

AN ANALYSIS OF SECONDARY SCHOOL CHEMISTRY CURRICULUM
IN TERMS OF EDUCATION FOR SUSTAINABLE DEVELOPMENT:
A CASE FROM TURKEY

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ABSTRACT

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Sustainable development (SD) has been one of the overarching objectives of the United Nations. Member countries and stakeholders are reorienting education at all levels of the system to overcome the environmental, economic, and social challenges that the world faces, and to achieve a sustainable future. There has been a strong increase in the integration of Education for Sustainable Development (ESD) into secondary school; there is a need for research to assess the relevance of the curriculum to reflect the environmental, social, and economic dimensions of SD.

With this thesis, the learning objectives of the Secondary School Chemistry Curriculum of Turkey employed between 2013 and 2018 were analyzed in terms of their relevance to ESD and their inclusion of environmental, economic, and social dimensions of SD was evaluated with supporting excerpts from the course textbooks.

The results of the study indicate that Fundamental Level Chemistry Curriculum successfully includes ESD related objectives. On the other hand, the inclusion of ESD related objectives in Advanced Level Chemistry Curriculum is found to be insufficient. Therefore, Secondary School Chemistry Curriculum of Turkey needs further improvement in terms of its ESD inclusion.

Keywords: Education for Sustainable Development, Chemistry Curriculum, Curriculum Analysis, Content Analysis

ÖZ

ORTAÖĞRETİM KİMYA EĞİTİM PROGRAMININ SÜRDÜRÜLEBİLİR KALKINMA İÇİN EĞİTİM BAKIMINDAN ANALİZİ: TÜRKİYE'DEN BİR VAKA

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Sürdürülebilir kalkınma (SK), Birleşmiş Milletler'in temel hedeflerinden biridir. Üye ülkeler ve paydaşlar, dünyanın içinde bulunduğu çevresel, sosyal ve ekonomik zorlukların üstesinden gelmek ve sürdürülebilir bir gelecek elde etmek için eğitimin her basamağının yönünü değiştiriyorlar. Bu nedenle Sürdürülebilir Kalkınma İçin Eğitim (SKE) ortaöğretime güçlü bir şekilde dahil edilmeye başlanmıştır; ancak SKE'nin çevresel, sosyal ve ekonomik boyutlarının öğretim programına yansımalarını araştırmaya ihtiyaç vardır.

Bu tezde Türkiye'de 2013 ve 2018 yılları arasında kullanılan Ortaöğretim Kimya Dersi Öğretim Programı'ndaki öğrenim hedeflerinin SKE ile olan uyumluluğu incelendi ve çevresel, sosyal ve ekonomik boyutları ile olan ilişkisi ders kitaplarından alıntılar yapılarak değerlendirildi.

Çalışmanın sonuçları, Temel Düzey Kimya Dersi Öğretim Programı'nın öğrenme hedeflerinin SKE'yi dahil etmekte başarılı olduğunu, ancak İleri Düzey Kimya Dersi Öğretim programının bu konuda yetersiz kaldığını göstermektedir. Bu nedenle, Ortaöğretim Kimya Dersi Öğretim Programı'ndaki öğrenim hedeflerinin SKE içeriğinin iyileştirilmesine ihtiyaç vardır.

Anahtar Kelimeler: Sürdürülebilir Kalkınma İçin Eğitim, Kimya Dersi Öğretim Programı, Öğretim Programı İncelemesi, İçerik Analizi

*To the passionate teachers everywhere
May their quest to change the world into a better place be fulfilled*

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ABBREVIATIONS

DESD	Decade of Education for Sustainable Development
EE	Environmental Education
ESCAP	Economic and Social Commission for Asia and the Pacific
ESD	Education for Sustainable Development
GAP	Global Action Programme
ICEE	Intergovernmental Conference on Environmental Education
MDGs	Millennium Development Goals
MoD	Ministry of Development of Republic of Turkey
MoNE	Ministry of National Education of Republic of Turkey
SD	Sustainable Development
SDGs	Sustainable Development Goals
UN	United Nations
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNCED	United Nations Conference on Environment and Development
UNCHE	United Nations Conference on Human Environment
WCED	World Commission on Environment and Development
WCESD	World Conference on Education for Sustainable Development

CHAPTER 1

INTRODUCTION

The world had faced many challenges and issues throughout its history however current problems we encounter today are mainly the results of the human activities. Ozone layer depletion, global climate change, extinction, deforestation, air pollution and water scarcity caused a significant impact on our realization of the problems and resulted in global interventions. In addition to environmental problems, there are social and economic issues such as inequality of wealth, oppression on women, social insecurity, immigration, and wars. Hence, current understanding of development and our interaction with environment requires a new strategy to ensure both natural balance and development, and to provide equal opportunity and prosperity for everyone (United Nations Conference on Environment and Development, 1993).

With the efforts of United Nations, sustainable development (SD) has been suggested to achieve “fulfillment of basic needs, improved living standards for all, better protected and managed ecosystems and a safer, more prosperous future” (UNCED, 1993, p. 15). Although it is hard to define the term because of its inclusive nature, sustainable development is stated as; “a development that meets the needs of the present without compromising the ability of future generations to meet their own needs” (World Commission on Environment and Development, 1987, p. 43). The term should be thought as a paradigm for thinking about a future in which environmental, economic, and social considerations are balanced in the pursuit of development and improved quality of life (McKeown R. , Hopkins, Rizzi, & Chrystalbridge, 2006). Reorientation of education is required, and steps are taken by many countries to shape their education system by including Education for Sustainable Development (ESD) in their curricula (McKeown et al., 2006).

The issues referred in education for sustainable development are quite diverse; climate change, environmental pollution, biodiversity, water conservation, food security, soil quality, public health, equal opportunity, gender equity, industrial growth, population

management and more. Furthermore; environmental, economic, and social dimensions of SD are vital in the handling of these issues (WCED, 1987).

