ÖZLEM ÖZTÜRK

USING PISA 2015 DATA TO ANALYZE HOW THE SCIENTIFIC LITERACY OF STUDENTS FROM DIFFERENT SOCIOECONOMIC LEVELS CAN BE PREDICTED BY ENVIRONMENTAL AWARENESS AND BY ENVIRONMENTAL OPTIMISM

A MASTER'S THESIS

BY

ÖZLEM ÖZTÜRK

THE PROGRAM OF CURRICULUM AND INSTRUCTION
İHSAN DOĞRAMACI BILKENT UNIVERSITY
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2018

To my beloved family

Using PISA 2015 Data to Analyze How the Scientific Literacy of Students from Different Socioeconomic Levels Can Be Predicted by Environmental Awareness and by Environmental Optimism

The Graduate School of Education

of

İhsan Doğramacı Bilkent University

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Özlem Öztürk

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Özlem Öztürk

May 2018

I certify that I have read this thesis and have found that it is fully adequate, in scope and in quality, as a thesis for the degree of Master of Arts in Curriculum and Instruction.

Asst. Prof. Dr. Jennie Farber Lane (Supervisor)

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Asst. Prof. Dr. İlker Kalender (Examining Committee Member)

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ABSTRACT

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M.A. in Curriculum and Instruction
Supervisor: Asst. Prof. Dr. Jennie Farber Lane

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People need scientific literacy to keep up with and to understand continuing developments and changes in our modern world. In Turkey, especially for the people from low socioeconomic backgrounds, scientific literacy level tends to be low. The current study investigated how two environmental-literacy related factors contributed to the scientific literacy of students from different socioeconomic backgrounds. The study was based on the results from the PISA 2015 cycle. The PISA sample was composed of 5,859 15-year-olds randomly selected from 187 schools in different regions of Turkey. The relationships between environmental awareness and scientific literacy and between environmental optimism and scientific literacy were investigated using a multiple linear regression analysis technique. The difference in the environmental literacy and the environmental optimism level of the students from different socioeconomic levels was analyzed by using one-way ANOVA. Results revealed that both environmental awareness and environmental optimism were found to be significantly related to scientific literacy. Also, socioeconomic status created significant differences in environmental awareness and in environmental optimism

among different socioeconomic levels. Finally, it was found that there is a significant relationship between scientific literacy and environmental awareness and between scientific literacy and environmental optimism for all socioeconomic levels.

Key words: Environmental awareness, environmental optimism, scientific literacy, socioeconomic status

ÖZET

PISA 2015 VERİSİ KULLANILARAK, ÇEVRE BİLİNCİ VE ÇEVRE İYİMSERLİĞİNİN, FEN OKURYAZARLIĞI İLE İLİŞKİSİNİN FARKLI SOSYOEKONOMİK DÜZEYLER ELE ALINARAK ARAŞTIRILMASI

Özlem Öztürk

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Hızla gelişen ve değişen günümüz dünyasında fen okuryazarlığı bireylerin kazanması gereken önemli bir özellik haline gelmiştir. Türkiye'de ise özellikle sosyoekonomik düzeyi düşük olan kesimlerde fen okuryazarlığı seviyesi düşük kalmaktadır. Bu çalışmada, 15 yaşında, PISA 2015 testine tabi tutulan farklı sosyoekonomik düzeylerden öğrencilerin fen okuryazarlığını etkileyen çevre okuryazarlığı ile ilişkili faktörler incelenmiştir. Çalışma örneklemini Türkiye'deki farklı bölgelerde bulunan 187 okuldan seçilen 5,859 öğrenci oluşturmaktadır. Çevre bilinci ve çevre iyimserliğinin, fen okuryazarlığı ile arasındaki ilişki çoklu regresyon yöntemi ile analiz edilmiştir. Farklı sosyoekonomik düzeye sahip grupların çevre bilinci ve çevre iyimserliği düzeyleri arasındaki fark ANOVA tekniği ile incelenmiştir. Sonuçlara göre, çevre bilinci ve çevre iyimserliği ile fen okuryazarlığı arasında anlamlı bir ilişki bulunmuştur. Ayrıca, sosyoekonomik düzey, gruplar arasında çevre bilinci ve çevre iyimserliği açısından anlamlı farklar yaratmıştır. Çevre bilinci ve çevre iyimserliği ile fen okuryazarlığı arasında tüm sosyoekonomik düzeylerde de anlamlı bir ilişki bulunmuştur.

Anahtar Kelimeler: Fen okuryazarlığı, çevre bilinci, çevre iyimserliği, sosyoekonomik düzey,

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CHAPTER 1: INTRODUCTION

Introduction

Every three years, 15-year-old students from around the world complete the Program of International Student Assessment (PISA) test and questionnaire. In addition to assessing students' knowledge and attitudes, the questionnaire provides extensive demographic information. Researchers can use the data to explore various questions about study populations. The current study used PISA data to explore relations between science literacy and environmental attitudes and optimism. This introductory chapter provides background, states the problem, explains the purpose, and lists the research questions of the current study. The analysis used the PISA 2015 dataset which is compatible with Statistical Package for Social Sciences (SPSS). Environmental awareness and environmental optimism are the variables from the questionnaire that give insight about the students' environmental literacy. Information related with socioeconomic status (SES) was also available within the questionnaire data. Information related with scientific literacy was derived by the PISA test developers based on the students' test results. Main analysis techniques used in this research were a one-way ANOVA and multiple linear regression analysis.

Background

Scientific literacy is a characteristic of an active citizen and is defined as the capability to comprehend and address issues and ideas related with science. Scientific literacy includes three competencies: being able to make a scientific explanation for a phenomenon; being able to design a scientific exploration process

(like an experiment) and evaluate it; and being able to scientifically interpret the collected data (OECD, 2012). Therefore, a scientifically literate person who has these competencies is capable of taking part in conversations related to science and technology, comprehend and respond to a wide range of issues that involve science.

In twenty first century, scientific literacy is essential for recognizing, understanding, analyzing, and resolving societal issues. Typically, individuals gain this literacy during their school years where their science classes provide them with essential scientific knowledge, skills, attitudes and behavior. Given the importance of science literacy for today's world, many researchers analyze and assess science education programs to address the weaknesses and strengths (Gormally, Brickman, & Luts, 2012; Hudson, 2001; Ryder, 2001).

Science literacy is critical for understanding past, current, and potential environmental issues, especially the many human-caused environmental problems such as ecosystem destruction, accumulation of waste, inconsiderate consumption of natural resources, and more. These issues are often the subject of lawsuits and litigations. Scientists are involved in studying the issues and suggesting solutions. To address the issues, government agencies will develop policies or pass laws and regulations to protect the environment. Everyday citizens need to have a certain level of awareness about environmental issues to understand the problems and to be cognizant of their effect on the environment.

Studies also have shown that scientific knowledge is important for appreciating the environment and for understanding and addressing environmental problems (Hadzigeorgiou & Skoumios, 2013; Summers, Kruger, & Childs, 2001). The reason behind this is that features of environmental systems and factors lying under the

environmental problems are explained with scientific facts. People who are scientifically literate are more likely to have better dispositions about the environment and dispositions lead environmentally proactive behavior (Hansla, Gamble, Juliusson, & Gärling, 2008).

However, there are some sectors of the population who lack the opportunity to develop scientific literacy, Often, these people usually are less concerned about environmental issues. Some may feel that there is little they can do to affect the environment, negatively or positively. Studies have revealed that developing environmental literacy is more common for people from higher socioeconomic levels (Chu et al., 2007; Coertjens, Boeve-de-Pauw, De Maeyer, & Van Petegem, 2010; Erbaş, Teksöz, & Tekkaya, 2012; Negev, Sagy, Garb, Salzberg, & Tal, 2008; Yilmaz, Boone, & Andersen, 2004).

Subsequently, low socioeconomic status (SES) is one of the factors that affects students' academic achievement (Davis-Kean, 2005). SES has three main indicators: family income, occupation and education (Baker, 2014). In low SES families, children frequently face problems caused by the lack of healthy child-care. Also, they may be affected by unstable responses from their parents resulting in uncontrolled stress, anger, mood changes, negative thoughts and even the clinical problems like depression, anxiety and so forth (Demir, 2016). Child may suffer from different psychological and emotional problems such as mistrust, shame and doubt. Also, families suffering from socioeconomic problems may be less involved in their child's schooling (Velsor & Orozco, 2007). All these negative outcomes end up lowering the academic performance of the student when they start schooling. As their performance diminishes, this will likely cause problems related to self-doubt and lower academic achievement.

Research shows that people from low SES families tend to have a lower level of literacy (Buckingham, Wheldall, & Beaman-Wheldall, 2013). In accordance with their environmental awareness level, they are also not very concerned about the environment (Sulemana, James, & Valdivia, 2016). The main reason for this situation is that these people are mainly focused on their basic needs, health, accommodation, sometimes even survival and being concerned about the environment is not a priority within their circumstance as it is explained with Maslow's Hierarchy of Needs (Maslow, 1970). Affluent people often do not have concerns about their basic needs and they have a better access to the necessary resources to be informed about the environment.

Just like the research done in the other parts of the world, SES was found to be an important predictor of the environmental literacy and environmental behavior in Turkey (Erdoğan, 2009). Some studies also investigated the place of the environment in the current educational system (Hamalosmanoğlu, 2012). However, there is a need for more research about the relationship between scientific literacy and environmental literacy for students from diverse levels of SES.

To explore the reasons behind this phenomenon, there needs to be some reliable data sources. PISA is a respected and reliable survey that has been developed and administered by the Organisation for Economic Co-operation and Development (OECD) since 2000. It is conducted in every three years and 15-year-old students from many different countries complete this survey (OECD, 2017a). The main purpose of PISA is to assess knowledge and different skills of those students (especially reading, science, and mathematics and financial literacy). Students also provide demographic information and opinions about their educational experience. Researchers and educators from around the world have access to this data and can

learn about the academic status of their youth. They gain information about social, cultural and economic circumstance of country.

Several studies in Turkey have used PISA data to gain insights into various aspects of students' academic achievement in relation to selected demographic data (Anagun, 2011; Anıl, 2011; Erbaş, Teksöz, & Tekkaya, 2012). The current study sought to use this data to gain insights into relations among students' scientific literacy, environmental attitude, and their socioeconomic status. Regarding environmental literacy, since this study relied on data provided by the international PISA exam, it was limited to only environmental awareness and environmental optimism. There are many other contributors and characteristics of environmental literacy (e.g., sensitivity, ethics, agency); however, since they were not assessed by PISA were not included in the current study.

Based on the results of the students taking PISA test, OECD formed seven proficiency levels (Table 1) (OECD, 2017b). Characteristics of the students from those seven proficiency levels are also determined by OECD (See Appendix A). Results in Table 2 show that 35.5% of the Turkish students clustered in level 1a which is the second lowest proficiency level on the scale. Furthermore, 67.3% of Turkish students were under level 1a and level 2. There are 11.4% who are from the lowest level 1b and none of the Turkish students were able to reach the level 6. Only 0.1% of the students reached level 5 and all of those students are from the highest quartile in terms of socioeconomic status. All those results show that Turkish students' scientific literacy level is quite low in terms of PISA proficiency levels and low socioeconomic status makes the circumstance even worse.

Table 1
Scientific literacy performance band definitions on the PISA scale

Level	Score Points on the PISA Scale
6	Higher than 707.93
5	Higher than 633.33 and less than or equal to 707.93
4	Higher than 558.73 and less than or equal to 633.33
3	Higher than 484.14 and less than or equal to 558.73
2	Higher than 409.54 and less than or equal to 484.14
1a	Higher than 334.94 and less than or equal to 409.54
1b	260.54 to less than or equal to 334.94

Table 2
Turkish students' frequency distributions of PISA 2015 proficiency levels based on their socioeconomic status

	PISA 2015 Scientific Literacy Levels Set by OECD						
Groups*	1b	1a	2	3	4	5	6
ESCS1	5.7	24.2	33.5	28.5	7.6	0.5	-
ESCS2	11.5	34.1	32.6	18.6	3.2	-	-
ESCS3	11.7	39.5	32.5	14.0	2.3	-	-
ESCS4	16.5	44.0	28.6	9.7	1.2	-	-
Total	11.4	35.5	31.8	17.7	3.6	0.1	

* ESCS1, ESCS2, ESCS3 and ESCS4 are the socioeconomic levels determined by the researcher. Every level represents a quartile and ESCS1 is the highest quartile whereas ESCS4 is the lowest quartile.

Problem

According to PISA results, Turkish students' scientific literacy is very low compared to most other OECD countries. This poor performance is even more pronounced with children from low SES backgrounds. Therefore, it will be important to identify contributors to scientific literacy to help identify if there are possible ways to address this issue.

Some researchers advocate that there is a relationship between scientific literacy and environmental literacy. Furthermore, it has been shown that people with a high

socioeconomic background tend to have higher scientific and environmental literacy. There are limited studies that provide findings to show if this is true for Turkey.

