that its reliability and validity have been tested again and again, and registered considerable approval (Vesterinen, Aksela & Lavonen, 2013). The framework and its manuscript have been accessed via the Boğaziçi University Library by contacting Chiappetta and getting his permission to use the framework at November 22, 2013. The detailed information for the analysis procedure is given in the manuscript of Chiappetta, Fillman and Sethna (2004).

In the framework, the main science literacy aspects are categorized under four main themes, namely, science as a body of knowledge (SL Theme 1), science as a way of investigating (SL Theme 2), science as a way of thinking (SL Theme 3) and the interaction among science, technology, and society (SL Theme 4). There are totally 34 subthemes of the total 4 main science literacy themes.

The entire themes and subthemes framework are presented in Table 6.

Table 6. Themes and Subthemes of the SL

Themes	Subthemes
Knowledge of Science	A. facts, concepts, laws, and principles
	B. hypothesis, theories, or models
	C. questions asking for recall of information
	D. tentativeness and durability of scientific knowledge
	E. distinctness of scientific knowledge
Investigative Nature of Science	A. learn through the use of materials
	B. learn through the use of charts and tables
	C. make calculations
	D. reason out an answer
	E. participate in a “thought” experiment
	F. get information from the Internet
	G. use scientific observation and inference
	H. analysis and interpretation of data
Science as a Way of Thinking	A. describes how a scientist discovered or experimented
	B. historical development of an idea
	C. empirical basis of science
	D. use of assumptions
	E. inductive or deductive reasoning
	F. cause and effect relationship
	G. evidence and/or proof
	H. presents scientific method(s) or problem solving steps
	I. skepticism and criticism
	J. human imagination and creativity
	K. characteristics of scientists (subjectivity and bias)
	L. various ways of understanding the natural world

Interactions among Science, Technology, and Society	A. usefulness of science or technology
	B. negative effects of science or technology
	C. discussion of social issues related to science or technology
	D. careers in science or technology
	E. contribution of diversity
	F. societal or cultural influences
	G. make public or peer collaboration
	H. limitation of science
	I. ethics in science

First SL Theme: Science as a Body of Knowledge

The paragraphs which present, discuss, or ask the student to recall information, facts, concepts, principles, laws, theories, etc. belongs to this category (Chiappetta, Fillman & Sethna, 2004). Paragraphs coded under this theme aim to transfer scientific or subject matter knowledge. It has 5 subthemes as shown in the Table 6.

Second SL Theme: Science as a Way of Investigation

This theme includes the paragraphs stimulate thinking and doing by "asking the student to find out" (Chiappetta, Fillman & Sethna, 2004, p. 4). In other words, this type of text reflects the active aspect of inquiry and learning, which involves the student in the methods and processes of science such as observing, measuring, classifying, inferring, recording data, making calculations, experimenting, etc. (Vesterinen, Aksela & Lavonen, 2013). This category has 8 subthemes as shown in the Table 6.

Third SL Theme: Science as a Way of Thinking

This theme includes the paragraphs which intent to illustrate how science in general or a scientist in particular went about discovering ideas (Chiappetta, Fillman & Sethna, 2004, p. 5). That is to say; this aspect of the nature of science represents thinking, reasoning, and reflection where the student is told how the scientific enterprise operates (Vesterinen, Aksela & Lavonen, 2013). This main theme has 12 subthemes as shown in the Table 6.

Fourth SL Theme: Interaction among Science, Technology and Society

This category includes the paragraphs which illustrate the effect or impact of science on society. In other words, this aspect of scientific literacy pertains to the application of science and how technology helps or hinders humankind. It involves social issues and careers (Vesterinen, Aksela & Lavonen, 2013). Nevertheless, "in the presentation of this type of material, the student receives information and generally does not have to find out" (Chiappetta, Fillman & Sethna, 2004, p. 5). This category has 9 subthemes as shown in the Table 6.

Earth Science Literacy Framework

To analyze the earth science literacy (ESL) themes, an analysis framework developed by the researcher by using the related research in the earth science literature (Assaraf & Orion, 2005; Chiappetta, Fillman & Sethna, 2004; Dal, 2009; Edelson, Salierno & Sherin, 2006, Kastens & Manduca, 2012; King, 2008, 2010;

Manduca & Mogk, 2006; Orion, 2002, Reynold et al., 2005). In this section, the development of each theme was presented.

Improvement of the 1st theme (ESLT-1): Geological Time

Geological time is one of the core subjects and themes in earth science education (AGI, 2011; Kastens & Manduca, 2006; King, 2008). There is a number of studies emphasizing the teaching and importance of geological time (e.g., Chaochen, Hoare & Ravn, 1991; Schoon, 1992; Trend, 1998, 2001; Zen, 2001; Thompson, 2002; King, 2002, 2008; Dodick & Orion, 2003; Dal, 2005, 2007, 2008; Decker, Summers and Borrow, 2007; Libarkin, Kurdzie & Anderson, 2007; King, 2008; Karahan, Nam, Roehrig & Moore, 2012). That is why; geological time should take place in an earth science chapter. There are two dimensions in geological time: (1) knowledge of absolute or deep time and (2) sequence of the geological events (Karahan, Nam, Roehrig & Moore, 2012; Decker, Summers and Borrow, 2007; King, 2008). Moreover, textbooks materials are expected to enhance time-based thinking skills, enable students to solve relative time-based problems (King, 2008).

The first theme of the framework has the following subtopics (also shown in Table 7),

- a knowledge of the length of geological time (absolute or deep time);
- the development of a time framework into which major geological events fit; and
- the enhancement of time-based thinking skills, enabling students to solve relative time-based problems.