According to McKeown (2006), ESD should provide the knowledge, issues, skills, perspectives, and values of sustainable development for students to understand the environmental, economic and social dimensions of these issues and build on the skills to develop solutions. Students should acquire the knowledge about fundamentals of natural sciences, social sciences, humanities, and economics while understanding the importance of the ethical and social values (McKeown et al., 2006).

Member countries must make a fundamental decision about their method of implementation and determine the aim of ESD either to teach about sustainable development or to change the goals and methods of education to achieve sustainable development (McKeown et al., 2006).

The general ESD related purpose of secondary school chemistry curriculum of Turkey employed in between 2013 and 2018 is stated below;

“Acquire the basic concepts, principles, models, theories, laws, and skills concerning the science of chemistry; and use this knowledge and skills in order to explain the phenomena relating to everyday life, human health, and industrial and environmental problems.

Develop an attitude that can discriminate between the positive and negative effects of chemical technologies on human life; the students evaluate this in terms of human health, society, environment, and quality of life.” (MoNE Commission, 2013, pp. 1,23)

In light of the general purpose of chemistry curriculum, it is expected to include learning objectives that would support those aims. Hence, this study is directed toward understanding the inclusion of ESD and dimensions of SD in Secondary School Chemistry Curriculum of Turkey (2013-2018).

1.1. Need for the Study

Reorienting existing educational programmes to address sustainability was expected from United Nations Educational, Scientific and Cultural Organization (UNESCO) Member States during the UN Decade of Education for Sustainable Development (2005-2014), and Secondary School Chemistry Curriculum has been updated in 2013 by Ministry of

National Education of Turkey (MoNE). Investigating the inclusion of ESD in updated chemistry curriculum is required to assess the overall inclusion of ESD in Turkish education programme. A literature review of the subject showed the research gap in the area of curriculum analysis of chemistry education in terms of ESD. Furthermore, Global Action Programme (GAP) seeks to accelerate progress toward SD by extending good examples of ESD in a global level. Hence, it is essential to analyze the current state of the curriculum in order to contribute to and benefit from the international practices.

1.2. Purpose of the Study

The purpose of this qualitative study is to reveal the inclusion of learning objectives that reflect Education for Sustainable Development in the Secondary School Chemistry Curriculum of Turkey employed between 2013 and 2018.

1.3. Significance of the Study

Obtaining descriptive information about the inclusion of ESD in Secondary Science Chemistry Curriculum of Turkey contributes to the investigation of inclusion of ESD in Turkish education program for UN Decade of Education for Sustainable Development (2005-2014). For further improvements of the curriculum, it is required to have an in-depth analysis of objectives of the curriculum in terms of their relation to ESD and this study provides a base for Chemistry Education.

Moreover, this research provides ESD related excerpts from the course textbooks to support the objectives of the curriculum, and they contribute to content development literature in the areas or ESD and Chemistry Education.

CHAPTER 2

LITERATURE REVIEW

This chapter presents the essential information and research from literature related to the subject of this study. The historical background of the development of Education for Sustainable Development is given in the first section. In the second, steps taken in global level to establish ESD are explained. The contextual background of sustainable development and dimensions of sustainable development are presented in the following section. Implementation of ESD into education systems through research and policy change is briefly stated in the fourth section. In the last section, studies that are related to ESD in chemistry education are explained.

2.1. A Brief History of Education for Sustainable Development

The history of Education for Sustainable Development dates to United Nations Conference on the Human Environment (UNCHE) held in Stockholm, Sweden, in 1972. “Education in environmental matters” is stated as essential in protecting and improving the environment (UNCHE, 1972). Later, the first Intergovernmental Conference on Environmental Education (ICEE) was organized by the UNESCO and UNEP, in Tbilisi, Georgia, in 1977 and conference resulted in the Tbilisi Declaration. The aim of environmental education is stated as;

A basic aim of environmental education is to succeed in making individuals and communities understand the complex nature of the natural and the built environments resulting from the interaction of their biological, physical, social, economic, and cultural aspects, and acquire the knowledge, values, attitudes, and practical skills to participate in a responsible and effective way in anticipating and solving environmental problems, and in the management of the quality of the environment. (p. 25)

Ongoing environmental, economic, and cultural problems lead UN to initiate an independent commission, World Commission on Environment and Development

(WCED), to focus on environmental and developmental problems and solutions in 1984. WCED, also known as the Brundtland Commission, published the organization's report; *Our Common Future* in 1987, and the term "sustainable development" emerged from the report.

2.2. Moving Towards Sustainable Development

Sustainable development is defined as; "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (WCED, 1987, p. 43). The term should be thought as a paradigm for thinking about a future in which environmental, economic, and social considerations are balanced in the pursuit of development and improved quality of life (McKeown et al., 2006).

In 1992, United Nations Conference on Environment and Development (UNCED), also known as Earth Summit, was held and three documents were published as the result of the conference; Rio Declaration on Environment and Development, Agenda 21, and Forest Principles. Agenda 21, a non-binding action plan for the implementation of sustainable development in local, national and global levels, included *Chapter 36: Promoting education, public awareness and training*, later regarded as Education for Sustainable Development (UNCED, 1993, p. 264). The goals cover the three dimensions of sustainable development: economic growth, social inclusion, and environmental protection.

The Millennium Development Goals (MDGs) were the eight international development goals for the year 2015 that had been established following the Millennium Summit of the United Nations in 2000.

In 2002, United Nations General Assembly (UNGA) initiated the Decade of Education for Sustainable Development (DESD) 2005-2014 based on proposals by Japan and Sweden, and UNESCO was designated as the lead agency (UNCED, 2002). DESD aimed to improve education toward the MDGs.