Purpose

The purpose of this study is to use PISA 2015 data to learn the extent to which environmental awareness and environmental optimism predict the scientific literacy of Turkish students. Furthermore, the study will examine whether the relationship is comparable for students from different socioeconomic levels. The first purpose will be addressed through a multiple linear regression of the data and the second with a one-way ANOVA.

Research questions

This study will address the following questions:

1) To what extent is the scientific literacy of the Turkish students is predicted by:
   - environmental awareness
   - environmental optimism
2) When students are grouped into four different socioeconomic levels, is there a difference in their:
   - environmental awareness
   - environmental optimism
3) To what extent is the scientific literacy of the students grouped into these four different socioeconomic levels predicted by:
   - Environmental awareness
   - Environmental optimism

Significance

This study brings scientific literacy, environmental awareness, environmental optimism and socioeconomic status together. The findings of this study can help teachers, stakeholders and educational policy developers to appreciate the contribution of the environment related knowledge and dispositions to the scientific literacy of the Turkish students. In other words, by increasing students' environmental education, their academic achievement in science can be enhanced. Curriculum designers may provide novel ways for teachers to implement environment-based education in and outside of the school. Teachers and parents can be informed and educated to support the students' knowledge about environment and enhance their dispositions about environment as a fundamental step to build up their scientific literacy. Environmental education experiences can be accomplished with limited resources, by simply taking students out to explore their school grounds. Therefore, even schools in less affluent societies can provide students with an environmental education and thereby improve their scientific literacy.

Definition of key terms

Environmental awareness: The particular body of knowledge, critical thinking, and attitudes related with environment that can be justified by the concept of awareness, means, awareness that causes a change in perception, which leads a change in attitude, behavior and action about the environment (Hadzigeorgiou & Skoumios, 2013).

Environmental literacy: the capacity of perceiving, interpreting the state of environmental systems and when necessary, being proactive to maintain, improve, or restore these systems (Roth, 1992).

Environmental optimism: Individuals' perception of different environmental issues as a concern for the future (OECD, 2017c).

Scientific literacy: A characteristic of a reflective citizen, which is mainly the ability to engage in issues and ideas related with science (OECD, 2017c)

Socioeconomic status: It is the status of the family which is defined with the characteristics namely, parental income, parental education and parental occupation (Duncan, Featherman & Duncan, 1972).

CHAPTER 2: REVIEW OF RELATED LITERATURE

Introduction

Every day there are advances in science that affect our lives. The purposes of these innovations are to benefit society, but often there are unforeseen consequences that affect human health and the environment. As environmental problems continuously increase, threaten health, and deplete resources, it is important to understand the science behind the causes and proposed solution. For this reason, many researchers have conducted studies to investigate individuals' scientific literacy, including how it is supported or challenged. In this chapter, the findings of these studies and their relevance to the current research will be presented.

Scientific literacy and environmental literacy

Understanding the science behind environmental problems is important for policymakers, governmental officials, and other members of society (Cashmore, 2004; Liu, Gupta, Springer, & Wagener, 2008). According to the report of National Environmental Education and Training Foundation (NEETF), people may hear about issues such as water pollution, global warming in the media, but do not comprehend their causes and how their lives are affected (1997). NEETF has explored the relation between scientific literacy and environmental literacy and recommends that environmental education grounded with a sound scientific background for people to understand environmental issues. Hudson cautions that environmental education needs competent educators who can teach students complex scientific facts in an understandable, approachable way (Hudson, 2001). Clearly there is a connection between scientific and environmental literacy. Below, literature about these two

literacies is explored further. Followed by a discussion of how both are affected by students' socioeconomic status.

Measuring, or assessing the scientific literacy is as important as increasing the level of scientific literacy of individuals. For that purpose, different tests are developed and implemented by the researchers. Gormally, Brickman and Luts (2012) developed and validated a test called "Test of Scientific Literacy Skills (TOSLS)" and in three different institutes, they applied this test to five general education biology classes. They aimed to test the students' ability to understand and organize the inquiry methods that will end up producing scientific knowledge, and to arrange and analyse the scientific data. Results show that TOSLS can be used to understand the students' scientific literacy level and how it is changed through time, as well as it can be used by instructors to assess their expectations and their reflection in their classes.

Assessment of scientific literacy should give information about whether individuals can use scientific knowledge in their daily lives. This is also important in terms of comprehending environmental problems as a case people face in the real life. In his research, Ryder (2001) explored various case studies about individuals lacking a proper scientific knowledge had to handle the situations that have scientific aspects. Among those situations, some of them are related with environmental problems like acid rains and public policies, herbicides, local industrial hazards, Chernobyl fallout. The aim of the study was to construct a framework of scientific knowledge needed by those individuals to handle these cases. It is proposed that such individuals have difficulties in dealing with real life situations like getting counselling from a healthcare professional, asking critical questions about an environmental issue etc. As a result of these findings, Ryder emphasized the importance of science education in the schools and the curriculum's role of letting students enjoy science and

showing the students that science is an indispensable part of their everyday life. Furthermore, the study also showed that scientific knowledge is needed to understand environmental issues.

Klosterman (2010) investigated the effect of socioscientific issue (SSI) based education on the scientific literacy level of the students. The sample was composed of 108 students from two schools. A three-week long unit about global warming was implemented and a pre-test post-test design was used. A standards-aligned knowledge exam and a curriculum-aligned exam were used in order to assess student content knowledge. Post-test results were found to be significantly different from the pre-test results. Students showed a better comprehension of global warming, and the scientific reasons behind it like greenhouse effect. This study shows the importance of the educational techniques used in the classroom and also, since the chosen SSI was global warming, results also show the relationship between the understanding of scientific facts and the understanding of environmental issues.

In the course of increasing the environmental awareness of the people, just like scientific literacy, it is very important to measure and evaluate individuals' environmental literacy as well. Therefore, there have been studies that investigated the environmental literacy of the students.

Barraza and Walford (2002) measured environmental literacy of English and Mexican school children, including their knowledge, perception, and attitudes, . Their independent variables were the national policy and classroom practice which is affected by school ethos. Students were selected from eight schools. The sample was composed of 246 children from the third grade. A questionnaire was used but at the same time students wrote poems and made drawing. According to the results,

classroom practices created a difference and children mainly using textbooks are found to be disadvantaged even though the curriculum includes content related with environment. Schools having strong environmental ethos were more successful in terms of creating environmental literacy. Cultural difference is another factor affecting the environmental attitudes of the children but, the main recommendation was about forming school policies which will create an effective classroom environment that will transmit environmental knowledge, behavior and attitudes to the students.

Another study was conducted with Dutch students to assess and evaluate environmental knowledge, attitudes and behavior by using the data from the Dutch National Assessment Program (Kuhlemeier, Bergh, & Lagerweij, 1999). The sample was composed of more than 9000 students from 206 secondary schools aged mostly around 15 years. Even though the students have a positive attitude towards environment, their environmental knowledge was mostly incorrect and many of them do not know exactly what to do for the environment even though they try to act in an environmentally responsible way. Additionally, environmental behavior and environmental knowledge of those students were found to have a weak correlation. They also report that willingness to make sacrifices is more related to environmentally responsible behavior rather than attitudes towards the environment. This study shows that the knowledge is not enough to behave in an appropriate way.

One example of a study that assessed both environmental and scientific literacy was conducted by Uitto, Juuti, Lavonen, Byman, and Meisalo (2011). They investigated students from a secondary school in Finland to learn about their interests, attitudes and values about their school science topics related to the environmental problems using the Relevance of Science Education (ROSE) questionnaire. The sample was

composed 3626 students from 68 different schools. Using a MANOVA analysis of the data, the results found that attitude is significantly correlated to value factors and interest. Gender difference was found as well with girls having stronger biocentric values and more positive attitudes toward the environment than boys. The school grounds did not have a noticeable effect on students' interests, attitudes and values about science Researchers suggested that schools need to get involved in environmental projects, activities or the projects related with sustainable development as a part of their science education.

SES and environmental literacy

Although studies that explore environmental education and academic achievement are limited, there are studies of environmental literacy that explore other variables. One variable of particular interest to the current study is socioeconomic status. Negev, Sagy, Garb, Salzberg, and Tal (2008) investigated environmental literacy of the Israeli elementary and high school students from 6^{th} and 12^{th} grades with a survey. This survey evaluated s environmental knowledge, behavior and attitudes. The relationship of these aspects with the demographic background of the students was interpreted by the researchers as well. Results show that for environmental literacy, ethnic and socioeconomic characteristics had a moderate effect. If there are adults in their lives who put importance in forming connection between children and environment, students tend to have better behavior and attitudes about environment. Just by looking at these results, it can be said that socioeconomic factors are important in terms of having environmental literacy, because, parents and their education level is also a determinant factor for SES.

A similar study by Chu et al., (2007) investigated the Korean year 3 students' level of environmental literacy. However, this time with an addition of environmental skills to knowledge, attitude and behavior as the four dimensions of environmental literacy. Researchers developed an instrument called Environment Literacy Instrument for Korean Children (ELIKC) that has 69 items with 13 variables to be investigated: gender, the environmental information source, parents' educational background, the role of science and technology in solving environmental problems, the main solver of environmental problems, their favourite subjects in school, the region they are from, cognition of science, and environmental education before schooling. The sample was composed of 969 students from three different areas: large cities, medium sized cities and rural areas. The statistical technique used was MANOVA to determine by which variables environmental literacy is affected. Also, they conducted a correlational analysis for the four dimensions of environmental literacy. Correlational analysis results show that environmental attitude and behavior has a strong correlation and the weakest correlation was between knowledge and behavior. This is an important finding because like the study conducted by Kuhlemeier, Bergh. and Lagerweij (1999), this study also shows that just knowing the content does not necessarily mean that the students will have the right dispositions.

Another study reporting contradictory result about the relationship between SES and environmental literacy was conducted by Liu, Vedlitz, and Shi (2014). They examined the determinants of environmental concern by using three national public surveys conducted in United States. These surveys are from 2004, 2007, and 2013. Based on the results, they concluded that political ideology, gender, race, and fundamental beliefs about human-nature relations can explain public environmental

concern. They found that age is positively related to environmental concern; that is, as people get older, they tend to be more concerned about the future of the environment. Furthermore, the results show that education level, which is a determinant of SES as well, mostly fails to explain public environmental concern. This last result can also be related to scientific literacy because, individuals' scientific knowledge is mostly related to their education level as well, and people having a good level of education are mostly the ones having scientifically literate.

Similarly, Dunlap and Mertig (1995) claimed a different point of view, stating that high SES is not a requirement for environmental concern. Researchers used the data from The Health of the Planet (HOP) 1992 survey which was conducted by George H. Gallup International Institute. The data was from 24 geographically and financially different nations and Turkey was one of them as a low SES country. They created national-level scores and conducted the analysis accordingly. Results show that overall affluence of a nation is negatively related to citizen-level environmental concern.

Studies in Turkey

Scientific literacy and its connection with environmental literacy and SES has been widely studied around the world, including Turkey. In this section, some studies that took place in or about Turkey will be presented and their results will be discussed.

Scientific literacy, environmental literacy and SES

Berberoğlu and Tosunoğlu (1995) studied 639 Turkish university students to assess their knowledge and attitudes about environmental issues. The instrument was a four-dimensional Environmental Attitude Scale (EAS) with 47 attitude statements and 172 items. Given four dimensional traits were population growth, environmental

problems, nuclear energy and energy conservation. According to the results, university students do not give a sufficient level of importance to these four dimensions. The researchers provided two reasons for these results: in Turkey, environment related topics are not prominently covered in the curriculum and mass media fails to raise awareness and provide sufficient information about the given environmental issues.

This study took place in 1995 and since then the Turkish curriculum has undergone many changes. The following three studies indicate an improvement in the environmental literacy of Turkish students. This may be a result of the alterations done with the curriculum. However, as discussed, low SES still seems to be an issue that lowers the level of environmental literacy.

Erdoğan and Ok (2011) assessed Turkish students' environmental literacy with a survey by considering six environmental components. The instrument was called Elementary School Environmental Literacy Instrument (ESELI) and was divided into five parts and 75 items. The sample was composed of 2,412 fifth grader students from 78 elementary schools. Among those schools, 26 of them were private and 52 of them were public schools and they were from 26 provinces of Turkey. Results showed that 27 % of the students had a high level of environmental literacy while 61 % of the students had moderate level of environmental literacy. Results of this study draws a positive picture about the country by reporting that only around 1% of the students had low environmental literacy.

Çetin and Nişancı (2010) investigated the new Biology curriculum in terms of its effect on the ninth graders' environmental awareness. The researchers worked with 91 ninth grader students from a school in Balıkesir. The instrument used was called

Environmental Awareness Questionnaire and it included a pre-test and a post-test. They had an experimental group and a control group. The experimental group received five weeks of the new instructional methods from the new curriculum, while the control group was taught by the traditional methods. After the treatment, researchers interviewed the experimental group students. According to the findings, the new Biology curriculum is more powerful in terms of increasing the environmental awareness level of the ninth-grade students.