Improvement of the 2nd theme (ESLT-2): Spatial Thinking

Spatial thinking is another domain specific characteristic of earth science (AGI, 2011; Kastens & Manduca, 2006; King, 2008). It has a very significance place in earth science education. There is a number of studies emphasizing the teaching and importance of spatial thinking (AGI, 2011; Orion, Ben-Chaim & Kall, 1997; Gaspersz, 1999; Reynold et al., 2005; Kastens & Ishikawa, 2006; Manduca & Mogk, 2006; National Research Council, 2006; King, 2008, 2010; Kastens & Manduca, 2012). National Research Council (2006) defines spatial thinking as a thinking which attempts to find "meaning in the shape, size, orientation, location, direction or trajectory, of objects, processes or phenomena, or the relative positions in space of multiple objects, processes or phenomena". Kastens and Ishikawa (2006) emphasizes that both learners and instructors need to have the extensive spatial thinking skills in order to grasp the meaning of earth science. Spatial thinking refers to the three dimensional thinking in the literature (Gaspersz1999; Kasten and Manduca, 2012; Orion, Ben-Chaim and Kall, 1997).In addition to 3D thinking, 2D visuals which has a relation with text are also taken into consideration under this theme since 2D visuals are also helping 3D thinking ability (Wu & Shah, 2004).

The second theme of the framework has the following subtopics (also shown in Table 7):

- Textbooks should direct readers computer graphics, computer software and computer animations (Slattery, Mayer, & Klemm, 2002; Reynold et al., 2005)
- Textbooks should use information technologies (Manduca & Mogk, 2006) and have 3D visualizations and graphics (King, 2010).
- Textbooks should have 2D visualizations with text relations (Wu & Shah, 2004).

Improvement of the 3rd theme (ESLT-3): Holistic System Thinking

Holistic system thinking is about earth's having subsystems and being a whole system. It is very important to understand the earth (AGI, 2011; Kastens & Manduca, 2006; King, 2008). There are studies emphasizing holistic system thinking in earth science literature (e.g., Assaraf& Orion, 2005; Dal, 2009; King, 2008; Kastens & Manduca, 2012; Orion, 2002).There are causal relationships between the systems (Dal, 2009). Human-beings can affect the subsystems, which may have negative results for the earth (Mayer & Kumano, 2002). Subcategories of this theme are listed as in the following in the earth science education literature (also shown in Table 7):

- Inter-relationship between sub-systems;
- The cycling thinking (having no starting point and no end point in the cycle) and systemic thinking (cycle in the context of its interrelationship with the other Earth systems) on Earth;
- Earth as a whole system;
- Human effect on systems (Assaraf & Orion, 2005; King, 2008; Mayer & Kumano, 2002; Orion, 2002).

Improvement of the 4rd theme (ESLT-4): Fieldwork

Fieldwork in earth science is just as important as laboratory work in the context of education in the physical sciences (AGI, 2011; Kastens & Manduca, 2006; King, 2008; Marques, Praia & Kempa, 2003). Earth science demands teaching in the field for understanding of earth science. In the literature, it is very common to find studies about importance of fieldwork (e.g., Goto, 2002; Thompson, 2002; Marques, Praia & Kempa, 2003; Libarkin & Anderson, 2005;Edelson, Manduca & Mogk, 2006; Salierno & Sherin, 2006; King, 2008).That is why; earth science chapter should have paragraphs about fieldwork. Subtopics of fieldwork, which are suggested by

Edelson, Salierno and Sherin (2006) and King (2008) for textbooks, are listed as in the following (also shown in Table 7):

- Field trip advice,
- The centrality of fieldwork and direct observation,
- The interpretation of historical data,
- Testing students' practical application in the classroom,
- Data exploration in the field,
- The detective work involved in retrodiction (prediction of the past).

Improvement of the 5th theme (ESLT-5): Body of Earth Science Knowledge

Body of earth science knowledge mainly refers to core knowledge of earth science such as concepts, principles, theories, models and laws. In other words, the category is completely related to knowledge or information about earth science. In order to understand the connection between earth science concepts, it is necessary to teach earth science knowledge (Dal, 2008; Klemm, 2002). Subthemes of this category were adapted from the framework of Chiappetta, Fillman and Sethna (2004) for this study. The followings are the analysis unit for this theme (also shown in Table 7):

- Facts, concepts, principles and laws of earth science,
- Hypotheses, theories, and models of earth science.

Improvement of the 6th theme (ESLT-6): Earth Science, Technology and Society

Interactions among science, technology, and society theme is important to indicate that earth science has a close relation with society. This theme was also adapted from the framework of Chiappetta, Fillman and Sethna (2004) in order to reveal the specific interaction of earth science, technology and society. These subthemes are also emphasized by Klemm, (2002), Goto (2002), Mayer, Shimono, Goto and Kumano (2002); Slattery, Mayer and Klemm (2002), Mayer and Fortner (2002), Fortner (2002), Thompson (2002), Orion (2002), Kieffer (2006) and Manduca and Mogk (2006). The followings are the analysis units for this theme (also shown in Table 7):

- Usefulness of earth science or technology,
- Negative effects of earth science or technology,
- Discussion of social issues related to earth science or technology,
- Careers in earth science or technology,
- Contribution of diversity,
- Societal or cultural influences,
- Make public or peer collaboration,
- Limitation of earth science,
- Ethics in earth science.

The framework with 6 themes of earth science was developed by reviewing the literature deeply. All of these themes are necessary in teaching earth science to students in all grade levels. Each main theme was written from the earth science literature. Then, subthemes were written with respect to earth science education literature, which should be found in textbooks.

This framework can be used to analyze earth science chapter in science textbooks and earth science textbooks. The aim and the content of the framework were given to two earth science education experts in order to reveal its validity. The experts agreed upon the validity of the framework.

There are totally 27 subthemes of the total 6 main earth science literacy themes as shown in the Table 7. The examples presenting how the paragraphs analyzed from various resources could be found in the Appendix A.