2030 Agenda for Sustainable Development, also known as Sustainable Development Goals (SDGs), a collection of seventeen global goals set at United Nations Sustainable Development Summit in 2015.

World Conference on Education for Sustainable Development (WCESD) held in 2014 and published Aichi-Nagoya Declaration on Education for Sustainable Development and

Global Action Programme (GAP) on ESD was launched in 2014 (WCESD, 2017).

The objectives of the GAP are stated as;

Objective 1 “to reorient education and learning so that everyone has the opportunity to acquire the knowledge, skills, values and attitudes that empower them to contribute to sustainable development”

Objective 2 “to strengthen education and learning in all agendas, programmes and activities that promote sustainable development” (UNESCO)

In 2015, 2030 Agenda for Sustainable Development, also known as Sustainable Development Goals (SDGs), is determined. SDGs consist of 17 global goals, and they replaced the MDGs in 2016. The United Nations Development Programme (UNDP) will support governments over the next 15 years to achieve the SDGs.

Throughout the world, reorientation of education is needed, and steps are taken by many countries to shape their education system by including ESD in their curricula (McKeown et al., 2006).

2.3. Dimensions of Sustainable Development

SDGs announced with 2030 Agenda seek to take bold and transformative steps to shift the world on to a sustainable and resilient path by adapting the three dimensions of sustainable development - environmental, economic, and social - in a balanced and integrated manner.

The challenges of today’s and future generation are stated in the 2030 for Sustainable Development in paragraph 14;

We are meeting at a time of immense challenges to sustainable development. Billions of our citizens continue to live in poverty and are denied a life of dignity. There are rising inequalities within and among countries. There are enormous disparities of opportunity, wealth, and power. Gender inequality remains a key challenge. Unemployment, particularly youth unemployment, is a major concern. Global health threats, more frequent and intense natural disasters, spiraling conflict, violent extremism, terrorism, and related humanitarian crises and forced displacement of people threaten to reverse much of the development progress made in recent decades. Natural resource depletion and adverse impacts of environmental degradation, including desertification, drought, land degradation, freshwater

scarcity, and loss of biodiversity, add to and exacerbate the list of challenges which humanity faces. Climate change is one of the greatest challenges of our time and its adverse impacts undermine the ability of all countries to achieve sustainable development. Increases in global temperature, sea level rise, ocean acidification and other climate change impacts are seriously affecting coastal areas and low lying coastal countries, including many least developed countries and small island developing States. The survival of many societies, and of the biological support systems of the planet, is at risk. (UNCED, 1993, p. 14)

To address these interdependent issues effectively, an integrated approach of environmental, economic and social dimensions is necessary to establish improvement across the policy cycle (ESCAP, 2015) (Goodland, 1995). These dimensions of sustainable development are explained in the following sections and they serve as a framework for this study as illustrated in *Figure 1*.

2.3.1. The Environmental Dimension of Sustainable Development

The environment provides raw materials; such as food, water, air, and energy; hence it has the capacity to provide sources. In addition to this, environment acts as a sink for disposal of the waste. The balance between the regeneration of the sources and assimilation of the waste is required to achieve sustainable use of the capacities of the environment since it is also the home for all living beings including humans (Goodland, 1995; Meadows, Meadows, Randers, & Behrens, 1972).

The issues that reflect the environmental dimension of sustainable development in Agenda 21 are given in *Table 1*, and they serve as the base for the Environmental Dimensions of Sustainable Development in *Figure 1*.

Table 1: The Environmental Dimension of Sustainable Development

The Chapter in Agenda 21	Environmental Issues
Protection of the atmosphere	Ozone Layer Depletion
	Greenhouse Gases
	Climate Change
	Transboundary Atmosphere Pollution
	Renewable Energy Sources
	Alternative Energy Sources

Table 1 (Cont'd): The Environmental Dimension of Sustainable Development

The Chapter in Agenda 21	Environmental Issues
Integrated approach to the planning and management of land resources	Land Resources
	Ecology
Combating deforestation	Deforestation
	Forest Rehabilitation
	Afforestation
Managing fragile ecosystems: combating desertification and drought	Desertification
	Drought
Managing fragile ecosystems: sustainable mountain development	Soil Erosion
	Loss of Habitat
	Genetic Diversity
	Mountain Ecosystems
Promoting sustainable agriculture and rural development	Pest Management
	Land Conservation and Rehabilitation
	Soil Fertility
	Food Security
Conservation of biological diversity	Biodiversity
	Protection of Ecosystems
Protection of the oceans, all kinds of seas, including enclosed and semi-enclosed seas, and coastal areas and the protection, rational use, and development of their living resources	Marine Ecosystem
	Climate Change
	Small Islands
	Marine Pollution
	Bioaccumulation
Protection of the quality and supply of freshwater resources: application of integrated approaches to the development, management and use of water resources	Hydrological Cycle
	Climate Change
	Atmospheric Pollution
	Freshwater Scarcity
	Flood Prevention

Table 1 (Cont'd): The Environmental Dimension of Sustainable Development

The Chapter in Agenda 21	Environmental Issues
Environmentally sound management of toxic chemicals, including prevention of illegal international traffic in toxic and dangerous products	Chemical Contamination
Environmentally sound management of hazardous wastes, in hazardous wastes	Hazardous Wastes Rehabilitation of Contaminated Sites
Environmentally sound management of solid wastes and sewage-related issues	Solid Wastes Life Cycle Management Waste Reuse and Recycling Waste Disposal and Treatment Sewage Disposal
Safe and environmentally sound management of radioactive wastes	Radioactive Wastes

2.3.2. The Economic Dimension of Sustainable Development

The definition of economy differs in which context it is used. The first and second definition for the word reflect the financial activity of a country or a region, while the third definition reflects a certain philosophy of resource management that also includes the financial activity of a country or a region. The definitions of the word are given below;

1. *An economy is the system according to which the money, industry, and trade of a country or region are organized.*
2. *A country's economy is the wealth that it gets from business and industry.*
3. *Economy is the use of the minimum amount of money, time, or other resources needed to achieve something, so that nothing is wasted. (Collins English Dictionary, 2018)*

When it comes to sustainable development, the third definition of economy provide a better base to represent the economic dimension of SD. The issues and concepts that reflect the economic dimension of SD are present in Section 1 in Agenda 21 and they are listed in

Table 2. It constitutes as a base for Social Dimensions of Sustainable Development in Figure 1 and it is used for coding the objectives in the curriculum and content of the textbooks for this study.