Yilmaz, Boone, and Andersen (2004) conducted a study to assess the elementary and middle school Turkish students' views about environmental issues via an instrument called Attitude toward Environmental Issues Scale (ATEIS). Attitude was defined by the researchers as the positive or negative feeling towards something, in this case, environment. ATEIS was composed of 51 items and in addition to the items about 30 different environmental issues, it also provided background information about gender, SES, grade level, school location and previous science achievement. The important aspect of the questionnaire is that it included environmental issues that were in the Turkish curriculum. The sample was composed of 458 students from fourth to eighth grade. Interestingly, students could not comprehend the importance of some environmental problems over the economic growth. However, they accepted the importance and presence of the environmental problems which are also present in Turkey. Also, ANOVA results showed that recent high achievement contributes to a more positive attitude towards the environmental problems. According to the *t*-test results, older female students, students with high family income, and students from urban areas have a more positive attitude towards the environment. Results of this study clearly states the relationship between SES and scientific literacy and that

socioeconomically advantaged students show a better level of scientific literacy for both attitudes, behavior and knowledge.

Programme of International Student Assessment (PISA)

Common among the studies described above is that they used or developed an instrument to focus on science or environmental literacy. Some studies have tapped into data provided by other assessments, such as PISA. Since PISA is accepted as a very well-known reliable assessment which provides detailed information on a very large scale in terms of its sampling, it has been an attractive data source for researchers. This section will provide some example research conducted both in the world and also in Turkey.

PISA 2006

Just like the PISA 2015 cycle, PISA 2006 also had scientific literacy as a focus; therefore, it included items related with science and environmental literacy. For that reason, there are some studies using PISA 2006 data that investigated students' scientific and environmental literacy level and the related factors.

Lavonen and Laaksonen (2009) used the results of PISA 2006 to assess Finnish students' opinions about the teaching and learning environment, their interest and beliefs about their competence in science in general, their sense of self efficacy and their scientific literacy results. The sample was 4,714 students from 155 different schools. After a regression analysis, predictors related to science literacy included self-efficacy and self-concept, interest in physics and chemistry, and potential job skills. The most powerful predictors for scientific literacy were practical work, number of demonstrations, and the possibility for making conclusions. Surprisingly, students' opinions about debate activities and the number of science inquiries had a

very strong negative correlation to their scientific achievement and also, Finnish students were not very interested in the science process itself, such asthe designing experiments or developing scientific explanations. The results of this study is important since it reflects the profile of one of the most successful countries in education; it is interesting that predictors like debate activities and most interestingly inquiry were found to be negative predictors of scientific literacy.

As with scientific literacy, some researchers were focused on environmental literacy more. Coertjens, Boeve-de-Pauw, De Maeyer and Van Petegem (2010) were exploring whether the school policies creates a difference in the environmental attitudes and awareness of the students as well as the students' characteristics as predictors of environmental attitudes and awareness. A multivariate analysis was conducted with the data from 4,999 Flemish students from 156 schools; the results revealed that SES, gender, immigrant status, and educational track were important predictors of environmental attitudes and awareness. Additionally, schools contributed to the students' environmental awareness and attitudes when science classes included more hands-on activities. These school effects were not different between the high scientifically-literate students and other students with moderate or low scientifically-literate ones. Just like Lavonen and Laaksonen's findings described above, this study reveals the importance of the implementation of science curriculum but, in this study, demographic factors and the effect of SES were also highlighted as a predictor of environmental literacy.

Another study about the factors related with environmental literacy was conducted by Lin & Shi (2014) to compare the students from US and Canada. According to the results of PISA 2006, even though these two countries share similarities like universal public systems and student population diversity, American students show

an average level of scientific literacy while Canada was one of the top performing countries. Therefore, while exploring the factors related with environmental literacy, the study highlights the relationship between environmental and scientific literacy. School and individual related factors were examined by comparing the two countries' students in terms of environmental awareness, knowledge, attitude and behavior. The two countries show similarities in students' ability of self-expression and self-evaluation. According to the results, environmental knowledge, awareness, attitude and behavior were found to be inter-related. Also, paper states that low performance is not solely caused by SES related factors, and educational policies, location, and cultural differences should be considered as well.

PISA and Turkey

As with other countries, Turkish researchers have used PISA data to gain deeper insights into various aspects of the student population. Anagun (2011) conducted a study to examine the teaching-learning process effect on the scientific literacy of Turkish students by using the data from PISA 2006 cycle. The sample was composed of 4.942 students from 160 schools and the technique used was Structural Equation Model that determined to what extent the variables predict scientific literacy. Results of the study revealed that spending time for learning was the strongest predictor of scientific literacy among other teaching-learning process variables. Furthermore, conducting experiments in the classroom, inquiry-based activities were found to be the other teaching-learning related predictors. In addition to these predictor variables, Anagun stated that self-concept and attitudes toward science did not have a significant relationship with the scientific literacy of Turkish students.

Kaya and Doğan (2017) investigated the characteristics of the students that have an effect on scientific literacy of Turkish students. Researchers aimed to compare Turkish students with three other countries: Finland, America and Israel. They used PISA 2012 data and the sample was composed of 23710 students from these four countries. They concluded that parental education level created a difference in the scientific literacy of Turkish students. Furthermore, availability of computers in home, educational software, types and number of books in home were different among four countries and they affected scientific literacy of Turkish students.

Erbaş, Teksöz, and Tekkaya (2012) investigated the factors related with the environmental responsibility among Turkish students. The researchers emphasized the importance of science education in forming environmental literacy and their role in PISA 2006, but they did not analyse the relationship between them. They mainly tried to find out the relationship between environmental responsibility and socio-demographic factors such as SES, school activities, environmental optimism, parents' sense of responsibility and gender. The results revealed that gender, presence of school activities related with environment, SES, environmental optimism and parents' sense of responsibility were found to be the socio-demographic predictors of environmental responsibility. Additionally, parental optimism about the environment was a strong but negative predictor of environmental responsibility. They concluded that for the Turkish context, SES was the strongest factor contributing to environmental literacy. Also, researchers emphasized the fact that Turkish educational system lacks the strategies to develop the environmental literacy of 15 year-olds. Based on their assumption that environmental awareness and responsibility will contribute positively to the SES within the country, they

underlined the importance of developing educational policies having strategies about environment.

Another study that explore relationship between SES and scientific literacy was conducted by Anıl (2009) who used PISA 2006 data to investigate the factors related with the scientific literacy of Turkish students. The sample was composed of 4942 students. Educational status of the father and mother, student's attitudes about science, availability of the computer and the cultural wealth of the family were the investigated independent variables. Multi-regression analysis was used in order to reveal how the selected factors contributed to scientific literacy. These factors contributed 20% of the scientific literacy level of the students and among these variables, the most effective predictor was the educational status of the father followed by the attitudes against science and availability of the computer.

Anıl (2011) conducted another study for the same purpose. She used PISA 2006 data to analyze the factors affecting scientific literacy. The technique used was a Structural equation Model that revealed the presence of simultaneous change between at least two variables. Among the predictors, "Time allocated to learning" was found to be the strongest followed by the "learning environment." The latter is associated to SES since it includes information about having a room for studying, a computer and a computer program, a desk, and having an internet connection within the houses of the students. The last two predictors of the scientific literacy were parental education which is also an SES related factor and attitudes towards science whose relation was not as high as the other variables.

Gürsakal (2012) investigated the factors affecting the Turkish students' literacy levels based on PISA 2009 results. The sample was composed of 4996 students from

170 schools. Scientific, mathematical and reading literacies were examined as dependent factors. Logistic regression analysis results showed that gender, the age of starting school, and the educational level of the parents are critical factors affecting all literacy levels. The results of this study also show the effect of SES on scientific literacy level of Turkish students.

The above and their results indicate the relationship between environmental literacy and SES and low SES seems to be a factor that is associated with low scientific and environmental literacy. This relationship between SES, environmental and scientific literacy is observable for both global settings and Turkey. In Turkey, different studies have been conducted in the past, and the current study will help the future researchers to show whether this relationship is still present after 20 years.

CHAPTER 3: METHOD

Introduction

This chapter presents detailed information about the methodology, including research design, sampling methodology, instrumentation, collection and analysis of the data. The methods include a description of multiple linear regression analysis and a One-Way Analysis Of Variance (ANOVA).

Research design

The main purpose of this study is to analyze the relationship between students' scientific literacy and their environmental awareness and their optimism (with and without considering the effect of socioeconomic status). This is a quantitative study that used 2015 PISA results to gain insights into students' environmental attitudes in relation to their scientific literacy. PISA includes a test of student's math, science and reading literacies as well as a questionnaire to gather demographic information and assess attitudes. By utilizing the information coming from this test and questionnaire, a correlational study is conducted to investigate the relationships between a dependent variable and independent variables. For this study, the dependent variable was scientific literacy and the independent variables were environmental awareness and environmental optimism.

Context

PISA is a respected international survey that examines knowledge and skills of selected 15-year-old students from around the world. In 2015, over half a million students from 72 countries participated; the students are from different familial and educational backgrounds. The scores of these students represent 28 million 15-year-

old students from those countries. The literacy test is composed of domains called reading, science, mathematics, financial literacy and collaborative problem-solving items. Each time the PISA is administered a different discipline is featured; in 2015, the focus was science. In addition to literacy tests, students also completed questionnaires that collect details about their background and educational experience.

Turkey is a country which has some problems related to education. Students struggle with learning the basic skills and their implementation to real life situations based on the results of PISA 2003 and Student Selection Examination (SSE) in Turkey. School type creates a dramatically big difference in terms of learning and achievement. This shows that there is an unequal distribution of educational resources and opportunities among different school types. Also, in Turkey, students are placed to high schools via the performance they showed in the centralized examinations. Therefore, high achievers are clustered in some schools like science high schools and low achievers are clustered in other schools like vocational and technical high schools. This further increases the difference in their achievement in the examinations like PISA and SSE. These issues affect Turkish students throughout the nation. Compared to other nations around the world that may have certain parts of their country that are more disadvantaged than others, Berberoğlu and Kalender (2005) report that Turkey's low academic performance is a comparable issue for all regions of the country.

Researchers, educators, and policy makers from various countries use the data from all the PISA instruments to evaluate their educational systems and gather a variety of information related to student performance. Based on this information, governments are able to compare the current educational environment within the country to other countries. Also, governments are able to receive valuable feedback and to gain

insight into their educational system's strengths and limitations that may affect the educational success of their students.

Sampling

Sampling by OECD

The PISA test is developed by Organization for Economic Co-operation and Development (OECD). The target population for PISA is composed of the students between the ages of 15 years, three months and 16 years, two months (OECD, 2016a). They need to be registered and a student of their school from at least the seventh grade.

The OECD uses a number of categories to determine which schools are selected to participate, including the region, public or private educational programs, gender, time of instruction (morning or afternoon), and so forth. Schools may opt to not participate because of reasons such as cost or scheduling issues. The goal is to make sure that the final selection represents at least the 95% of the desired target population. After PISA-eligible schools are selected, students are randomly sampled from each school (OECD, 2016a).

According to the report of Turkey's Ministry of National Education (2016), there are 1,324,089 15-year old students in Turkey and 925,366 of them were an eligible population for the test. Stratified random sampling was used to first select the schools and then to identify students within those schools. According to the Classification of Territorial Units for Statistics, 187 schools from 61 cities within 12 territories were selected to participate in PISA. Those territories were Istanbul, West Marmara, Aegean, East Marmara, West Anatolia, Mediterranean, Central Anatolia, Western Black Sea, Eastern Black Sea, Northeastern Anatolia, Central Eastern

Anatolia, Southeastern Anatolia. The schools were classified under eight types: Middle school, Anatolian high school, science high school, social sciences high school, fine arts high school, vocational and technical high school, multiple programmed Anatolian high school, Anatolian imam hatip high school (where mainly the religious courses are taken). The majority of students are from Anatolian high schools and vocational and technical Anatolian high schools (75%). In total, 5,895 students from Turkey provided PISA data in 2015. In Turkey, the majority of students who participated in PISA were in ninth grade (72.9%) and tenth grade (20.7%). Half of the population was male and half were female.

Sampling used for the current study

For the current study, only the Turkish students were selected and students from other countries were excluded. Then grouping was based on students' socioeconomic background. For determining the students' socioeconomic status, the PISA index of economic, social and cultural status (ESCS) was used.

ESCS is a kind of composite score that is derived from three indicator variables called parental education (PARED), home possessions (HOMEPOS), and highest parental occupation (HISEI) (M = 0, SD = 1) (See Appendix D). During the calculation of ESCS, if two or three of those scores of a specific student are missing, ESCS score is not calculated for that student. The main rationale behind the calculation of ESCS for the PISA questionnaire is that socioeconomic status is usually linked with occupation, education and income (OECD, 2017d).