Table 7. Themes and Subthemes of the Earth Science Literacy

Themes	Subthemes
Geological Time	A. a knowledge of the length of geological time (absolute or deep time)
	B. the development of a time framework into which major geological events fit
	C. the enhancement of time-based thinking skills, enabling students to solve relative time-based problems
Spatial Thinking	A. Textbooks direct readers computer graphics, computer software and computer animations (Information technologies)
	B. Textbooks have 3D visualizations and graphics
	C. 2D visualizations with text relation
Holistic System Thinking	A. Inter-relationship between sub-systems
	B. The cycling thinking (having no starting point and no end point in the cycle) and systemic thinking (cycle in the context of its interrelationship with the other Earth systems) on Earth
	C. Earth as a whole system
	D. Human effect on systems
Fieldwork	A. Fieldtrip advice
	B. The centrality of fieldwork and direct observation
	C. The interpretation of historical data
	D. Testing students' practical application in the classroom
	E. Data exploration in the field
	F. The detective work involved in retrodiction (prediction of the past)
Body of Earth Science Knowledge	A. Facts, concepts, principles and laws of earth science
	B. Hypotheses, theories, and models of earth science
Interaction among Earth Science, Technology and Society	A. usefulness of earth science or technology
	B. negative effects of earth science or technology
	C. discussion of social issues related to earth science or technology
	D. careers in earth science or technology
	E. contribution of diversity
	F. societal or cultural influences
	G. make public or peer collaboration
	H. limitation of earth science
	I. ethics in earth science

Reliability of the Frameworks

The inter-rater agreement result is the representation of the reliability. The evaluation of inter-rater reliability provides a way of quantifying the degree of agreement between two or more raters who make independent ratings about the features of a set of subjects (Hallgren, 2012). All reading paragraphs in the earth science chapter of the textbook were carefully read and themes determined above were coded and counted by each interrater independently.

There is always a possibility of chance when two raters rate a product. Because of that, Cohen's Kappa (k) was used as a beneficial statistical method which is a coefficient of inter-rater agreement that determines whether the agreement occurs by chance. Thus, if a value of kappa is higher from the value of zero (positive), the agreement between raters can be attributed to factors other than chance. As the value of kappa increases, the interrater agreement by chance decreases. The value of kappa can be + 1.00 at most which shows a perfect positive agreement between raters. If the value of kappa is found to be close to zero, the agreement between the raters can be attributed to the factor of chance and there exists no consistency between raters (Chiappetta, Fillman & Sethna, 2004).

To evaluate the reliability of the frameworks, percent of agreement and Cohen's Kappa are calculated as suggested in the manuscript of Chiappetta, Fillman and Sethna (2004). To calculate those, the following formulas were used:

$$\text{Percent of agreement} = \frac{\text{Number of agreements between 2 raters x 100}}{\text{Total number of agreements possible}}$$

$$\text{Value of Kappa (k)} = (Po - Pc) / (1 - Pc)$$

where k = Cohen's kappa, Po = the proportion of agreements between two raters, Pc = the proportion of interrater agreements which may occur due to chance.

Percent of agreement refers to a measure of agreement between two raters who use an identical instrument to examine a product (Stemler, 2001). For earth science literacy in this study, 2 independent raters analyzed the earth science unit of 5th grade science textbook for categories of earth science literacy. There are 118 units of analysis in the earth science chapter. The raters agreed on 105 units to be the same. Therefore, the percent of agreement between the two raters was calculated as in the following:

$$\text{Percent of agreement for SL} = \frac{115 \times 100}{118}$$

$$= 97{,}4\ \%$$

$$\text{Value of Kappa (k) for SL} = \frac{(0.97 - 0.25)}{(1 - 0.25)}$$

$$= \frac{(0.72)}{(0.75)}$$

For science literacy in this study, 2 independent raters analyzed the earth science unit of 5th grade science textbook for categories of earth science literacy. There are 118 paragraphs in this chapter of the textbook to analyze. The raters agreed on 115 paragraphs to be the same. Therefore, the percent of agreement between the two raters for science literacy was calculated as in the following:

$$\text{Percent of agreement for ESL} = \frac{105 \times 100}{118}$$

$$= 88{,}9\ \%$$

$$\text{Value of Kappa (k) for ESL} = \frac{(0.88 - 0.25)}{(1 - 0.25)}$$

$$= \frac{(0.63)}{(0.75)}$$

$$= 0.84$$

Chiapeptta, Fillman and Sethna (2004) claimed that values of kappa that are below 0.4 are considered to indicate fair to poor agreement after excluding possibility of agreement due to chance. Values that fall between 0.4 and 0.75 are taken to indicate fair to good level of interrater agreement. When values of kappa are more than 0.75, they represent excellent agreement beyond chance. Therefore, in both of the studies kappa values as above 0.75, which means there is an excellent agreement between the raters.

Analysis Procedure

Analysis of the earth science chapter of the textbook was carried out by two independent researchers. Two researches are both science teachers and graduate students at the science education department. In order to eliminate different interpretations and develop a common understanding of the meaning of evaluation criterion, all criteria were discussed before using for analysis of the chapter. Each rater firstly read carefully the steps in the framework of Chiappetta, Fillman and Sethna (2004).The examples in the framework were exercised together. The process of analysis started with numbering the paragraphs which provide information about science and earth science literacy themes and those were coded as suggested in the manual by Chiappetta, Fillman and Sethna (2004). The numbered units of analysis in the chapter placed in the Appendix E. For both of the analysis same procedure was performed. They rated the units of analysis independently. The unit of analysis is the statement that paragraph, group of sentences, sentence, or phrase which contain a single unambiguous theme about the nature of science (Palmquist & Finley, 1997). In this study, as suggested by Chiappetta, Fillman and Sethna (2004, p. 6), "Complete paragraphs, questions, figures, tables, pictures with captions, each complete step of a laboratory or hands-on activity" were considered as unit of analysis. However, "a page with only one picture, with fewer than two analyzable paragraphs, pages containing only review questions, vocabulary words, etc." were not analyzed in the light of the manuscript (p. 6). After finishing the coding, in case of non-agreement, the raters discussed their results. They rated again.

CHAPTER 4

RESULTS

In this chapter, results of the science literacy framework and earth science literacy framework were represented with some descriptive statistics. Additionally, this chapter presented findings under each research question.

Results of Science Literacy Analysis Framework

The quantitative content analysis results were presented in the chapter including the percentages of each science literacy theme reflected in the earth science chapter of 5th grade science textbook.

There were 118 units of analysis examined in terms of science literacy. Table 8 and 9 show the frequencies and percentages of science literacy themes and subthemes in earth science chapter.