Table 2: *The Economic Dimension of Sustainable Development*

The Chapter in Agenda 21	Economic Issues
International cooperation to accelerate sustainable development in developing countries and related domestic policies	National Economic Policies International Economic Relations Multilateral Trading System Market Access for Developing Countries
Combating poverty	Equity in Income Distribution Human Resource Development Strengthening Employment Poverty Eradication Food Security
Changing consumption patterns	Economic Growth Patterns of Consumption and Production Minimizing Waste Rules and Regulations for Industry
Demographic dynamics and sustainability	Population Growth Capacity of Planet
Promoting sustainable human settlement development	City Planning Transportation Renewable Energy Life Cycle Cost Sustainable Construction Industry
Integrating environment and development in decision-making	Research & Development Science & Technology

2.3.3. The Social Dimension of Sustainable Development

Social sustainability can be defined as “the ability to guarantee welfare (security, health education), equitably distributed among social classes and gender” (McKenzie, 2004). The issues that reflect the social dimension of SD are present in Section I in Agenda 21 and they are listed in *Table 3*. They serve as the base for the Social Dimension of Sustainable Development in *Figure 1*.

Table 3: The Social Dimension of Sustainable Development

Agenda 21 Title	Social Issues
Combating poverty	Empowering Communities Disadvantaged Groups (Women, Children and Youth, Refugees) Food Security
Changing consumption patterns	Sustainable Consumption Patterns Promotion of Energy Efficiency Minimizing Waste Awareness & Responsibility
Demographic dynamics and sustainability	Protecting Vulnerable Groups (Rural Landless Workers, Ethnic Minorities, Refugees, Migrants, Women Heads of Household, Indigenous People)
Protecting and promoting human health conditions	Human Health Quality of Life Protecting Vulnerable Groups
Promoting sustainable human settlement development	Shelter for All Urbanization Living and Working Environments Sustainable Transportation Raising Awareness
Integrating environment and development in decision-making	Policy & Planning and & Management Legal and Regulatory Framework Education Public Awareness Legal and Regulatory Instruments

Intersections

There are some issues that reflect more than one or two dimensions of sustainable development, and they would fall into the intersection area of two or three dimensions of SD. The framework that is employed in this study is presented in *Figure 1*. The issues deducted from Agenda 21 for each dimension are presented in *Table 1*, *Table 2* and *Table 3*, the issues that lay in intersection areas, such as Environmental Justice, Local Issues, Consumption Patterns, Energy Efficiency, Soil Quality, Fair Trade, Worker's Rights, Job Opportunities, Quality of Life, Responsibility, Equal Opportunity, and Laws & Regulations, lay either in intersection areas of the dimensions of SD.