The researcher used SPSS to divide the students into quartiles by using their ESCS scores. The data from 36 students were excluded because their ESCS score was not calculated due to the stated reasons (see Table 3). Students in ESCS1 are the most

socioeconomically advantaged (lowest quartile) and ESCS 4 is comprised of the most socioeconomically disadvantaged students. In order to give a better picture of the groups in terms of their SES levels, descriptive analysis was conducted to see group mean scores for selection of items within the ESCS score (See Appendix E).

Table 3
Four groups based on their ESCS values

Groups	Frequency	Percent	Valid Percent	Cumulative Percent
ESCS1	1464	24.8	25.0	25.0
ESCS2	1465	24.9	25.0	50.0
ESCS3	1465	24.9	25.0	75.0
ESCS4	1465	24.9	25.0	100.0
Missing	36	0.6		
Total	5859	99.4	100.0	

The difference in scientific literacy among the four socioeconomic levels was investigated. As shown in Table 4, the descriptive analysis of the scientific literacy shows that students with higher socioeconomic levels have higher scientific literacy scores.

Table 4
Descriptive analysis of scientific literacy among four different SES groups

Groups	N	Minimum	Maximum	M	SE	SD	Proficiency Level
ESCS1	1464	234.210	681.430	454.004	1.973	75.481	2
ESCS2	1465	241.710	622.520	422.233	1.886	72.179	2
ESCS3	1465	239.850	627.400	413.632	1.802	68.968	2
ESCS4	1465	246.950	628.600	398.864	1.687	64.581	1a

The descriptive analysis of environmental awareness revealed that students with higher socioeconomic levels also have higher environmental awareness. Table 5 shows how the mean score of environmental awareness changes among the groups.

Table 5
Descriptive analysis of environmental awareness among four different SES groups

Groups	N	Minimum	Maximum	M	SE	SD
ESCS1	1464	-3.377	3.281	.820	.040	1.518
ESCS2	1465	-3.377	3.293	.586	.038	1.425
ESCS3	1465	-3.377	3.293	.500	.038	1.440
ESCS4	1465	-3.377	3.293	.405	.040	1.489

Descriptive analysis of environmental optimism presented in Table 6 shows that as the students have a better socioeconomic status, they tend to be more pessimistic about the future of the environment.

Table 6
Descriptive analysis of environmental optimism among four different SES groups

Groups	N	Minimum	Maximum	M	SE	SD
ESCS1	1464	-1.793	3.013	-0.777	.035	1.339
ESCS2	1465	-1.793	3.013	-.550	.038	1.450
ESCS3	1465	-1.793	3.013	-.469	.039	1.472
ESCS4	1465	-1.793	3.013	-.385	.041	1.507

Figure 1 shows that environmental awareness and environmental optimism have opposite trends. As environmental awareness increases, environmental optimism decreases. Also, low SES seems related to the decrease of environmental awareness and the increase in environmental optimism.

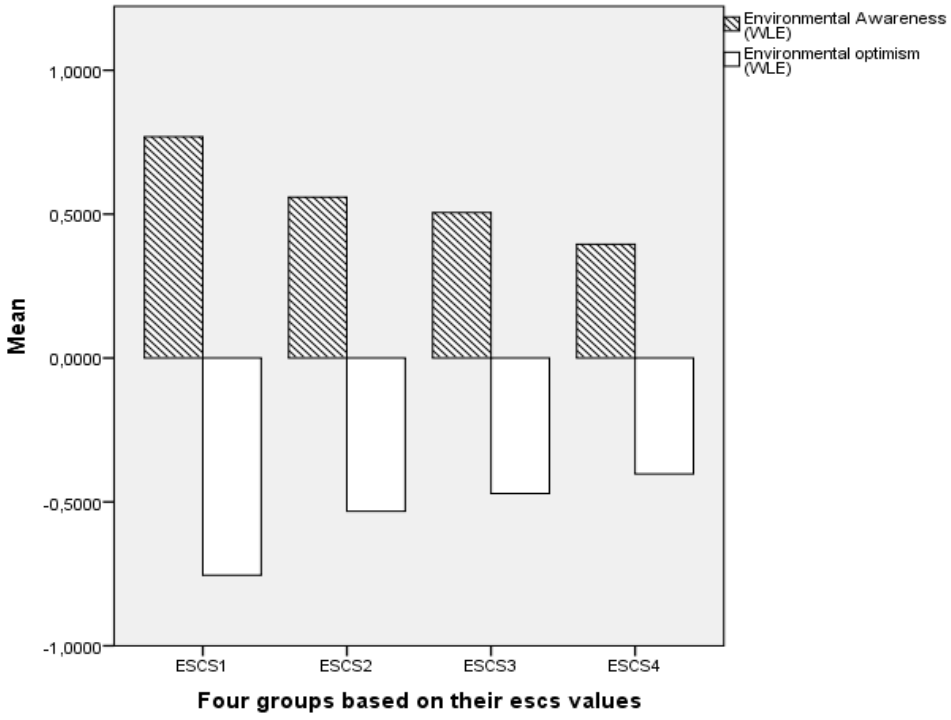

Figure 1. Bar-chart of environmental awareness and environmental optimism levels of the SES groups

Instrumentation

The PISA test focuses on science, mathematics, reading, collaborative problem solving and financial literacy. In the 2015 cycle, the main focus was scientific literacy. The scientific literacy test of PISA assesses three main competencies: To explain phenomena scientifically; to evaluate and design scientific enquiry; and to interpret evidence and data scientifically. These competencies and knowledge types are then assessed in the contexts of health, the environment, the frontiers of science and technology, natural resources, and hazards in personal, local and global settings (OECD, 2012).

In the Turkish educational system, scientific literacy is defined as "the skill of working with the ideas and of science and dealing with the issues of science as an active individual" (MoNE, 2016, pg. 9). According to MoNE these competencies

rely on three types of scientific knowledge: content knowledge, procedural knowledge and epistemic knowledge.

The questionnaire also includes items to assess students' attitudes about various topics, including environmental issues. For the current study, the variables ENVAWARE and ENVOPT were used from the questionnaire. ENVAWARE is a score calculated from the student responses to a question (ST092) that asks about various environmental issues (see Appendix B).

ENVOPT is again a single score calculated from the student responses to question (ST093); this question assesses students' prospects of the same environmental issues (see Appendix C).

Method of data collection

The PISA test is administered in two 60-minute periods, with a five to ten minutes break between periods. After the literacy tests and a 15-minute long break, students are given 35 minutes to complete the questionnaire. The data (student responses) is accurately transcribed through a computer-based platform (OECD, 2017e).
For this research, the data has been provided by the OECD, which is available on the organization's website, was used (http://www.oecd.org/pisa/). The data for all student responses can be downloaded in SPSS file format. All the analysis in this research was completed using Statistical Package for the Social Sciences (SPSS). The website also provides information how the instruments were developed and an executive summary of worldwide and country specific statistics. Researchers can also find technical reports and research documentations related to PISA 2015 and previous cycles.

Method of data analysis

The analysis investigated and interpreted the PISA data through a multiple linear regression and a one-way analysis of variance (ANOVA). Multiple linear regression allows a researcher to predict the value of a dependent variable based on the values of at least two independent variables. The ANOVA shows whether there is a statistically significant difference among the mean values of two or more independent groups. Every analysis was conducted ten times (since there are ten plausible values for scientific literacy) and the averages of their results were reported.

For the current study, the variables came from data sets of the PISA results. The dependent variable was scientific literacy. PISA determines scientific literacy through ten plausible values that represent the proficiency of the students in different ways (OECD, 2017f). The independent variables were Environmental Awareness (ENVAWARE) and Environmental Optimism (ENVOPT). The independent groups were derived by using the scores under the variable called Economic, Social and Cultural Status (ESCS). ESCS is measured by questionnaire items related with parents' occupation and education level, and the home possessions like a single room to study, internet connection, the number of books etc. The abbreviations in parentheses are directly taken from the PISA database. The researcher used multiple linear regression to examine to what extent environmental awareness and environmental optimism values predict the scientific literacy of Turkish students. The students were divided into four socioeconomic levels and the predictive values of each variable were explored for each level. The researcher used ANOVA to learn if the mean responses for environmental awareness and environmental optimism were significantly different among students from each socioeconomic level.

As explained in the population sampling discussion, a first step of the analysis was to group the Turkish respondents into four different socioeconomic levels. The data analysis manual of PISA (OECD, 2009) requires data weighting to ensure the reliability of the analysis is not affected. The data was weighted for the following reasons:

- the probability of selection is not necessarily same for all the students and schools within a country
- based on some student characteristics within schools, different participation rates occurred, and non-response adjustment is needed
- there are some over-sampled explicit strata for national reporting purposes.

Prior to conducting the regression analysis and the ANOVA, assumptions of both tests were checked. First step of the assumption check was an outlier analysis for the independent variables: environmental awareness and environmental optimism. This analysis ensures that any extreme data responses that violate the reliability of regression analysis are eliminated. Based on the results, no outlier values were detected (Figures 2 and 3).

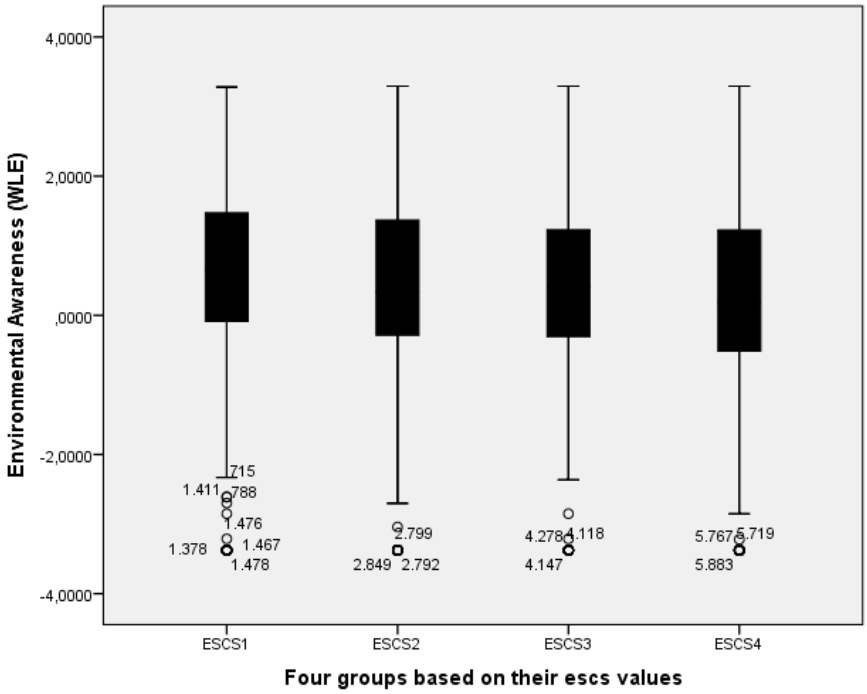

Figure 2. Boxplot of environmental awareness for four groups of different SES levels.

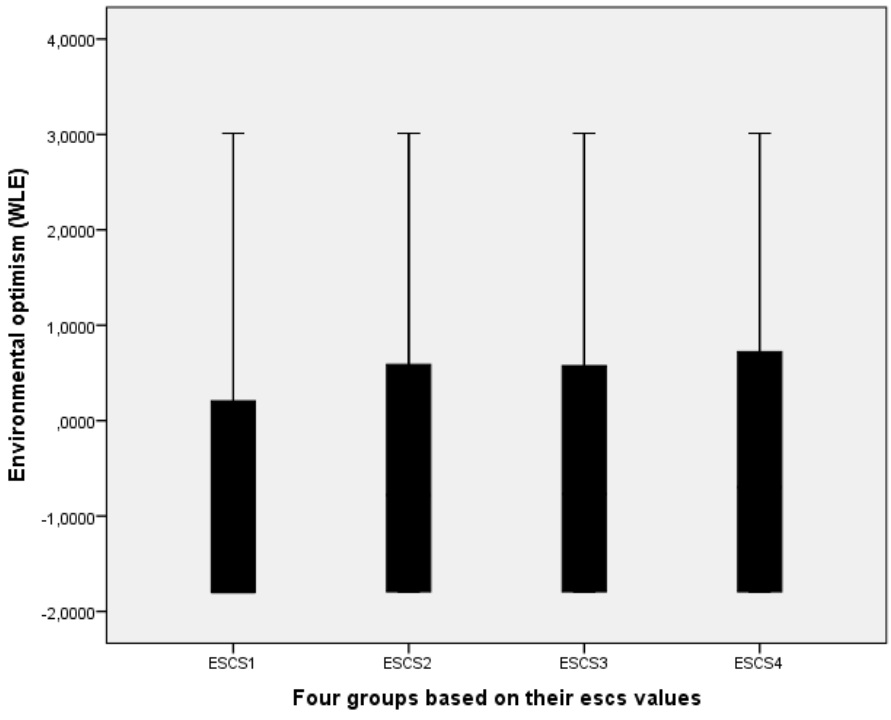

Figure 3. Boxplot of environmental optimism for four groups of different SES levels.