Table 8. Percentages of the Science Literacy Themes in the Earth Science Chapter

	Knowledge of Science	Investigative Nature of Science	Science as a Way of Thinking	Interaction of Science, Technology and Society	Total
Frequency	47	37	9	25	118
Percentage	39.8	19.6	4.7	21.1	100

Table 9. Frequencies and Percentages of the Science Literacy Themes in the 5th Earth Science Chapter

Theme	Subtheme	Frequency	Percentage
Knowledge of Science	Facts, concepts, laws and principles	43	36.4
	Hypothesis, theories, or models	3	2.54
	Questions asking for recall of information	1	0.84
	Tentativeness and durability of scientific knowledge	0	0
	Distinctness of scientific knowledge	0	0
Investigative Nature of Science	Learn through the use of materials	7	5.93
	Learn through the use of charts and tables	6	5.08
	Make calculations	0	0
	Reason out an answer	6	5.08
	Participate in a “thought” experiment	1	0.84
	Get information from the Internet	3	2.54
	Use scientific observation and inference	6	5.08
	Analysis and interpretation of data	7	5.93
Science as a way of Thinking	Describes how a scientist discovered or experimented	0	0
	Historical development of an idea	1	0.84
	Empirical basis of science	0	0
	Use of assumptions	2	1.69
	Inductive or deductive reasoning	1	0.84
	Cause and effect relationship	2	1.69
	Evidence and/or proof	0	0
	Presents scientific method(s) or problem solving steps	0	0
	Skepticism and criticism	1	0.84
	Human imagination and creativity	0	0
	Characteristics of scientists (subjectivity and bias)	0	0
	Various ways of understanding the natural world	2	1.69
Interaction of science, technology and society	Usefulness of science or technology	7	5.93
	Negative effects of science or technology	6	5.08
	Discussion of social issues related to science or technology	3	2.54
	Careers in science or technology	3	2.54
	Contribution of diversity	0	0
	Societal or cultural influences	3	2.54
	Make public or peer collaboration	3	2.54
	Limitation of science	0	0
	Ethics in science	0	0
Total		118	100

Related Research Question

The first research question was “To what extent does the earth science chapter of 5th grade science textbook in Turkey represent the science literacy themes?”. In order to answer this research question, the following questions are examined.

1. What is the Percentage of Body of Knowledge in Earth Science Chapter of 5th Grade Science Textbook in Turkey?

This analysis study focused on the earth science chapter of 5th grade science textbook. 47 out of 118 unit of analysis belong to the knowledge of science theme. It means that the percentage of the body of knowledge in earth science chapter is 39.8. It has the highest percentage among the four main themes. In this category, there were 5 subthemes as shown also in Table 10. The most represented subtheme is “facts, concepts, laws and principles” with 36.4 percent of the total subthemes. There are subthemes, which are not emphasized, namely “tentativeness and durability of scientific knowledge” and “distinctness of scientific knowledge”. Moreover, Table 10 showed that there is no balance between the subthemes of this category.

Table 10. Frequencies and Percentages of the Knowledge of Science Theme

Theme	Subthemes	Frequency	Percentage
Knowledge of Science	Facts, concepts, laws and principles	43	36.4
	Hypothesis, theories, or models	3	2.54
	Questions asking for recall of information	1	0.84
	Tentativeness and durability of scientific knowledge	0	0
	Distinctness of scientific knowledge	0	0

2. What is the Percentage of Investigations Students Engage in Earth Science Chapter of 5th Grade Science Textbook in Turkey?

In the earth science chapter of 5th grade science textbook, 37 out of 118 unit of analysis belong to the investigative nature of science theme. It means that the percentage of the investigative nature of science theme in earth science chapter is 19.6. In this category, there were 7 subthemes as shown also in Table 11. Table 11 shows that there is more balance between subthemes comparing to other themes. Yet, there is only one subtheme which is not emphasized in this category that is "make calculations".

Table 11. Frequencies and Percentages of the Investigative Nature of Science Theme

Theme	Subthemes	Frequency	Percentage
Investigative Nature of Science	Learn through the use of materials	7	5.93
	Learn through the use of charts and tables	6	5.08
	Make calculations	0	0
	Reason out an answer	6	5.08
	Participate in a "thought" experiment	1	0.84
	Get information from the Internet	3	2.54
	Use scientific observation and inference	6	5.08

3. What is the percentage of scientific thinking and the scientific enterprise in earth science chapter of 5th grade science textbook in Turkey?

In the earth science chapter of 5th grade science textbook, 9 out of 118 unit of analysis belong to the science as a way of thinking theme. It means that the percentage of the science as a way of thinking theme in earth science chapter is 4.7. It has the lowest percentage value among the four main themes. In this category, there are 12 subthemes as shown also in Table 12. The mostly represented subthemes in this category are “use of assumptions, cause and effect relationship and various ways of understanding the natural world” with 1.7% value. However, there are also subthemes which are not appeared namely, “describes how a scientist discovered or experimented, empirical basis of science, human imagination and creativity and characteristics of scientists (subjectivity and bias)”.

Table 12. Frequencies and Percentages of the Science as a way of Thinking Theme

Theme	Subthemes	Frequency	Percentage
Science as a way of Thinking	Describes how a scientist discovered or experimented	0	0
	Historical development of an idea	1	0.84
	Empirical basis of science	0	0
	Use of assumptions	2	1.69
	Inductive or deductive reasoning	1	0.84
	Cause and effect relationship	2	1.69
	Evidence and/or proof	0	0
	Presents scientific method(s) or problem solving steps	0	0
	Skepticism and criticism	1	0.84
	Human imagination and creativity	0	0
	Characteristics of scientists (subjectivity and bias)	0	0
	Various ways of understanding the natural world	2	1.69

<u>4. What is the Percentage of Interactions among Science, Technology, and Society in Earth Science Chapter of 5th Grade Science Textbook in Turkey?</u>

In the earth science chapter of 5th grade science textbook, 25 out of 118 units belonged to the interaction of science, technology and society theme. It means that the percentage of the interaction of science, technology and society in earth science chapter is 21.1. In this category, there are 9 subthemes as shown also in Table 13. The Table 13 shows that there is more balance between subthemes comparing to other themes. However, “contribution of diversity”, “limitation of science” and “ethics in science” are the subthemes which are not emphasized.