Dimensions of Sustainable Development

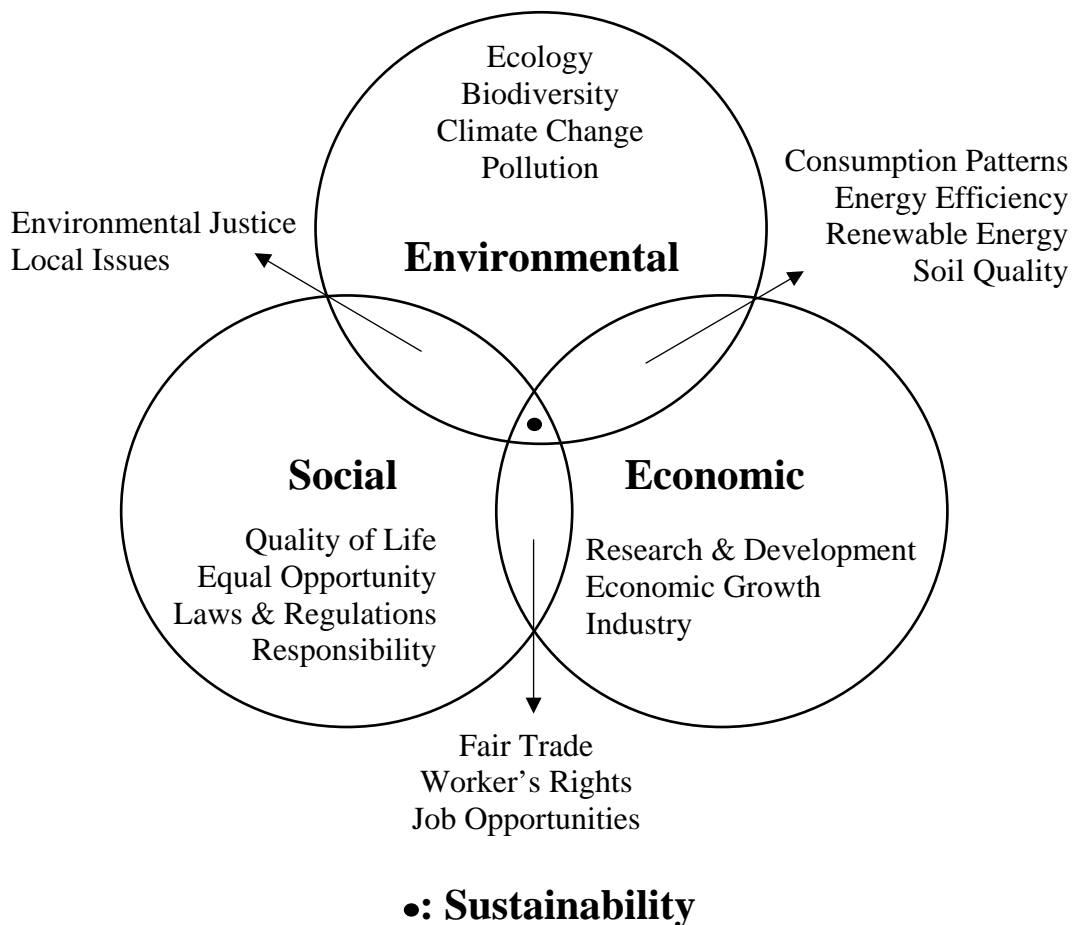


Figure 1: Dimensions of Sustainable Development

2.4. Implementing ESD into Education Systems

Historically, EE and ESD share the common root originated in UNCHE in 1972 and in the following forty years there has been changes in the understanding of the terms, yet both remain to be in use in the recent studies. There is an ongoing debate on the relation of these two terms, whether ESD take over EE by expanding it with the economic and social dimensions, or EE and ESD share the environmental issues as a common ground but there are certain differences in between their study areas (Kopnina, 2012; McKeown & Hopkins, 2003). On the other hand, the decisions put, and actions taken by the initiatives of UN affect the direction of the research and progress of these study areas. ESD, being endorsed and promoted by UN, has gained importance during the Decade of Education for Sustainable Development and Global Action Program for Education for Sustainable Development, many countries have taken steps to implement ESD into their national education curriculum (Ryan & Tilbury, 2013).

In the period of DESD followed by GAP, many countries put efforts to increase the quality of education in national and regional level and previous studies may provide insight for the analysis of Secondary Science Chemistry Curriculum. Literature research for this study show that there are studies on ESD in primary education (Summers & Kruger, 2003; Tanrıverdi, 2009; Kadji-Beltran, et al., 2017), secondary education (Berglund, Gericke, & Chang Rundgen, 2014; Jegstad & Sinnes, 2015; Firth & Winter, 2007), higher education (Ryan & Tilbury, 2013; Sterling & Scott, 2008) and preservice and in-service teacher education (Tuncer Teksöz, Boone, Yılmaz Tüzün, & Öztekin, 2014; Kanyimba & Coetzer, 2011; Sarıbaş, Doğanca Küçük, & Ertepinar, 2017; Higgins & Kirk, 2006) as well as studies on the whole national curriculum (Jóhannesson, Norðdahl, Óskarsdóttir, Pálsdóttir, & Pétursdóttir, 2011; Dymont, Hill, & Emery, 2015; Barthes & Lange, 2018; Warner & Elser, 2015).

Olsson and Gericke (2016) states that different ages respond differently to the issues on sustainability, hence the level of education that is under investigation requires distinctive approaches to curriculum and instruction. Considering this study examine Secondary School Chemistry Curriculum, the literature on ESD inclusion into secondary school would provide more suitable theoretical ground.

There are certain differences encountered by teachers based on the subject area of the

course (Borg, Gericke, Høglund, & Bergman, 2012), yet the framework must have a sound basis for the specific course handled. Therefore, imposed frameworks, curricula and teaching activities should address specific needs and barriers of the discipline under investigation (Borg, Gericke, Høglund, & Bergman, 2012).

Literature research on curriculum analysis studies in Turkey in terms of ESD point at Tanrıverdi's study on environmental education in the primary education curriculum in Turkey. It is concluded by Tanrıverdi (2009) that sustainability issues are not sufficiently addressed in the curriculum, and there is a need for research on teachers' perspectives on EE and ESD and inclusion of ESD in the curricula to be studied for further improvement of the education systems.

In Turkey, MoNE Board of Education and Morality has updated the secondary school chemistry curriculum in 2013. According to the news in Bianet, the Director of the Board stated that the physics, chemistry, and mathematics curricula had been updated to include more content that has daily life applications rather than giving abstract information (Bianet, 2013).

There is not any available information about the ESD policy of MoNE for public use, hence the agenda of MoNE on ESD is not clear. Nonetheless, the documents on plans, programs and reports on Sustainable Development in Turkey published by Ministry of Development (MoD) are focused on Quality of Education and Education for All, however ESD is not mentioned in the existing plans. Yet, the need for improving the curriculum as a part of education system is stated in the Routes for 2030 Development Agenda of Turkey; Possible Way Forward from Millenium Development Goals to Sustainable Development Goals document published by MoD (Bayazıt & Önsal, 2017).

Besides, there have been several attempts to improve physical conditions of schools including the education materials. Nevertheless, differences in success levels among various school types and regions are obvious and there is a huge need to improve the performance and quality of education system as a whole including teacher's skills, curriculum and physical learning environment. (p. 8)

In addition to this, Bayazıt and Önsal (2017) stated the achievements in the field of education in terms of MDGs while emphasizing the importance of education in the national agenda.

The numeric successes in terms of school enrollments, reducing gender disparities, number of students per class or increasing number of schools even universities do not necessarily mean increasing quality of education or reducing disparities among regions in Turkey. Therefore, education will have the special room in the national development agenda. Although some targets may be achieved but some others should be realized by efforts for adding success stories into agenda. (p. 22)

In this regard, research on inclusion of ESD in the existing curricula would provide information for policy makers, curriculum, and content developers to build on. As a result, analysis of the curricula in all levels of the education system in terms of ESD is necessary as a reference for the upcoming improvements in the field of education in Turkey to reach sustainable development.