Normality was checked as an assumption of both multiple linear regression and one-way ANOVA. According to the results of Kolmogorov-Smirnov test, it has been seen that the data is not normally distributed which is probably because of the

extreme values that created curves at the extremities of the line in the scatterplot. However, the ANOVA and multiple linear regression analysis are robust against non-normality when skewness and kurtosis values are between -2 and +2 (George & Mallery, 2010). All skewness and kurtosis values for the dependent variable scientific literacy were between +0.5 and -0.5 range. All skewness and kurtosis values for the first independent variable environmental awareness were found to be between +0.5 and -0.5. All skewness and kurtosis values for the second independent variable environmental optimism were between +1.5 and -1.5 range. Among all the skewness and kurtosis values, the most extreme value was the skewness of environmental optimism for the group ESCS1: 1.132 and still it is within the range of +2 and -2.

Another assumption of the multiple linear regression analysis is homoscedasticity, which looks to see if variances are equally distributed through the data; on a scatterplot of the data, the responses should be evenly spread out. For the current study, there did appear to be some minor outliers, but overall the data showed homoscedasticity.

As the final assumption, the data was checked to make sure the independent variables are not highly correlated to each other; that they do not show multicollinearity. If the data exhibits too much multicollinearity it causes calculation problems during regression analysis and it becomes hard to understand which independent variable caused the variance in the dependent variable. The Variance Inflation Factors (VIF) analysis for the current study was close to 1 (VIF = 1,083) which indicates there was no multicollinearity among the independent variables.

After weighting the data and checking the assumptions, the multiple linear regression analysis was conducted. The researcher used 10 plausible values as the dependent variables and Environmental awareness (ENVAWARE) and environmental optimism (ENVOPT) as the independent variables. The multiple regression related both independent variables to each of the 10 plausible values. Finally, the average of the adjusted R square values and the standardized beta coefficients for each of the plausible values were calculated in order to see how ENVAWARE and ENVOPT predicted the scientific literacy among four different groups of Turkish students.

The one-way ANOVA was conducted to compare the ENVAWARE and ENVOPT mean responses of the four different socioeconomic level groups. MANOVA was not preferred because of the correlation of the independent variables. Pearson Correlation analysis found that these two variables have a negative weak correlation, $r(5893) = -.277$, $p < .01$ and moderate correlation is a prerequisite for MANOVA. In order to determine which Post Hoc test should be used, the homogeneity of variances table was checked. If the homogeneity of variances is not violated, a one-way ANOVA with Tukey HSD test is preferred. In the opposite case, a Welch ANOVA should be conducted with Games-Howell as the Post Hoc test preference.

Post-hoc tests are useful in terms of making pairwise comparisons of groups when the researcher wants to find out between which of the groups the significant difference is observed. Tukey HSD test is a kind of post-hoc test that assumes the equal variances and sample sizes. Therefore, it needs to be used when the equality of variances assumption is not violated. Games-Howell on the other hand, is a type of post-hoc test which should be used when the equality of variances assumption is violated. This test does not have the equal sample size assumption as well and it

needs to be used with a Welch's ANOVA rather than the classic one. Welch's ANOVA is robust against the violation of the equality of variances assumption.

CHAPTER 4: RESULTS

Introduction

In this chapter, the results of this study will be examined based on the following questions:

Based on the results of the PISA 2015 student questionnaire and science test;

1) To what extent is the scientific literacy of the Turkish students is predicted by:
   - environmental awareness
   - environmental optimism
2) When students are grouped into four different socioeconomic levels, is there a difference in their:
   - environmental awareness
   - environmental optimism
3) To what extent is the scientific literacy of the students grouped into these four different socioeconomic levels predicted by:
   - environmental awareness
   - environmental optimism

As it is described in the Methods chapter, based on the ESCS scores, students were placed into four groups representing four socioeconomic levels. In those groups, ESCS1 represents the most socioeconomically advantaged students while ESCS 4 represents the most disadvantaged students. A descriptive analysis of these groups helped determine their levels of scientific literacy, environmental awareness and environmental optimism.

The main analysis techniques used in this study were a one-way ANOVA and multiple regression analysis. The multiple linear regression was conducted to see how environmental awareness and environmental optimism predicted the scientific literacy. Scientific literacy of the students is determined with 10 different plausible values in PISA 2015 dataset. Plausible values were the dependent variables of the regression analysis and the independent variables were environmental awareness and environmental optimism. For each of these 10 plausible values, regression analysis was conducted and later on, the averages of these results were calculated as the final step.

After this analysis, the students were divided into four groups. The index called PISA Index of Economic, Social and Cultural Status (ESCS) was used as an independent variable to determine the groups. A one-way ANOVA was conducted to learn whether there is any significant difference among these groups in terms of environmental awareness and environmental optimism. Variables called Environmental Awareness (ENVAWARE) and Environmental Optimism (ENVOPT) were used as the independent variables.

The final analysis was to use the multiple regression again, but this time with the four groups. The purpose was see if environmental awareness and environmental optimism predicted the scientific literacy for all SES levels.

Contribution of environmental awareness and environmental optimism to scientific literacy

Prior to examining how the socioeconomic groups differed in their scientific literacy, the researcher investigated how environmental awareness and environmental optimism predicts scientific literacy for all students in the study. Results in Table 7

revealed that environmental awareness and environmental optimism contribute considerably and significantly to the scientific literacy of the students.

Table 7
R squares of the students' scientific literacy based on environmental awareness and environmental optimism

R	R square	Adjusted R Square	Std. Error of The Estimate
.430	.185	.185	71.070

The results of individual predictions of environmental awareness and environmental optimism are shown in Table 8. A 1-unit change in environmental awareness resulted in 12.858 points change in scientific literacy score in the same direction and 1-unit change in environmental awareness resulted in -16.048 points change in scientific literacy score in the opposite direction. According to the standardized scores, the change in the standard deviation in the scientific literacy is -0.241 for environmental awareness and -0.295 for environmental optimism. Effect size, as calculated as f^2 was medium (0.227) according to Cohen's criteria (Cohen, 1988).

Table 8
Regression analysis of environmental awareness and environmental optimism based on scientific literacy results

	Unstandardized Coefficients		Standardized Coefficients	
Variables	B	Std. Error	Beta	t
(Constant)	411.983	1.054		390.982*
E. Awareness	12.858	0.669	.241	19.232*
E. Optimism	-16.048	0.681	-.295	-23.560*

* $p < .05$

In conclusion, these results showed that both environmental awareness and environmental optimism were good predictors of scientific literacy. However, their contribution was opposite, means, the increase in environmental awareness resulted

in an increase in scientific literacy, whereas the increase in environmental optimism resulted in a decrease in scientific literacy.

Analysis of environmental awareness and environmental optimism in terms of socioeconomic status of the students

In the descriptive analysis of environmental awareness and environmental optimism, it has been found that they differ between four socioeconomic groups. In order to understand whether these differences are statistically significant or not, a one-way ANOVA was used. Table 9 below shows the results of the analysis. Effect size, was found to be small for both environmental awareness ($\eta^2 = 0.011$) and for environmental optimism ($\eta^2 = 0.010$) according to Cohen's criteria (Cohen, 1988).

Table 9
Results of one-way ANOVA for environmental awareness and environmental optimism across four different SES groups

Variable		Sum of Squares	df	Mean Square	F
Environmental awareness	Between	135.410	3	45.137	20.922*
	Within	12214.960	5662	2.157	
	Total	12350.370	5665		
Environmental Optimism	Between	121.439	3	40.480	19.459*
	Within	11815.738	5680	2.080	
	Total	11937.177	5683		

* $p < .05$

The results reveal that there is significant mean difference among the groups for both environmental awareness and environmental optimism. However, further analysis is needed to learn between which of these groups that significant difference is observed. For that purpose, post-hoc analysis is needed. Based on the results of the homogeneity of variances assumption from Methods chapter, Games-Howell was preferred as a post-hoc test and the results are shown in Table 10.

Table 10
Results of post-hoc test for environmental awareness and environmental optimism across four different SES groups

Variable	Group (i)	Group (j)	Mean Difference (i-j)
Environmental Awareness	ESCS1	ESCS2	0.234*
		ESCS3	0.321*
		ESCS4	0.415*
	ESCS2	ESCS1	-0.234*
		ESCS3	0.087
		ESCS4	0.181*
	ESCS3	ESCS1	-0.321*
		ESCS2	-0.087
		ESCS4	0.094
	ESCS4	ESCS1	-0.415*
		ESCS2	-0.181*
		ESCS3	-0.094
Environmental Optimism	ESCS1	ESCS2	-0.226*
		ESCS3	-0.307*
		ESCS4	-0.391*
	ESCS2	ESCS1	0.226*
		ESCS3	-0.081
		ESCS4	-0.165*
	ESCS3	ESCS1	0.307*
		ESCS2	0.081
		ESCS4	-0.084
	ESCS4	ESCS1	0.391*
		ESCS2	0.165*
		ESCS3	0.084

* $p < .05$

Based on the results of post-hoc test, for both for environmental awareness and environmental optimism;

1) ESCS1 is statistically different from all the other groups
2) ESCS4 is statistically different from all the other groups except ESCS3.

Analysis of scientific literacy with respect to environmental awareness and environmental optimism in terms of socioeconomic status

This section shows how environmental awareness and environmental optimism contributes to the variance in scientific literacy among four different socioeconomic groups. Based on the results presented in Table 11, environmental awareness and environmental optimism contribute considerably and significantly to the scientific literacy in ESCS1 (Adjusted R^2 =.140, $p < .05$), ESCS2 (Adjusted R^2 =.186, $p < .05$),

ESCS3 (Adjusted R^2 =.182, $p < .05$), and ESCS4 (Adjusted R^2 =.184, $p < .05$). From all the groups, environmental awareness and environmental optimism contributed least to scientific literacy for ESCS1, which are the most socioeconomically advantaged. Effect size calculated as f^2 was found to be medium for all the groups according to Cohen's criteria (Cohen, 1988): for ESCS1 (0.163), for ESCS2 (0.229), for ESCS3 (0.222), and for ESCS4 (0.225).

Table 11
R squares of the students' scientific literacy across four SES groups

Groups	R	R square	Adjusted R Square	Std. Error of The Estimate
ESCS1	.376	.141	.140	73,278
ESCS2	.433	.188	.186	69,188
ESCS3	.428	.183	.182	67,469
ESCS4	.430	.185	.184	65,037

After R square results in which the combined effect of environmental awareness and environmental optimism is presented for four groups' scientific literacy, individual contributions of these two variables are also examined. Results show that a change in the environmental awareness and environmental optimism always created a substantial but opposite change in scientific literacy. This means that a higher environmental awareness contributes to a higher scientific literacy; whereas, a higher environmental optimism contributes to a lower scientific literacy. Results are shown in Table 12.

For every 1-unit change in the environmental awareness, scientific literacy score showed 12.100 points change for ESCS1, 11.816 points change for ESCS2, 14.283 points change for ESCS3, and 9.531 points change for ESCS4. The degree of change in the scientific literacy is .232 for ESCS1, .219 for ESCS2, .276 for ESCS3, and

.197 for ESCS4. The degree of change is the number of standard deviation change in the dependent variable for every 1-unit change in the independent variable.

For every 1-unit change in the environmental optimism, scientific literacy score showed -14.513 points change for ESCS1, -16.968 points change for ESCS2, -12.880 points change for ESCS3, and -15.900 points change for ESCS4. Degree of change in the scientific literacy is -.246 for ESCS1, -.319 for ESCS2, -.254 for ESCS3, and -.333 for ESCS4.

Table 12
Regression analysis of environmental awareness and environmental optimism of four SES groups based on scientific literacy results

		Unstandardized Coefficients		Standardized Coefficients	
Groups	Variables	B	Std. Error	Beta	t
ESCS1	(Constant)	439.961	2.370		185.696*
	E. Awareness	12.100	1.310	.232	9.236*
	E. Optimism	-14.513	1.484	-.246	-9.783*
ESCS2	(Constant)	412.905	2.056		200.804*
	E. Awareness	11.816	1.338	.219	8.834*
	E. Optimism	-16.968	1.321	-.319	-12.850*
ESCS3	(Constant)	405.661	1.954		207.662*
	E. Awareness	14.283	1.314	.276	10.872*
	E. Optimism	-12.880	1.284	-.254	-10.028*
ESCS4	(Constant)	392.119	1.858		211.063*
	E. Awareness	9.531	1.234	.197	7.727*
	E. Optimism	-15.900	1.215	-.333	-13.084*

* $p < .05$

In conclusion, a one-way ANOVA results revealed that socioeconomically advantaged students tend to have higher environmental awareness and lower environmental optimism. However, the one-way ANOVA and post-hoc analysis shows that:

1) The scores of ESCS1 are significantly different from the other groups regarding having higher environmental awareness and lower environmental optimism.
2) As for the opposite trend, only the lowest socioeconomic group responses (ESCS4) were significantly different than all the other groups except for ESCS3.