Table 13. Frequencies and Percentages of the Interaction of Science, Technology and Society

Theme	Subthemes	Frequency	Percentage
Interaction of Science, Technology and Society	Usefulness of science or technology	7	5.93
	Negative effects of science or technology	6	5.08
	Discussion of social issues related to science or technology	3	2.54
	Careers in science or technology	3	2.54
	Contribution of diversity	0	0
	Societal or cultural influences	3	2.54
	Make public or peer collaboration	4	3.38
	Limitation of science	0	0
	Ethics in science	0	0

As a summary, the highest ratio of the analyzed units related to science literacy belongs to investigative nature of science. The most presented subcategory of this theme is the one which is about analysis and interpretation of data. On the other hand, “science as a way of thinking” was the lowest aspect reflected in the earth science chapter. Moreover, the following subthemes were not emphasized:

- Tentativeness and durability of scientific knowledge (SL Theme 1)
- Distinctness of scientific knowledge (SL Theme 1)
- Make calculations (SL Theme 2)
- Describes how a scientist discovered or experimented (SL Theme 3)
- Empirical basis of science (SL Theme 3)
- Evidence and/or proof (SL Theme 3)
- Presents scientific method(s) or problem solving steps (SL Theme 3)
- Human imagination and creativity (SL Theme 3)
- Characteristics of scientists (SL Theme 3)
- Contribution of diversity (SL Theme 4)
- Limitation of science (SL Theme 4)
- Ethics in science (SL Theme 4)

Results of Earth Science Literacy Analysis Framework

Table 14 and 15 show the frequencies and percentages of earth science literacy themes and subthemes in earth science chapter. There were 118 units of analysis examined in terms of earth science literacy.

Table 14. Frequencies and Percentages of the Earth Science Literacy Themes

	Geolo gical Time	Spatial Thinking	Holistic System Thinking	Field work	Knowledge of Earth Science	Earth Science, Technology Society	Total
Frequency	1	14	5	39	23	36	118
Percentage	0.84	11.8	4.23	33.1	19.4	30.5	100

Table 15. Frequencies and Percentages of the Earth Science Literacy Themes

Themes	Subthemes	Frequency	Percentage
Geological time	Knowledge of the length of geological time (absolute or deep time)	0	0
	The development of a time framework into which major geological events fit	0	0
	The enhancement of time-based thinking skills, enabling students to solve relative time-based problems	1	0.84
Spatial Thinking	Textbooks direct readers computer graphics, computer software and computer animations (Information technologies)	0	0
	Textbooks have 3D visualizations and graphics	0	0
	2D visualizations with text relation	14	11.8
Holistic System Thinking	Inter-relationship between sub-systems	0	0
	The cycling thinking (having no starting point and no end point in the cycle) and systemic thinking (cycle in the context of its interrelationship with the other Earth systems) on Earth	0	0
	Earth as a whole system	0	0
	Human effect on systems	5	4.23

Fieldwork	Fieldtrip advice	2	1.69
	The centrality of fieldwork and direct observation	0	0
	The interpretation of historical data	0	0
	Testing students' practical application in the classroom	28	23.7
	Data exploration in the field	6	5.08
	The detective work involved in retrodiction (prediction of the past)	3	2.88
Knowledge of Earth Science	Facts, concepts, principles and laws of earth science	24	19.2
	Hypotheses, theories, and models of earth science	3	2.54
Earth Science, Technology and Society	Usefulness of earth science or technology	8	6.77
	Negative effects of earth science or technology	5	4.23
	Discussion of social issues related to earth science or technology	4	3.38
	Careers in earth science or technology	4	3.38
	Contribution of diversity	0	0
	Societal or cultural influences	0	0
	Make public or peer collaboration	11	9.32
	Limitation of earth science	0	0
	Ethics in earth science	0	0
Total		118	100

Related Research Question

The second research question of the study was "To what extent does the earth science chapter of 5th grade science textbook in Turkey represent the earth science literacy themes?". In order to answer this research question, the following questions are examined.

1. What is the Percentage of Representations Related with Geological Time in Earth Science Chapter of 5th Grade Science Textbook in Turkey?

In the earth science chapter of 5th grade science textbook, 1 out of 118 units belong to the geological time theme. It means that the percentage of the geological time theme in earth science chapter is 0.84. It has the lowest percentage value among the six main earth science themes. In this category, there are 3 subthemes as shown also in Table 16. There is only one subthemes emphasized in the unit of analysis, which is "The enhancement of time-based thinking skills, enabling students to solve relative time-based problems". The other two subthemes are not emphasized in the earth science chapter. They are "knowledge of the length of geological time (absolute or deep time) and the development of a time framework into which major geological events fit".

Table 16. Frequencies and Percentages of the Geological Time Theme in the Earth Science Chapter

Theme	Subthemes	Frequency	Percentage
Geological time	Knowledge of the length of geological time (absolute or deep time)	0	0
	The development of a time framework into which major geological events fit	0	0
	The enhancement of time-based thinking skills, enabling students to solve relative time-based problems	1	0.84

2. What is the Percentage of Representations Related with Spatial Thinking in Earth Science Chapter of 5th Grade Science Textbook in Turkey?

In the earth science chapter of 5th grade science textbook, 14 out of 118 units belong to the spatial thinking theme. It means that the percentage of the spatial thinking theme in earth science chapter is 11.8. In this category, there are 3 subthemes as shown also in Table 17. There is only one subtheme emphasized in the unit of analysis, which is “2D visualizations with text relation”. The other two subthemes are not emphasized in the earth science chapter. They are “textbooks direct readers computer graphics, computer software and computer animations (Information technologies) and textbooks have 3D visualizations and graphics”.

Table 17. Frequencies and Percentages of the Spatial Thinking Theme

Theme	Subthemes	Frequency	Percentage
Spatial Thinking	Textbooks direct readers computer graphics, computer software and computer animations (Information technologies)	0	0
	Textbooks have 3D visualizations and graphics	0	0
	2D visualizations with text relation	14	11.8

<u>3. What is the Percentage of Representations Related with Holistic System Thinking in Earth Science Chapter of 5th Grade Science Textbook in Turkey?</u>

In the earth science chapter of 5th grade science textbook, 5 out of 118 units belong to the holistic system thinking theme. It means that the percentage of the holistic system thinking theme in earth science chapter is 4.23. In this category, there are 4 subthemes as shown also in Table 18. There is only one subtheme emphasized in the unit of analysis, which is “Human effect on systems”. The other three subthemes are not emphasized in the earth science chapter. They are “inter-relationship between sub-systems, the cycling thinking (having no starting point and no end point in the cycle) and systemic thinking (cycle in the context of its interrelationship with the other Earth systems) on Earth and earth as a whole system”.