2.5. ESD in Chemistry Education

Utilizing issues that reflect the environmental dimension of SD in chemistry education is not an innovative approach. The causes and results of acid rain, preventing ozone layer depletion, damage of hazardous waste on environment and recycling of paper, metals and plastics have been implemented into chemistry curriculum on the ground of Environmental Education. Nevertheless, ESD requires economic and social dimensions to be integrated into chemistry education with the existing environmental dimension (Burmeister, Rauch, & Eilks, 2012).

In agreement with Burmeister, Rauch, & Eilks (2012) and UNESCO (2006), ESD for chemistry education should provide the following characteristics;

- *Be interdisciplinary and holistic: ESD should be embedded in the entire chemistry curriculum and not merely be presented as a separate topic.*
- *Become value-driven: The ethical values and principles underpinning sustainable development should be accepted as the guiding principle of chemistry education, too.*
- *Promote critical thinking and problem solving: Addressing and understanding the dilemmas and challenges of sustainable development requires skills in critical thinking and problem solving.*
- *Be based on multi-dimensional methods: Word, art, drama, debate, experience,*

etc. should be used to construct a multi-faceted pedagogy which can cope with the multi-dimensional character of ESD.

- *Involve participatory decision-making: Learners should be given the chance to participate in decisions and learn how they are to be drawn.*
- *Focus on applicability: Learning should be integrated in day-to-day personal and professional life contexts.*
- *Achieve local relevance: Teaching should address global as well as local issues, including use of the language(s) which the learners most commonly use. (p. 62)*

The study reported by Burmeister, Schmidt-Jacob, and Eilks (2013) shows that chemistry teachers are lacking subject matter knowledge and pedagogical content knowledge related to ESD in chemistry education, and they are barely able to integrate environmental, economic and social dimensions of SD. Accordingly, preservice and in-service teacher education and curriculum material development are recommended in order to improve the quality of chemistry education in terms of ESD.

Burmeister et al. (2012) proposes four models of implementing ESD in chemistry education; Model 1: Adopting green chemistry principles to the practice of science education lab work, Model 2: Adding sustainability strategies as content in chemistry education, Model 3: Using controversial sustainability issues for socio-scientific issues which drive chemistry education, Model 4: Chemistry education as a part of ESD-driven school development.

In addition to the models of Burmeister et al., Jegstad and Sinnes (2015) suggest a model for chemistry education that could be applied to existing curriculum without further adding more content knowledge. Consequently, there is a need for curriculum and content developers to be supported to provide the tools for chemistry teachers and relevant chemistry content for students to engage in (Juntunen & Aksela, 2014).

As a result, this study is aimed to provide information about inclusion of ESD in the Secondary School Chemistry Curriculum of Turkey for policy makers, curriculum and content developers and researchers to build on and restructure the curricular program relevant to SD.

CHAPTER 3

METHODOLOGY

This chapter presents an overview of the methodology and design of the current study. In the first section, the aim of the study is restated and research questions are listed. In the second section, research methods used in the study are explained. Then the data sources used for this study are listed and described. Furthermore, design employed in the study is illustrated and the processes are explained. In the following section, trustworthiness of the study is presented with the strategies used for increasing credibility, transferability, dependability and confirmability. In the last section, the limitations of the study is presented.

3.1. Research Questions

The purpose of this qualitative study is to reveal the inclusion of learning objectives that reflect Education for Sustainable Development in the Secondary School Chemistry Curriculum of Turkey employed between 2013 and 2018. In order to achieve that, the inclusion of ESD related content from chemistry course textbooks are also included. The aim of the study can be restated in research questions by separating into meaningful segments. As a result, this study addresses the three research questions given below;

Research Question 1: Which objectives of Secondary School Chemistry Curriculum of Turkey (2013-2018) are related to ESD?

Research Question 2: Which dimensions of Sustainable Development are reflected through ESD related objectives in Secondary School Chemistry Curriculum of Turkey (2013-2018)?

Research Question 3: How are the ESD related objectives of the Secondary School Chemistry Curriculum of Turkey (2013-2018) reflected in the chemistry textbooks approved by the Ministry of National Education?

3.2. Research Method

This is a qualitative research of a case study that evolve around chemistry curriculum applied in Turkey and it employs content analysis of secondary science curriculum and chemistry course textbooks. Qualitative research, case study and content analysis are briefly explained in the following sections.

3.2.1. Qualitative Research

According to Creswell (1994) qualitative research is “an approach for exploring and understanding the meaning individuals or groups ascribe to a social or human problem” (p. 4). The process attempts to answer open-ended questions by making interpretations of the meaning of the data (Creswell, *Research Design: Qualitative, Quantitative, and Mixed Methods Approaches*, 1994). Morse (1991) explained the characteristics of qualitative research problem;

Characteristics of a qualitative research problem are: (a) the concept is “immature” due to a conspicuous lack of theory and previous research; (b) a notion that the available theory may be inaccurate, inappropriate, incorrect, or biased; (c) a need exists to explore and describe the phenomena and to develop theory; or (d) the nature of the phenomenon may not be suited to quantitative measures. (p. 120)

Since ESD inclusion through objectives of the curriculum and content of the course textbooks is an emerging study, especially in the secondary science chemistry context; research questions stated for this study require a qualitative research design.

3.2.2. Case Study

Case studies is a time and/or activity bounded data collection procedure, and researcher collect detailed information from variety of sources throughout the research process (Creswell, 2007; Stake, 1995). There are three variations in terms of the intent of the case studies; the single instrumental case study, the collective or multiple case study, and the intrinsic case study. In single instrumental case studies, the researcher focusses on a single issue to select the boundaries of the case and explain the issue (Denzin & Lincoln, 2005; Stake, 1995). The use of case studies in educational research is quite common.