The multiple linear regression analysis results show that both environmental awareness and environmental optimism make a significant and noticeable prediction of science achievement for all four socioeconomic groups. However, that prediction was lower in ESCS1 compared to the other groups.

High environmental awareness contributed positively to the scientific literacy within all four groups, whereas high environmental optimism made a negative contribution to the scientific literacy within all the groups. This result is in concordance with the negative and weak correlation between environmental awareness and environmental optimism, as discussed in the Methods chapter concerning multicollinearity. It can be said that scientific literacy is predicted at a significant level by both environmental awareness and environmental optimism within all four groups.

CHAPTER 5: DISCUSSION

Introduction

The purpose of this study is use PISA 2015 data to reveal to what extent environmental awareness and environmental optimism predict the scientific literacy of Turkish students. These students were divided into four socioeconomic levels by the researcher and similar analysis was performed to see if environmental awareness and environmental optimism would predict the scientific literacy of students each of these levels. The researcher found that environmental awareness and environmental optimism are the predictors of scientific literacy, regardless of the socioeconomic status (SES) of the students. Furthermore, results revealed that SES affects whether students have environmental awareness or optimism.

Overview of the study

In this study, the aim was to investigate to what extent the Turkish students' scientific literacy is predicted by their environmental awareness and environmental optimism level. For this purpose, the researcher used the PISA 2015 dataset from the OECD website singling out the data of Turkish students. In PISA, the scientific literacy level of students is determined by ten plausible values that come from a science test. The instrument also had items that assessed students' perceived environmental awareness and environmental optimism.

Another aim of this study is to explore how the scientific literacy of students in different socioeconomic levels was affected by environmental awareness and environmental optimism. In order to form these levels, the researcher formed four

groups by using the Index of Economic, Social and Cultural Status (ESCS) scores of Turkish students.

The analysis involved a multiple linear regression analysis to learn to what extent the environmental awareness and environmental optimism predicted the scientific literacy of Turkish students. Scientific literacy scores were the dependent variable and environmental literacy and environmental optimism were the independent variables. Secondly, the researcher investigated whether there is a significant difference between the four SES groups in terms of environmental literacy and environmental awareness by using a one-way ANOVA. Before conducting the one-way ANOVA, descriptive analysis of environmental awareness and environmental optimism was completed for the four groups. Finally, another multiple linear regression analysis was conducted to learn how environmental awareness and environmental optimism predicted the scientific literacy of Turkish students among the four SES groups.

Researcher investigated the following research questions:

1) To what extent is the scientific literacy of the Turkish students is predicted by
    - Environmental awareness
    - Environmental optimism
2) When students are grouped into four different SES levels, is there a difference in:
    - Environmental awareness
    - Environmental optimism

3) To what extent is the scientific literacy of the students grouped into four SES levels predicted by:
    - Environmental awareness
    - Environmental optimism

Major findings and conclusions

In this study, the researcher investigated to what extent environmental awareness and environmental optimism predict scientific literacy of Turkish students based on PISA 2015 dataset. Additionally, the contribution of environmental awareness and environmental optimism to the scientific literacy of the students grouped into four SES levels. The difference created by SES of the students in their environmental awareness and environmental optimism was also explored.

Findings for research question 1: To what extent is the scientific literacy of the Turkish students is predicted by

- Environmental awareness
- Environmental optimism

Results of the multiple linear regression analysis revealed that environmental awareness and environmental optimism made a significant and considerable contribution to the scientific literacy of the students. An increase in environmental awareness is associated with an increase in scientific literacy; whereas an increase in environmental optimism is associated with a decrease in scientific literacy.

As Cashmore (2004), Liu, Gupta, Springer, & Wagener (2008) stated in their studies, proper scientific knowledge is required to understand the environmental problems. The results of current study show that the students with high environmental awareness were more scientifically literate as well. Results also confirm the findings

of Ryder (2001) that showed the importance of science to understand various everyday life situations related to the environment.

The current study showed that environmental awareness and environmental optimism can predict the scientific literacy at an important level. Therefore, it is clearer that environmental literacy related elements may have the capability of increasing the environmental literacy of the students. Literature shows a similar understanding, students need to be supported with a proper environmental education and this can be more effective if environmental knowledge is provided with scientific facts that lies under the health of environmental systems and environmental problems (Hudson, 2001; Klosterman, 2010; Ryder, 2001). Also, environmental education needs to be equipped with experience, field trips, hands-on activities that help develop students' understanding, awareness and dispositions about environment (Barazza & Walford, 2002; Klosterman, 2010; Uitto, Juuti, Lavonen, Byman, & Meisalo, 2011). The relationship between scientific literacy and environmental literacy is discussed more under the third research question.

Findings for research question 2: When students are grouped into four different SES levels, is there a difference in:

- Environmental awareness
- Environmental optimism

A one-way ANOVA revealed the difference in environmental awareness and optimism among four SES groups but, the differences were small in practice. Low SES students usually lack the resources they need to be informed about the environmental issues. In addition to various sources of information like schools, teachers, resources that are also the indicators of SES were considered in this study. These students do not have sufficient physical resources like a computer, a room for

themselves or internet connection (See Appendix D) and also, their parental education level is low which is very important in terms of learning the environmental issues and having the right attitude, and behavior towards the environment (Anıl, 2011; Kaya & Doğan, 2017; Kuhlemeier, Bergh, & Lagerweij, 1999).

Since the environmental awareness and environmental optimism were found to have a negative but weak correlation between them, it can be concluded that since low SES students do not have the proper knowledge and awareness of the seriousness of environmental problems that can be the reason why they are also more optimistic about the future of the environment. These results are in accordance with the findings of Sulemana, James, and Valdivia (2016), as they stated that low SES is associated with low level of concern about the environmental issues. However, the results are in contradictory with the findings of Liu, Vedlitz, and Shi (2014), stating that education level is not related with individuals' environmental concern. However, within the Turkish context, based on the findings of this study, this is not the case.

The effect of SES on scientific literacy is interconnected with students' environmental literacy as well. A body of scientific knowledge is necessary to comprehend the environmental issues, and it is not surprising to see the contribution of environmental awareness and environmental optimism to the scientific literacy since high SES students probably have a better understanding of how science works and how it explains the environmental problems.

This study revealed that the students' environmental optimism tends to be higher if their SES and environmental awareness are low. This result is in accordance with the findings of Hansla, Gamble, Juliusson, and Gärling (2008) which also states that the environmental knowledge affects the attitudes towards the environmental issues. As

the students start to have an understanding of the reasons and outcomes of the environmental problems in scientific context, they can comprehend the urgency of them as well and that probably makes them pessimistic about the future. On the other hand, low SES students neither have the scientific knowledge to understand the environmental issues nor have the resources (indicated via the items under the variable ESCS) to change this situation. Therefore, they do not realize how serious these problems are and they tend to be optimistic about the future of the environment.

Based on the findings of Erbaş, Teksöz, and Tekkaya (2012), SES was a factor effecting the environmental literacy of the students. They used data from 2006; therefore, data from nine years later used in the current study reveals that SES is still a factor that created a significant difference in students' environmental awareness and environmental optimism. They stressed the importance of providing all students with an opportunity to gain an environmental education and it is apparent this need still exists today.

Findings for research question 3: To what extent is the scientific literacy of the students grouped into four SES levels predicted by:

- Environmental awareness
- Environmental optimism

After all these results of multiple regression analysis, researcher concludes that both environmental awareness and environmental optimism are the predictors of scientific literacy among all SES levels. However, it seems that environmental optimism is a stronger predictor compared to environmental awareness. Additionally, environmental optimism contributed negatively to scientific literacy whereas environmental awareness contributed positively.

With multiple linear regression analysis, researcher also investigated these two variables' contribution to scientific literacy among four SES groups. Results show that their environmental awareness and environmental optimism levels are different, high SES students likely to have a better environmental awareness and low environmental optimism whereas low SES students show an opposite trend. Even though the indicated levels are different, these two variables still predicted scientific literacy considerably for all four groups.

The findings of the current study are in accordance with the literature, they indicate a relationship between scientific literacy and environmental awareness/optimism. If the students' scientific literacy level is low, then they may have difficulties in terms of understanding the complex scientific explanations behind the environmental problems (Hadzigeorgiou & Skoumios, 2013; Hudson, 2001; Summers, Kruger, & Childs, 2001). This might be due to the lack of the content and activities related with the environment in science classes. Coertjens, Boeve-de-Pauw, De Maeyer, and Van Petegem (2010) also stated the importance of proper classroom environment, school ethos and educational policies in terms of increasing the environmental literacy of the students.

SES was found to be the determinant of scientific literacy by many researchers, and results of this study confirms the findings (Anıl, 2009; Chu et al., 2007; Kaya and Doğan, 2017; Negev, Sagy, Garb, Salzberg, & Tal, 2008). Lack of resources at home which was also related to the lack of income, and lack of parental education all end up causing deficiencies in scientific literacy. Also, these students are usually at public schools in poor areas which often do not have the resources within the classroom and the school. Techniques used in science classes, may be teacher centered and hands-on activities or experiments may not be performed by science

teachers in those schools (Coertjens, Boeve-de-Pauw, De Maeyer, & Van Petegem, 2010).

Implications for practice

Since Turkey is considered as a developing country, SES is an issue for our students, which means, it seems like Turkish educational system, policymakers have problems to provide equal educational opportunities to the students from different socioeconomical backgrounds. ESCS average of our country (M = -1.428, SD = 1.171) is way below the OECD average (M = 0, SD = 1). In the future, this may change by the policies of the Turkish government but, whatever the socioeconomic situation in the country will be, educators should always take the effect of SES into consideration and educational policies should be developed in order to eliminate the negative effects of low SES on teaching and learning. Free, easily achievable or affordable resources should be provided to those students to get rid of the inequality between them and the high SES students. Even though there are some free resources provided like textbooks, there needs to be more options and more variability in terms of resources. Mass media can be equipped with reliable and understandable scientific and environmental information that can be provided by the professionals, since it is one of the most achievable source of information for people regardless of SES.

Among the data PISA used to determine SES, the parent factor is silent but very important in terms of the level of scientific and environmental literacy of the students. Lack of parental education is one of the indicators of low SES families and the relationship between the education level of parents and the literacy level of students was revealed by researchers. Therefore, all ways of educational improvements should be supported by parent education as well. Since these families cannot afford an additional education for parents, it can be very useful to encourage

free science classes given by the educators who are good at transferring the scientific information in an understandable and uncomplicated way even though it can be highly demanding and hard to manage.

Teacher profile of the country might be problematic as well, and teacher education should be compulsory even for in-service teachers since they need to have an understanding of implementing efficient ways of teaching into science classes. Also, teachers need to be flexible and ready to implement novel ways of teaching within a different and helpful educational policy. They need to be aware of the SES profile of their classrooms and they need to be responsive to the needs of their students. Scientific inquiry, experimentation, hands-on activities are inevitable contributors of scientific literacy. Therefore, curriculum needs to be designed according to such an understanding. Classroom activities are quite strong in giving the students a proper knowledge about science and environment as well as leading good dispositions about science and environment.

In addition to classroom activities, more specifically, place-based education should be supported. Place-based education is defined by Semken and Freeman (2008) as a situated educational method to include the following:

- Learning activities based on experience in social and natural environments that has local characteristics
- Interdisciplinary and cross-cultural knowledge which is place-related
- Community service-based learning activities

Students need to observe and experience the environment and the scientific facts under the environmental problems within their local area as well. In order to realize and appreciate the enormous effect of environment on our lives, students need to be a

part of the environment from time to time. Even a school garden can be a very useful place for teachers to implement place-based education. Hearing and demonstrating the information within the classroom is helpful when appropriate techniques are used, but, environment is actually just outside the walls of the school, and even within the routines of their daily life, they interact with the environment without realizing it. It should be the teachers' responsibility to carry that interaction to the science courses and take the students outside of the classroom to let them explore their local environment.

Students having more environmental awareness tend to be pessimistic about the future of the environment. This needs further solutions, because even though the awareness needs to be increased, if it causes pessimism about the environmental problems' future this is not good for student morale and motivation to take action. Optimism will always be a factor that strengthens the efforts for environment, encourages the students and citizens to take actions to believe that they can make a positive change. In order to increase the optimism of the students, all the current and future positive improvements should be emphasized in science classes such as, the solutions of environmental problems, the actions that are already taken and their positive effects, the novel ideas about a better environment.