Table 18. Frequencies and Percentages of the Holistic System Thinking

Theme	Subthemes	Frequency	Percentage
Holistic System Thinking	Inter-relationship between sub-systems	0	0
	The cycling thinking (having no starting point and no end point in the cycle) and systemic thinking (cycle in the context of its interrelationship with the other Earth systems) on Earth	0	0
	Earth as a whole system	0	0
	Human effect on systems	5	4.23

4. What is the Percentage of Representations Related with Fieldwork of Earth Science in Earth Science Chapter of 5th Grade Science Textbook in Turkey?

In the earth science chapter of 5th grade science textbook, 39 out of 118 units belong to the fieldwork theme. It means that the percentage of the fieldwork theme in earth science chapter is 33.1. In this category, there are 6 subthemes as shown also in Table 19. The most emphasized subtheme is "testing students' practical application in the classroom". There are 2 subthemes which were not emphasized in the earth science chapter. They are "the centrality of fieldwork and direct observation and the interpretation of historical data".

Table 19. Frequencies and Percentages of the Fieldwork Theme

Theme	Subthemes	Frequency	Percentage
Fieldwork	Fieldtrip advice	2	1.69
	The centrality of fieldwork and direct observation	0	0
	The interpretation of historical data	0	0
	Testing students' practical application in the classroom	28	23.7
	Data exploration in the field	6	5.08
	The detective work involved in retrodiction (prediction of the past)	3	2.88

5. What is the Percentage of Representations Related to Body of Earth Science Knowledge in Earth Science Chapter of 5th Grade Science Textbook in Turkey?

In the earth science chapter of 5th grade science textbook, 23 out of 118 units belong to the knowledge of earth science theme. It means that the percentage of the knowledge of earth science theme in earth science chapter is 19.4. In this category, there are 2 subthemes as shown also in Table 20. The most emphasized subtheme is "facts, concepts, principles and laws of earth science".

Table 20. Frequencies and Percentages of the Knowledge of Earth Science Theme

Theme	Subthemes	Frequency	Percentage
Knowledge of Earth Science	Facts, concepts, principles and laws of earth science	24	19.2
	Hypotheses, theories, and models of earth science	3	2.54

6. What is the Percentage of Interactions among Earth Science, Technology, and Society in Earth Science Chapter of 5th Grade Science Textbook in Turkey?

In the earth science chapter of 5th grade science textbook, 36 out of 118 units belong to the earth science, technology and society theme. It means that the percentage of the earth science, technology and society theme in earth science chapter is 30.5. In this category, there are 9 subthemes as shown also in Table 21. The Table 21 shows that there is more balance between subthemes comparing to other themes. However, there are also subthemes which are not emphasized namely "contribution of diversity", "limitation of science" and ethics in science".

Table 21. Frequencies and Percentages of the Interaction among Earth Science, Technology and Society

Theme	Subthemes	Frequency	Percentage
Earth Science, Technology and Society	Usefulness of earth science or technology	8	6.77
	Negative effects of earth science or technology	5	4.23
	Discussion of social issues related to earth science or technology	4	3.38
	Careers in earth science or technology	4	3.38
	Contribution of diversity	0	0
	Societal or cultural influences	0	0
	Make public or peer collaboration	11	9.32
	Limitation of earth science	0	0
	Ethics in earth science	0	0

As a summary, the highest ratio of the analyzed units related to earth science themes belongs to fieldwork. The most presented subcategory of the fieldwork theme is the one which is about students' application in the classroom. On the other hand, geological time and holistic system thinking themes are the less emphasized themes in the chapter. Moreover, the following subthemes are not emphasized:

- Knowledge of the length of geological time (ESL Theme 1)
- The development of a time framework into which major geological events fit (ESL Theme 1)
- Textbooks direct readers computer graphics, computer software and computer animations (ESL Theme 2)
- Textbooks have 3D visualizations and graphics (ESL Theme 2)
- Inter-relationship between sub-systems (ESL Theme 3)
- The cycling thinking (having no starting point and no end point in the cycle) and systemic thinking (cycle in the context of its interrelationship with the other Earth systems) on Earth (ESL Theme 3)
- Earth as a whole system (ESL Theme 3)
- The centrality of fieldwork and direct observation (ESL Theme 4)
- The interpretation of historical data (ESL Theme 4)
- Contribution of diversity (ESL Theme 6)
- Societal or cultural influences (ESL Theme 6)
- Limitation of earth science (ESL Theme 6)
- Ethics in earth science (ESL Theme 6)

CHAPTER 5

CONCLUSION AND DISCUSSION

The main aim of the study was to analyze the earth science chapter of the 5th grade science textbook in terms of science literacy and earth science literacy. With this point of view, the results of the analysis were discussed in terms of science literacy and earth science literacy respectively in this chapter.

Garcia argued that 5% of a content of a textbook is well enough to represent the whole book (as cited in Başlantı, 2000, p. 120).In this study, nearly 15% of the 5th grade science textbook was analyzed in terms of earth science literacy and science literacy. Therefore, the analysis of earth science chapter draws a general picture of 5th grade science textbook about science.