The cases investigated in this research are the inclusion of ESD in Secondary Science Chemistry Curriculum of Turkey applied in between 2013 and 2018 and ESD related

content of the chemistry course textbooks for 9th, 10th, 11th and 12th grades. Since ESD is still in the process of implementation and improvement in Turkey, this study would provide insight on how to enhance ESD inclusion in the curriculum and textbooks. Hence this study is time, location and context bounded qualitative case study.

3.2.3. Content Analysis

Content analysis is the study of social artifacts including books, laws, forms of art, communication mediums and media (Neuendorf, 2002; Krippendorff, 2004). The detailed artifacts can provide manageable information to analyze and report the findings. Textual information from the artifacts can be used for coding into particular categories with predetermined rules in content analysis (Krippendorff, 2004).

In this study, the artifacts that are under the study of content analysis is the secondary science chemistry curriculum and chemistry course textbooks and they are mentioned in this study as the data sources for the analysis. The categories for coding are determined to be the environmental, economic, and social dimensions of sustainable development.

3.3. Data Sources

The data sources for this study are composed of the secondary science chemistry curriculum and the chemistry course textbooks. The objectives of the curriculum are investigated in terms of their relation to ESD. Then, the content of the chemistry course textbooks that are in alignment with the ESD related objectives are investigated in terms of their relevance to the dimensions of SD. The data sources used for the study are listed in *Table 4*.

Table 4: Data Sources

Data Sources	
Curriculum	Secondary Science Chemistry Course Curriculum (2013-2018)
Course Textbooks	9 th Grade Chemistry Course Textbook
	10 th Grade Chemistry Course Textbook
	11 th Grade Chemistry Course Textbook
	12 th Grade Chemistry Course Textbook

3.3.1. Secondary School Chemistry Curriculum

The curriculum selected for this study is the Secondary Science Chemistry Curriculum administered in the high schools of Turkey in between 2013 and 2018. The curriculum is composed of two major parts being Fundamental Level Chemistry Curriculum and Advanced Level Chemistry Curriculum. The fundamental level is comprised of 9th and 10th grades, while advanced level is comprised of 11th and 12th grades. The focus of the analysis is on the objectives that are present under each grade, and the objective annotations of the objectives serve as further information for the objectives. The curriculum under investigation had been updated in 2013 by the commission of MoNE and the textbooks have been written in order to support the updated curriculum. Board of MoNE decided to implement the updated curriculum in stages, beginning with 9th grade (see Appendices).

3.3.2. Chemistry Course Textbooks

The chemistry course textbooks for this study were selected based on their approval of MoNE, and four textbooks from each grade represent the whole content of Secondary School Chemistry Curriculum (20013-2018) of Turkey.

9th Grade Chemistry Course Textbook

The textbook is written by the Commission of MoNE as a coursebook for 9th grade secondary school students, and it has been approved at July 2013 by MoNE as a chemistry course textbook (MoNE Commission, 2013).

10th Grade Chemistry Course Textbook

The textbook is written by Melter Yıldız and Ayça Uğur Sümer and published by Tutku Publications. It has been approved at May 2014 by MoNE as a chemistry course textbook to be used for five years (Yıldız & Sümer, 2014).

11th Grade Chemistry Course Textbook

The textbook is written by Ali Kemal Bilenler and published by Ada Publications. It has been approved at February 2016 by MoNE as a chemistry course textbook to be used for five years (Bilenler, 2016).

12th Grade Chemistry Course Textbook

The textbook is written by Murat Yıldız and published by Nova Publications. It has been approved at November 2016 by MoNE as a chemistry course textbook to be used for five years (Yıldız M. , 2017).

3.4. Research Design

This study employs qualitative research of a case study that revolve around Secondary School Chemistry Curriculum of Turkey and the chemistry course textbooks approved by MoNE. Content analysis is employed for the data analysis processes and expert opinion is supplied by two scholars to ensure trustworthiness. Content analyses are conducted solely by me and reported as drafts to the experts. Further analysis and reconsideration of the draft are achieved through meetings with the experts. The discussions in the weekly meetings and the email conversation about the drafts were used in the data analysis and reporting processes. Flowchart of the design is illustrated in *Figure 2*.

Before the analysis, a literature review is conducted to designate the framework for coding and three dimensions of sustainable development (environmental, economic, and social dimension) are used as categories for coding the objectives of the curriculum and the content of the textbooks by the researcher and the experts. During the data analysis process, operational definitions of environmental, economic, and social dimensions are used, and issues in each dimension emerged as the analysis continue. The issues mentioned in Agenda 21 are listed in *Table 1*, *Table 2* and *Table 3*, and they served as a guide to code the objectives and excerpts from the textbook into three categories; environmental, economic and social dimensions of SD. *Table 5* shows the data sources used for the analysis, the procedure done on results and the research question they are serving.