Implications for further research

This study has provided further evidence that there is a relationship between students' scientific literacy and their environmental awareness and environmental optimism. Researchers can use the findings of this study to further analyze the relationship between these variables. For example, in addition to environmental awareness and environmental optimism, students' environmental behavior, attitude and knowledge can be included as well. Also, how the science classes are taught, the

techniques used in a science classroom and many other school-related factors based on PISA results can be analyzed in terms of their contribution to the environmental literacy and scientific literacy.

One of the findings of this research was that environmental awareness and environmental optimism predicted scientific literacy among four SES groups, but their contribution was lower for the first group. This can be further investigated with the factors affecting environmental awareness and optimism. These factors' relationship with scientific literacy and SES can be analyzed. Also, SES has different dimensions related to parental education, home possessions and parental occupation. Each of these dimensions could be analyzed separately in terms of the difference they create in the scientific and environmental literacy of the students.

PISA is one of the strongest and most popular ways of assessment that can reach an enormous number of students from all around the world and since it is repeated every three years, it can give a very extensive and helpful picture of a countries education performance through time. Based on the findings of this study, future research can be conducted after upcoming cycles of PISA in order to find out the effect of constantly changing educational policies of Turkey in the future. Also, since the data of successful countries is available to researchers, the country wise comparison can be made to find out the weaknesses of Turkish education in dealing with the negative effects of SES and in increasing and supporting the scientific and environmental literacy of the students.

In addition to strong characteristics of PISA, there are more detailed and extensive instruments to assess the environmental literacy of the students and, researchers can use those instruments to support the findings of PISA as well, or interviews with the

students, parents or teachers can be used as the supportive sources of data in addition to PISA data.

Limitations

The most important limitation of this study is about the representative power of PISA sample. For the students registered to a school, PISA sample is quite powerful but, Turkey has a problem of children that are not registered to any school. Based of the report here is a considerable number of 15-year-olds that do not have a chance of going to a school (TUIK, 2016), and child labor percentage was 21% for that age group in 2015. Also, absence rate is quite high for some students due to the reasons like child labor or transportation. Additionally, PISA questionnaire and test was not originally prepared in Turkish, so that it is not clear whether translation of the items into Turkish may have created problems in terms of students' comprehension of them. Final limitation is that PISA questionnaire only has two variables related with environmental literacy which are mainly based on students' self-perception, and it does not provide information about the assessment of environmentally responsible behavior, or an extensive assessment of environmental knowledge. There are other instruments that make a more extensive assessment of environmental literacy compared to PISA.

REFERENCES

Anagun, S. S. (2011). The impact of teaching-learning process variables to the students' scientific literacy levels based on PISA 2006 results. *Education and Science, 36*(162), 84-102.

Anıl, D. (2009). Factors affecting science achievement of science students in PISA in Turkey. *Education and Science, 34*(152), 88-100.

Anıl, D. (2011). Investigation of factors influencing Turkey's PISA 2006 science achievement with structural equation modelling. *Educational Sciences: Theory & Practice, 11*(3), 1253-1266.

Baker, E. H. (2014). Socioeconomic status, definition. *The Wiley Blackwell Encyclopedia of Health, Illness, Behavior, and Society,* 2210-2214. doi:10.1002/9781118410868.wbehibs395

Barraza, L., & Walford, R. A. (2002). Environmental education: A comparison between English and Mexican school children. *Environmental Education Research, 8*(2), 171-186. doi:10.1080/13504620220128239

Berberoğlu, G., & Kalender, İ. (2005). Investigation of student achievement across years, school types and regions: The SSE and PISA analyses. *Eğitim Bilimleri ve Uygulama, 4*(7), 21-35.

Berberoğlu, G., & Tosunoğlu, C. (1995). Exploratory and confirmatory factor analyses of an Environmental Attitude Scale (EAS) for Turkish university students. *The Journal of Environmental Education, 26*(3), 40–44.

Buckingham, J., Wheldall, K., & Beaman-Wheldall, R. (2013). Why poor children are more likely to become poor readers: The school years. *Australian Journal of Education, 57*(3), 190-213. doi:10.1177/0004944113495500

Cashmore, M. (2004). The role of science in environmental impact assessment: Process and procedure versus purpose in the development of theory. *Environmental Impact Assessment Review, 24*(4), 403-426. doi:10.1016/j.eiar.2003.12.002

Cetin, G., & Nisanci, S. H. (2010). Enhancing students' environmental awareness. *Procedia Social and Behavioral Sciences, 2*(2010), 1830-1834. doi:10.1016/j.sbspro.2010.03.993

Chu, H., Lee, E. A., Ko, H. R., Shin, D. H., Lee, M. N., Min, B. M., & Kang, K. H. (2007). Korean year 3 children's environmental literacy: A prerequisite for a Korean environmental education curriculum. *International Journal of Science Education, 29*(6), 731-746. doi:10.1080/09500690600823532

Coertjens, L., Pauw, J. B., Maeyer, S. D., & Petegem, P. V. (2010). Do schools make a difference in their students' environmental attitudes and awareness? Evidence from Pisa 2006. *International Journal of Science and Mathematics Education, 8*(3), 497-522. doi:10.1007/s10763-010-9200-0

Cohen, J. (1988). *Statistical power analysis for the behavioral sciences.* Hillsdale, N.J: L. Erlbaum Associates.

Davis-Kean, P. E. (2005). The influence of parent education and family income on child achievement: The indirect role of parental expectations and the home environment. *Journal of Family Psychology, 19*(2), 294-304. doi:10.1037/0893-3200.19.2.294

Demir, D. K. (2016). *What kinds of teacher-related and school-related factors foster student resiliency to socioeconomic status in Turkey?* (Unpublished master's thesis). Bilkent University, Ankara, Turkey

Deng, J., Walker, G. J., & Swinnerton, G. (2006). A comparison of environmental values and attitudes between Chinese in Canada and Anglo-Canadians. *Environment and Behavior, 38*(1), 22-47. doi:10.1177/0013916505278458

Duncan, O. D., Featherman, D. L., & Duncan, B. (1972). *Socio-economic background and achievement.* New York: Seminar Press.

Dunlap, R. E., & Mertig, A. G. (1995). Global concern for the environment: Is affluence a prerequisite? *Journal of Social Issues, 51*(4), 121-137. doi:10.1111/j.1540-4560.1995.tb01351.x

Erbaş, A. K., Teksöz, G. T., & Tekkaya, C. (2012). An evaluation of environmental responsibility and its associated factors: Reflections from PISA 2006. *Eurasian Journal of Educational Research, 12*(46), 41-62.

Erdoğan, M. (2009). *Fifth grade students' environmental literacy and factors affecting students' environmentally responsible behaviors* (Unpublished master's thesis). Middle East Technical University, Ankara, Turkey.

Erdoğan, M., & Ok, A. (2011). An assessment of Turkish young pupils' environmental literacy: A nationwide survey. *International Journal of Science Education, 33*(17), 1-32. doi:10.1080/09500693.2010.550653

George, D., & Mallery, M. (2010). *SPSS for Windows step by step: A simple guide and reference*, 17.0 update (10a ed.) Boston: Pearson

Gormally, C., Brickman, P., & Lutz, M. (2012). Developing a test of scientific literacy skills (TOSLS): Measuring undergraduates evaluation of scientific information and arguments. *Cell Biology Education, 11*(4), 364-377. doi:10.1187/cbe.12-03-0026

Gürsakal, S. (2012). An evaluation of PISA 2009 student achievement levels' affecting factors. *Suleyman Demirel University The Journal of Faculty Economics and Administrative Sciences, 17*(1), 441-452

Hadzigeorgiou, Y., & Skoumios, M. (2013). The development of environmental awareness through school science: Problems and possibilities. *International Journal of Environmental & Science Education, 8*(3), 405-426. doi:10.12973/ijese.2013.212a

Hamalosmanoglu, M. (2012). The place of environmental education in science education curricula in Turkey. *Procedia - Social and Behavioral Sciences, 46*, 4839-4844. doi:10.1016/j.sbspro.2012.06.345

Hansla, A., Gamble, A., Juliusson, A., & Gärling, T. (2008). The relationships between awareness of consequences, environmental concern, and value orientations. *Journal of Environmental Psychology, 28*(1), 1-9. doi:10.1016/j.jenvp.2007.08.004

Hudson, S. J. (2001). Challenges for environmental education: Issues and ideas for the 21st century. *BioScience, 51*(4), 283. doi:10.1641/0006-3568(2001)051[0283:cfeeia]2.0.co;2

Kaya, V. H., & Doğan, A. (2017). Determination and comparison of Turkish student characteristics affecting science literacy in Turkey According to PISA 2012. *Research Journal of Business and Management, 4*(1), 34-51. doi:10.17261/Pressacademia.2017.369

Klosterman, M. L., & Sadler, T. D. (2010). Multi‐level assessment of scientific content knowledge gains associated with socioscientific issues‐based instruction. *International Journal of Science Education, 32*(8), 1017-1043. doi:10.1080/09500690902894512

Kuhlemeier, H., Bergh, H. V., & Lagerweij, N. (1999). Environmental knowledge, attitudes, and behavior in Dutch secondary education. *The Journal of Environmental Education, 30*(2), 4-14. doi:10.1080/00958969909601864

Lavonen, J., & Laaksonen, S. (2009). Context of teaching and learning school science in Finland: Reflections on PISA 2006 results. *Journal of Research in Science Teaching, 46*(8), 922-944. doi:10.1002/tea.20339

Lin, E., & Shi, Q. (2014). Exploring individual and school-related factors and environmental literacy: Comparing U.S. and Canada using PISA 2006. *International Journal of Science and Mathematics Education, 12*(1), 73-97. doi:10.1007/s10763-012-9396-2

Liu, X., Vedlitz, A., & Shi, L. (2014). Examining the determinants of public environmental concern: Evidence from national public surveys. *Environmental Science & Policy, 39*, 77-94. doi:10.1016/j.envsci.2014.02.006

Liu, Y., Gupta, H., Springer, E., & Wagener, T. (2008). Linking science with environmental decision making: Experiences from an integrated modeling approach to supporting sustainable water resources management. *Environmental Modelling & Software, 23*(7), 846-858. doi:10.1016/j.envsoft.2007.10.007

Maslow, A.H. (1970). *Motivation and personality.* New York: Viking Press.

Ministry of National Education. (2016). *PISA 2015 ulusal raporu.* Ankara: General Directorate of Measurement, Evaluation and Examination Services.

Mohammadpour, E. (2013). A three-level multilevel analysis of Singaporean eighth-graders' science achievement. *Learning and Individual Differences, 26*, 212-220. doi:10.1016/j.lindif.2012.12.005

National Environmental Education and Training Foundation [NEETF]. 1997. Annual Report. Washington (DC): NEETF.

Negev, M., Sagy, G., Garb, Y., Salzberg, A., & Tal, A. (2008). Evaluating the environmental literacy of Israeli elementary and high school students. *The Journal of Environmental Education, 39*(2), 3-20. doi:10.3200/joee.39.2.3-20

Organisation for Economic Co-operation and Development [OECD]. (2009). *Data analysis manual.* Retrieved from http://archivos.agenciaeducacion.cl/Manual_de_Analisis_de_datos_SPSS_version_ingles.pdf

Organization for Economic Co-operation and Development [OECD]. (2011). *Lessons from PISA for the United States, strong performers and successful reformers in education*. OECD Publishing. Retrieved from http://dx.doi.org/10.1787/9789264096660-en

Organisation for Economic Co-operation and Development [OECD]. (2016a). *Sampling in PISA.* OECD Publishing. Retrieved from https://www.oecd.org/pisa/pisaproducts/SAMPLING-IN-PISA.pdf

Organisation for Economic Co-operation and Development [OECD]. (2017a). *Programme for International Student Assessment: An overview* In PISA 2015 technical report. Retrieved from https://www.oecd.org/pisa/sitedocument/PISA-2015-Technical-Report-Chapter-1-Programme-for-International-Student-Assessment-an-Overview.pdf

Organisation for Economic Co-operation and Development [OECD]. (2017b). *Proficiency scale construction.* In PISA 2015 technical report. Retrieved from https://www.oecd.org/pisa/sitedocument/PISA-2015-Technical-Report-Chapter-15-Proficiency-Scale-Construction.pdf

Organisation for Economic Co-operation and Development [OECD]. (2017c). *How does PISA for Development measure scientific literacy?* OECD Publishing. Retrieved from: https://www.oecd.org/pisa/pisa-for-development/10-How-PISA-D-measures-science-literacy.pdf

Organisation for Economic Co-operation and Development [OECD]. (2017d). *Scaling procedures and construct validation of context questionnaire data.* In PISA 2015 technical report. OECD Publishing. Retrieved from http://www.oecd.org/pisa/sitedocument/PISA-2015-Technical-Report-Chapter-16-Procedures-and-Construct-Validation-of-Context-Questionnaire-Data.pdf