The results of this study showed that earth science chapter of the new Turkish 5th grade science textbook emphasized the themes of knowledge of science (SL Theme 1), the investigative nature of science (SL Theme 2), and the interactions of science technology and society (SL Theme 4). However, science as a way of thinking theme (SL Theme 3) was the lowest theme reflected in the earth science chapter. Although science as a way thinkingwas stated as one of the aims in the science education curriculum (MoNE, 2013a, p. II), the new science textbook became the less evident emphasizing on this aspect of scientific literacy. One of the significance of the study was to find out whether the new science textbook had the potential to prepare scientifically literate citizens. In order to improve scientific literacy, science textbooks should emphasize all aspects of science literacy. The new textbook seemed to be improved over the previous ones with respect to the balancing the three themes. On the other hand, the knowledge of science (SL Theme 1) was still the predominant theme in the textbook as in the previous studies. For instance, before 2005 reform movement Başlantı (2000) examined the 8th grade MoNE science textbook. In another study, Yamak (2009) analyzed the 6th, 7th and 8th grade MoNE science textbooks which were written after science education reform at 2005. They both concluded that the very dominant theme portrayed in science textbooks was the knowledge of science. The highest ratio of the knowledge of science theme in textbooks means that science was generally portrayed as a collection of facts, not as a dynamic process of generating and testing alternative explanations about nature.

In other respects, when the results of the study were compared with the results of Başlantı (2000), it was seen that the percentage of emphasis on the knowledge of science theme decreased whereas SL Theme 2 (the investigative nature of science), and SL Theme 4 (the interactions of science technology and society) increased. Hence, distribution of themes which are knowledge of science (SL Theme 1), the investigative nature of science (SL Theme 2), and the interactions of science technology and society (SL Theme 4) became more balanced. This means that the chapter might have the advantage to encourage the students to be more active in the class, and the students to understand the relationships between science, technology and society as well as focusing on scientific knowledge.

On the other hand, inadequate emphasis upon science as a way of thinking (SL Theme 3) appeared as shortcoming for new Turkish science textbook. The aim of the study was not to examine the compatibility between the textbook and the curriculum. Yet, MoNE (2013b) stated that textbooks were written completely based upon the related curriculum. The results of this study showed that the earth science chapter, by itself, is not enough to support scientific thinking which is stated in the curriculum as one of the aims of science education. On the other hand, this study analyzed only one chapter of the relevant book. On that note, lack of coherence between one chapter and the curriculum does not necessarily mean that there was no compatibility between the whole book and the curriculum at all.

Moreover, when objectives of the earth science unit written in the curriculum was examined, there were two objectives related with formation of rocks in the earth science unit of the 5th grade science curriculum for the earth science chapter. O'Brien (2003) stated that formation of rocks is very good subject to teach the scientific thinking. Boujaoude (2002) stated that the way knowing deals with two major issues: How is scientific knowledge produced and what are the characteristics of this knowledge? Those questions serve students some metacognitive tools. These tools help students to understand the nature of observations and their relationships to theory, the nature of cause-effect relationships, the necessity of striving for objectivity in science, and the role of self-examination in science. These are very fundamental acquisitions and skills for science literacy. Acquisition, understanding and using of these skills and transferring of these skills to other situations in different areas play a crucial role in teaching science. For instance, these tools could be used to teach the objectives related the rocks.

Comparing with the science literacy themes, representation of earth science literacy themes was more unbalanced. Yet Chiappetta and Fillman (2007) stated that one would not expect an exact balance of text materials devoted for each theme. On the other hand, one would not expect to find strongly dominant themes over other themes. Yet, according to the results of the study, earth science chapter strongly stressed the three themes that are fieldwork (ESL Theme 4), knowledge of earth science (ESL Theme 5) and earth science, technology and society (ESL Theme 6). In fact the other three themes which were geological time (ESL Theme 1), spatial thinking (ESL Theme 2) and holistic system thinking (ESL Theme 3) appeared much less. As a matter of fact, geological time and holistic system thinking were below 5%. For instance, there were two objectives related with fossils in the earth science unit of the 5th grade science curriculum for the earth science chapter of the textbook. Inadequate emphasis on some of the domain specific characters of earth science literacy appeared as a deficiency for new Turkish science textbook. AGI (2011), Kastens and Manduca (2006) and King (2008) state these three themes (geological time, spatial thinking and holistic system thinking) as the main themes to achieve earth science literate citizens.

It seemed favorable that fieldwork theme has a very big portion in the main earth science themes in the chapter. However, the distribution among the subtheme is unbalanced. For instance, “testing students’ practical application in the classroom” is the strongly dominant whereas centrality of fieldwork and direct observation and interpretation of historical data were lightly emphasized. This result intended that even the fieldwork theme was the most emphasized in the chapter not all the subthemes of it represented in the chapter. As Chiappetta and Fillman (2007) stated, predominance of a subtheme over others was not appropriate in growing science literate citizens. According to the examination of the results of subthemes in both frameworks, in science literacy 12 out of 34 subthemes and in earth science literacy 13 out of 27 subthemes were not emphasized. Even it was not expected that an exact balance existed, lightly emphasis of some science literacy and earth science literacy subthemes was remarkable.

In conclusion, the results of the study showed that nearly the half of the earth science themes and subthemes of the ESL and SL lightly emphasized in the earth science chapter. It means that teaching of main ESL themes such as geological time, spatial thinking and holistic system thinking could pose some difficulties in analyzing this chapter of the textbook in the classroom.

Limitations of the Study

This study is limited with the earth science chapter of the fifth grade science textbook and the frameworks used for the analysis.

In this study, quantitative analysis method was used. There were some frequency and percentage values as descriptive statistics. Therefore, there is no information about quality of how the SL and ESL themes or subthemes represented. Only there is information about existence of the themes.

Manuscript of Chiappetta, Fillman and Sethna (2004) was used as guide for both of the analysis. It was claimed in the manuscript that if the researchers come across a paragraph that appears to have more than one type of message in it, they should try to find the major focus of the paragraph and categorize it accordingly" (p. 21). Therefore, this analysis study only paid attention to the most emphasized theme in a paragraph. Consequently the themes or subthemes which were not the dominant in the paragraphs were not indicated in the results of the study. That is why; it does not mean that the other themes or subthemes do not exist in the earth science chapter. In other words, it is only argued that they are not emphasized.

Suggestions for Further Research

This study is one of the first studies collecting the earth science literacy themes and analyzes them in a textbook. In order to have a picture of earth science education in Turkey, earth science chapters of 6^{th}, 7^{th} and 8^{th} grade science textbooks could also be analyzed in terms of literacy.