Organisation for Economic Co-operation and Development [OECD]. (2017e). *Data management procedures.* In PISA 2015 technical report. Retrieved from http://www.oecd.org/pisa/sitedocument/PISA-2015-Technical-Report-Chapter-10-Data-Management-Procedures.pdf

Organisation for Economic Co-operation and Development [OECD]. (2017f). *Scaling PISA data.* In PISA 2015 technical report. Retrieved from https://www.oecd.org/pisa/sitedocument/PISA-2015-Technical-Report-Chapter-9-Scaling-PISA-Data.pdf

Organisation for Economic Co-operation and Development, (2018). PISA 2015 key findings for Turkey. Retrieved from http://www.oecd.org/turkey/pisa-2015-turkey.htm

Roth, C. E. (1992). *Environmental literacy: Its roots, evolution and directions in the 1990s*. Columbus, OH: ERIC Clearinghouse for Science, Mathematics, and Environmental Education

Ryder, J. (2001). Identifying science understanding for functional scientific literacy. *Studies in Science Education, 36*(1), 1-44. doi:10.1080/03057260108560166

Semken, S., & Freeman, C. B. (2008). Sense of place in the practice and assessment of place-based science teaching. *Science Education, 92*(6), 1042-1057. doi:10.1002/sce.20279

Sulemana, I., James, H. S., & Valdivia, C. B. (2016). Perceived socioeconomic status as a predictor of environmental concern in African and developed countries. *Journal of Environmental Psychology, 46*, 83-95. doi:10.1016/j.jenvp.2016.04.002

Summers, M., Kruger, C., & Childs, A. (2001). Understanding the science of environmental issues: Development of a subject knowledge guide for primary teacher education. *International Journal of Science Education, 23*(1), 33-53. doi:10.1080/09500690116990

Turkish Statistical Institute [TUIK]. (2016). *İstatistiklerle çocuk.* Retrieved from http://www.tuik.gov.tr/PreHaberBultenleri.do?id=21521

Uitto, A., Juuti, K., Lavonen, J., Byman, R., & Meisalo, V. (2011). Secondary school students' interests, attitudes and values concerning school science related to environmental issues in Finland. *Environmental Education Research, 17*(2), 167-186. doi:10.1080/13504622.2010.522703

Velsor, P., Orozco, G. (2007). Involving low-income parents in the schools: Communitycentric strategies for school counselors. *Professional School Counseling, 11*(1), 17-24. doi:10.5330/PSC.n.2010-11.17

Yilmaz, O., Boone, W. J., & Andersen, H. O. (2004). Views of elementary and middle school Turkish students toward environmental issues. *International Journal of Science Education, 26*(12), 1527-1546. doi:10.1080/0950069042000177280

APPENDICES

APPENDIX A: PISA 2015 Summary Descriptions of the Seven Proficiency Levels on the Scientific Literacy Scale (OECD, 2017b)

Proficiency Level	What students can typically do
6	At Level 6, students can draw on a range of interrelated scientific ideas and concept from the physical, life and Earth and space sciences and use procedural and epistemic knowledge in order to offer explanatory hypotheses of novel scientific phenomena, events and processes that require multiple steps or to make predictions. In interpreting data and evidence, they are able to discriminate between relevant and irrelevant information and can draw on knowledge external to the normal school curriculum. They can distinguish between arguments that are based on scientific evidence and theory and those based on other considerations. Level 6 students can evaluate competing designs of complex experiments, field studies or simulations and justify their choices.
5	At Level 5, students can use abstract scientific ideas or concepts to explain unfamiliar and more complex phenomena, events and processes. They are able to apply more sophisticated epistemic knowledge to evaluate alternative experimental designs and justify their choices and use theoretical knowledge to interpret information or make predictions. Level 5 students can evaluate ways of exploring a given question scientifically and identify limitations in interpretations of data sets including sources and the effects of uncertainty in scientific data.
4	At Level 4, students can use more sophisticated content knowledge, which is either provided or recalled, to construct explanations of more complex or less familiar events and processes. They can conduct experiments involving two or more independent variables in a constrained context. They are able to justify an experimental design, drawing on elements of procedural and epistemic knowledge. Level 4 students can interpret data drawn from a moderately complex data set or less familiar contexts and draw appropriate conclusions that go beyond the data and provide justifications for their choices.
3	At Level 3, students can draw upon moderately complex content knowledge to identify or construct explanations of familiar phenomena. In less familiar or more complex situations, they can construct explanations with relevant cueing or support. They can draw on elements of procedural or epistemic knowledge to carry out a simple experiment in a constrained context. Level 3 students are able to distinguish between scientific and non-scientific issues and identify the evidence supporting a scientific claim.
2	At Level 2, students are able to draw on everyday content knowledge and basic procedural knowledge to identify an appropriate scientific explanation, interpret data, and identify the question being addressed in a simple experimental design. They can use everyday scientific knowledge to identify a valid conclusion from a simple data set. Level 2 students demonstrate basic epistemic knowledge by being able to identify questions that could be investigated scientifically.
1a	At Level 1a, students are able to use everyday content and procedural knowledge to recognise or identify explanations of simple scientific phenomenon. With support, they can undertake structured scientific enquiries with no more than two variables. They are able to identify simple causal or correlational relationships and interpret graphical and visual data that require a low level of cognitive demand. Level 1a students can select the best scientific explanation for given data in familiar personal, local and global contexts.
1b	At Level 1b, students can use everyday content knowledge to recognise aspects of simple scientific phenomenon. They are able to identify simple patterns in data, recognise basic scientific terms and follow explicit instructions to carry out a scientific procedure.

APPENDIX B: PISA 2015 Items for Environmental Awareness

ST092: How informed are you about the following environmental issues?				
Questionnaire Item	**1**	**2**	**3**	**4**
• ST092Q01TA: The increase of greenhouse gases in the atmosphere • ST092Q02TA: The use of genetically modified organisms (<GMO>) • ST092Q04TA: Nuclear waste • ST092Q05TA1: The consequences of clearing forests for other land use • ST092Q06NA: Air pollution • ST092Q08NA: Extinction of plants and animals • ST092Q09NA: Water shortage	I have never heard of this	I have heard about this, but I would not be able to explain what it is really about	I know something about this and could explain the general issue	I am familiar with this and I would be able to explain this well

APPENDIX C: PISA 2015 Items for Environmental Optimism

ST093: Do you think problems associated with the environmental issues below will improve or get worse over the next 20 years?			
Questionnaire Item	**1**	**2**	**3**
• ST093Q01TA: Air pollution • ST093Q03TA: Extinction of plants and animals • ST093Q04TA: Clearing of forests for other land use • ST093Q05TA: Water shortages • ST093Q06TA: Nuclear waste • ST093Q07NA: The increase of greenhouse gases in the atmosphere • ST093Q08NA: The use of genetically modified organisms (<GMO>)	Improve	Stay about the same	Get worse

APPENDIX D: PISA 2015 Items for the Three Indicators of the PISA Index of Economic, Social and Cultural Status (ESCS)

Parental education (PARED) - Mother

Question ST005	1	2	3	4	5
• ST005Q01TA: What is the <highest level of schooling> completed by your mother?	<ISCED level 3A> 1	<ISCED level 3B, 3C> 2	<ISCED level 2> 3	<ISCED level 1> 4	She did not complete <ISCED level 1> 5

Level of education increases from 5 to 1.

ST006: Does your mother have any of the following qualifications?		
Question ST005	**1**	**2**
• ST006Q01TA: <ISCED level 6> • ST006Q02TA: <ISCED level 5A> • ST006Q03TA: <ISCED level 5B> • ST006Q04TA: <ISCED level 4>	Yes	No

Parental education (PARED) - Father

Question ST007	1	2	3	4	5
• ST005Q01TA: What is the <highest level of schooling> completed by your father?	<ISCED level 3A> 1	<ISCED level 3B, 3C> 2	<ISCED level 2> 3	<ISCED level 1> 4	He did not complete <ISCED level 1> 5

Level of education increases from 5 to 1.

ST008: Does your father have any of the following qualifications?		
Question ST005	**1**	**2**
• ST008Q01TA: <ISCED level 6> • ST008Q02TA: <ISCED level 5A> • ST008Q03TA: <ISCED level 5B> • ST008Q04TA: <ISCED level 4>	Yes	No

Home possessions (HOMEPOS)

ST011: Which of the following are in your home?		
Questionnaire Item	**1**	**2**
• ST011Q01TA: A desk to study at • ST011Q02TA: A room of your own • ST011Q03TA: A quiet place to study • ST011Q04TA: A computer you can use for school work • ST011Q05TA: Educational software • ST011Q06TA: A link to the Internet • ST011Q07TA: Classic literature (e.g. <Shakespeare>) • ST011Q08TA: Books of poetry • ST011Q09TA: Works of art (e.g. paintings) • ST011Q10TA: Books to help with your school work • ST011Q11TA: <Technical reference books> • ST011Q12TA: A dictionary • ST011Q16NA: Books on art, music, or design • ST011Q17TA: <Country-specific wealth item 1> • ST011Q18TA: <Country-specific wealth item 2> • ST011Q19TA: <Country-specific wealth item 3>	Yes	No

ST012: How many of these are there at your home?				
Questionnaire Item	**1**	**2**	**3**	**4**
• ST012Q01TA: Televisions • ST012Q02TA: Cars • ST012Q03TA: Rooms with a bath or shower • ST012Q05NA: <Cell phones> with Internet access (e.g. smartphones) • ST012Q06NA: Computers (desktop computer, portable laptop, or notebook) • ST012Q07NA: <Tablet computers> (e.g. <iPad®>, <BlackBerry® PlayBookTM>) • ST012Q08NA: E-book readers (e.g. <KindleTM>, <Kobo>, <Bookeen>) • ST012Q09NA: Musical instruments (e.g. guitar, piano)	None	One	Two	Three or more

Question ST013	1	2	3	4	5	6
• ST013Q01TA: How many books are there in your home? (There are usually about 40 books per meter of shelving. Do not include magazines, newspapers, or your schoolbooks.)	0 – 10 books	11 – 25 books	26 – 100 books	101 – 200 books	201 – 500 books	More than 500 books

Highest parental occupational status (HISEI)

ST014: The following two questions concern your mother's job: (If she is not working now, please tell us her last main job.)

- ST014Q01TA: What is your mother's main job? (e.g. school teacher, kitchen-hand, sales manager)

  Please type in the job title. _____

- ST014Q02TA: What does your mother do in her main job? (e.g. teaches high school students, helps the cook prepare meals in a restaurant, manages a sales team)

  Please use a sentence to describe the kind of work she does or did in that job.

  _____

ST015: The following two questions concern your father's job: (If he is not working now, please tell us his last main job.)

- ST015Q01TA: What is your father's main job? (e.g. school teacher, kitchen-hand, sales manager)

  Please type in the job title. _____

- ST015Q02TA: What does your father do in his main job? (e.g. teaches high school students, helps the cook prepare meals in a restaurant, manages a sales team)

  Please use a sentence to describe the kind of work he does or did in that job.

  _____

APPENDIX E: Descriptive Analysis of the Selection of Items Under ESCS Score, Environmental Awareness and Environmental Optimism

ESCS

Item	ESCS1 Mean	ESCS2 Mean	ESCS3 Mean	ESCS4 Mean
What is the <highest level of schooling> completed by your mother?	2.26	2.81	3.56	4.25
What is the <highest level of schooling> completed by your father?	1.85	2.65	3.30	4.02
In your home: A room of your own	1.11	1.21	1.31	1.53
In your home: A computer you can use for school work	1.09	1.23	1.34	1.64
In your home: Educational software	1.39	1.54	1.62	1.76
In your home: A link to the internet	1.12	1.27	1.39	1.71
In your home: Books of poetry	1.28	1.41	1.46	1.54
In your home: Books to help with your school work	1.05	1.13	1.17	1.34
In your home: A dictionary	1.02	1.04	1.05	1.12
How many in your home: Televisions	2.82	2.52	2.38	2.20
How many in your home: Musical instruments (e.g. guitar, piano)	2.24	1.70	1.49	1.26
How many in your home: E-book readers (e.g. <KindleTM>, <Kobo>, <Bookeen>)	1.16	1.09	1.07	1.03
How many books are there in your home?	3.40	2.48	2.25	1.85

Environmental Awareness and Environmental Optimism

Question	Item	ESCS1 Mean	ESCS2 Mean	ESCS3 Mean	ESCS4 Mean
EA*: How informed are you about this environmental issue?	The increase of greenhouse gases in the atmosphere.	2.75	2.61	2.55	2.52
	Nuclear waste.	3.06	2.97	2.90	2.83
	Air pollution.	3.50	3.39	3.40	3.33
EO*: This issue will improve or get worse over next 20 years?	Air pollution.	2.63	2.52	2.48	2.44
	Nuclear waste.	2.66	2.57	2.54	2.50
	The increase of greenhouse gases in the atmosphere	2.63	2.54	2.54	2.48

* EA: Environmental Awareness, EO: Environmental Optimism.