In this study, the themes for earth science literacy were gathered together from the earth science literature. Qualitative textbook analysis could be done in order to reveal the quality of the representing the earth science literacy themes.

Researchers could also study the balance with curriculum and textbooks in terms of science and earth science literacy.

APPENDICIES

APPENDIX A

Examples of Earth Science Literacy Analysis from Various Resources

Example 1: The Earth formed more than 4 billion years ago along with the other planets in our solar system (Freudenrich, et al., 2009, p. 327).

This unit belongs to: 1-A (ESLT).

Example 2: More visuals and supplementary readings are available at http://interactive2.usgs.gov/learningweb/teachers/mapsshow_lesson4.htm (Freudenrich, et al., 2009, p. 46).

This unit belongs to: 2-A (ESLT)

Example 3: Soil is only a renewable resource if we carefully manage the ways in which we use soil. There are natural cycles of unfortunate events like drought or insect plagues or outbreaks of disease that negatively impact ecosystems and also harm the soil. But there are also many ways in which humans neglect or abuse this important resource (Freudenrich, et al., 2009, p. 247).

This unit belongs to: 3-D (ESLT)

Example 4: Take a trip to the natural history museum with your friend. During your visit, you will see minerals that are similar in color. Group the minerals with same colors. (Freudenrich, et al., 2009, 62).

This unit belongs to: 4A (ESLT)

Example 5: A soil is called a residual soil when it forms in place, with the underlying rock breaking down to form the layers of soil that reside above it. Only about one third of the soils in the United States form this way (Freudenrich, et al., 2009, 242).

This unit belongs to: 5A (ESLT)

Example 6:

Kayaç nedir?

1 Canlıların dünya üzerinde yaşadığı tabakaya **yer kabuğu** denir. Yer kabuğunda dağlar, vadiler ve ovaların olduğu karasal bölgelere **kara tabakası** adı verilmektedir. Yeryüzünde yaşadığımız kara tabakası temel olarak **kayaçlar**dan oluşur. Kayaçlar çok sayıda **mineral**in birikmesi ile oluşur.

(MoNE, 2013c, 5th Grade Science Textbook, p. 280.)

This unit belongs to ESLT subcategory 5A.

Example 7:

5 Fosil bilimciler, fosilleri özellikle belirli kayaçlarda arar. Fosil bulmanın en kolay yollarından biri, kayaç katmanlarının açığa çıktığı kesimlerde arama yapmaktır.

(MoNE, 2013c, 5th Grade Science Textbook, p. 286.)

This unit belongs to ESLT subcategory 4E.

Example 8:

> Fosilleri inceleyen bilim dalına **fosil bilimi** veya **paleontoloji**, bu alanda çalışan bilim insanlarına ise **fosil bilimci** ya da **paleontolog** adı verilir. Günümüzde fosil bilimciler, uydu görüntüleri kullanarak yeryüzü şekilleri yardımıyla fosillerin yerlerini tespit edebilirler. Fosilleri yine özel araçlar kullanarak bulundukları yerden çıkarırlar. Elde ettikleri fosillerin yaşını ve hangi türe ait olduğunu fiziksel, kimyasal ve biyolojik yöntemler kullanarak anlamaya çalışırlar.

(MoNE, 2013c, 5th Grade Science Textbook, p. 286.)

This unit belongs to ESLT subcategory 6D.

APPENDIX B

Science Literacy Analysis Framework

Themes	Subthemes
I. Knowledge of Science	A. facts, concepts, laws, and principles
	B. hypothesis, theories, or models
	C. questions asking for recall of information
	D. tentativeness and durability of scientific knowledge
	E. distinctness of scientific knowledge
II. Investigative Nature of Science	A. learn through the use of materials
	B. learn through the use of charts and tables
	C. make calculations
	D. reason out an answer
	E. participate in a “thought” experiment
	F. get information from the Internet
	G. use scientific observation and inference
	H. analysis and interpretation of data
III. Science as a Way of Thinking	A. describes how a scientist discovered or experimented
	B. historical development of an idea
	C. empirical basis of science
	D. use of assumptions
	E. inductive or deductive reasoning
	F. cause and effect relationship
	G. evidence and/or proof
	H. presents scientific method(s) or problem solving steps
	I. skepticism and criticism
	J. human imagination and creativity
	K. characteristics of scientists (subjectivity and bias)
	L. various ways of understanding the natural world
IV. Interactions among science, technology, and society and the social construct of knowledge	A. usefulness of science or technology
	B. negative effects of science or technology
	C. discussion of social issues related to science or technology
	D. careers in science or technology
	E. contribution of diversity
	F. societal or cultural influences
	G. make public or peer collaboration
	H. limitation of science
	I. ethics in science

APPENDIX C

Earth Science Literacy Analysis Framework

Themes	Subthemes
I. Geological Time	A. a knowledge of the length of geological time (absolute or deep time)
	B. the development of a time framework into which major geological events fit
	C. the enhancement of time-based thinking skills, enabling students to solve relative time-based problems
II. Spatial Thinking	A. Textbooks direct readers computer graphics, computer software and computer animations (Information technologies)
	B. Textbooks have 3D visualizations and graphics
	C. 2D visualizations with text relation
III. Holistic System Thinking	A. Inter-relationship between sub-systems
	B. The cycling thinking (having no starting point and no end point in the cycle) and systemic thinking (cycle in the context of its interrelationship with the other Earth systems) on Earth
	C. Earth as a whole system
	D. Human effect on systems
IV. Fieldwork	A. Fieldtrip advice
	B. The centrality of fieldwork and direct observation
	C. The interpretation of historical data
	D. Testing students' practical application in the classroom
	E. Data exploration in the field
	F. The detective work involved in retrodiction (prediction of the past)
V. Body of Earth Science Knowledge	A. Facts, concepts, principles and laws of earth science
	B. Hypotheses, theories, and models of earth science
VI. Interaction among Earth Science, Technology and Society	A. usefulness of earth science or technology
	B. negative effects of earth science or technology
	C. discussion of social issues related to earth science or technology
	D. careers in earth science or technology
	E. contribution of diversity
	F. societal or cultural influences
	G. make public or peer collaboration
	H. limitation of earth science
	I. ethics in earth science

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