Table 5: Data Sources, Data Analysis & Research Questions

Data Source	Data Analysis	Procedure	Research Question
Secondary School Chemistry Curriculum	Content Analysis & Expert Opinion	Listed	1 st RQ
ESD Related Objectives of the Curriculum	Content Analysis	Coded into Dimensions of SD	2 nd RQ
9 th Grade Textbook	Content Analysis & Expert Opinion	Matched with ESD	3 rd RQ
10 th Grade Textbook		Related Objectives	
11 th Grade Textbook		&	
12 th Grade Textbook		Coded into Dimensions of SD	

Research Design of the Study

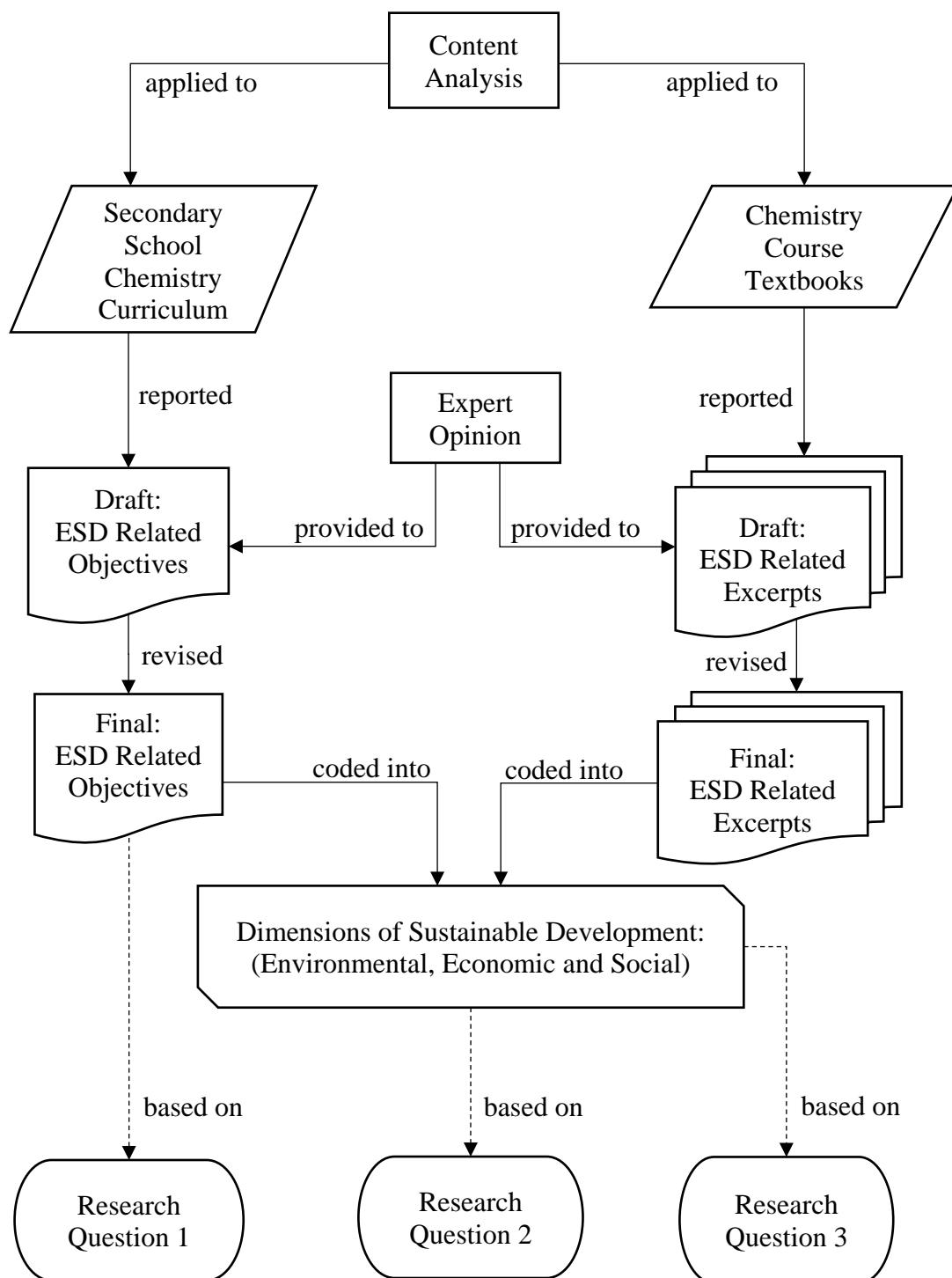


Figure 2: Research Design of the Study

3.4.1. Analysis of the Curriculum

Secondary Science Chemistry Curriculum of Turkey (2013-2018) published by the MoNE is used the sample for the content analysis. The unit of analysis is determined to be the objectives and the objective annotations. The objectives of the two levels of the curriculum, Fundamental Level and Advanced Level, coded together and the objectives that are related to ESD are marked. The results of the first analysis are regarded as the *Draft: ESD Related Objectives*. Then, the results of the first analysis are investigated by the experts and agreement on the final version of ESD related objectives are achieved. *Final: ESD Related Objectives* is used as a base to answer *Research Question 1*. The final version of ESD related objectives are coded into three categories; environmental, economic, and social dimensions, and the results are used as a base to answer *Research Question 2*. *Figure 2* illustrates the process of analysis of the curriculum, coding the ESD related objectives into categories and the base for the *Research Question 1* and *Research Question 2*. *Table 5* shows the data sources used for the analysis and the research question they are serving.

3.4.2. Analysis of the Textbooks

The chemistry course textbooks of 9th, 10th, 11th and 12th grades approved by MONE were used as the sample for content analysis. The unit of analysis is decided to be the ESD related content of the book including figures, graphs, and tables, besides texts. First, the contents of the textbooks were marked in terms of their relevance to ESD, afterward, ESD related contents were matched with *Final: ESD Related Objectives* obtained from the first part of the analysis (if applicable). The results of the analysis were regarded as *Draft: ESD Related Excerpts*. The expert opinion on *Draft: ESD Related Excerpts* obtained through meetings and emails, and agreement on the final version of ESD related content. *Final: ESD Related Excerpts* coded into three categories and results are reported with the related ESD related objective from the curriculum (if applicable) to be used as a base to answer *Research Question 3*. *Figure 2* illustrates the process of analysis of the textbooks, coding the ESD related content from textbook into categories and the base for the *Research Question 3*. *Table 5* shows the data sources used for the analysis and the research question they are serving, and *Figure 3* illustrates the coding process.

Coding Process into the Dimensions of SD

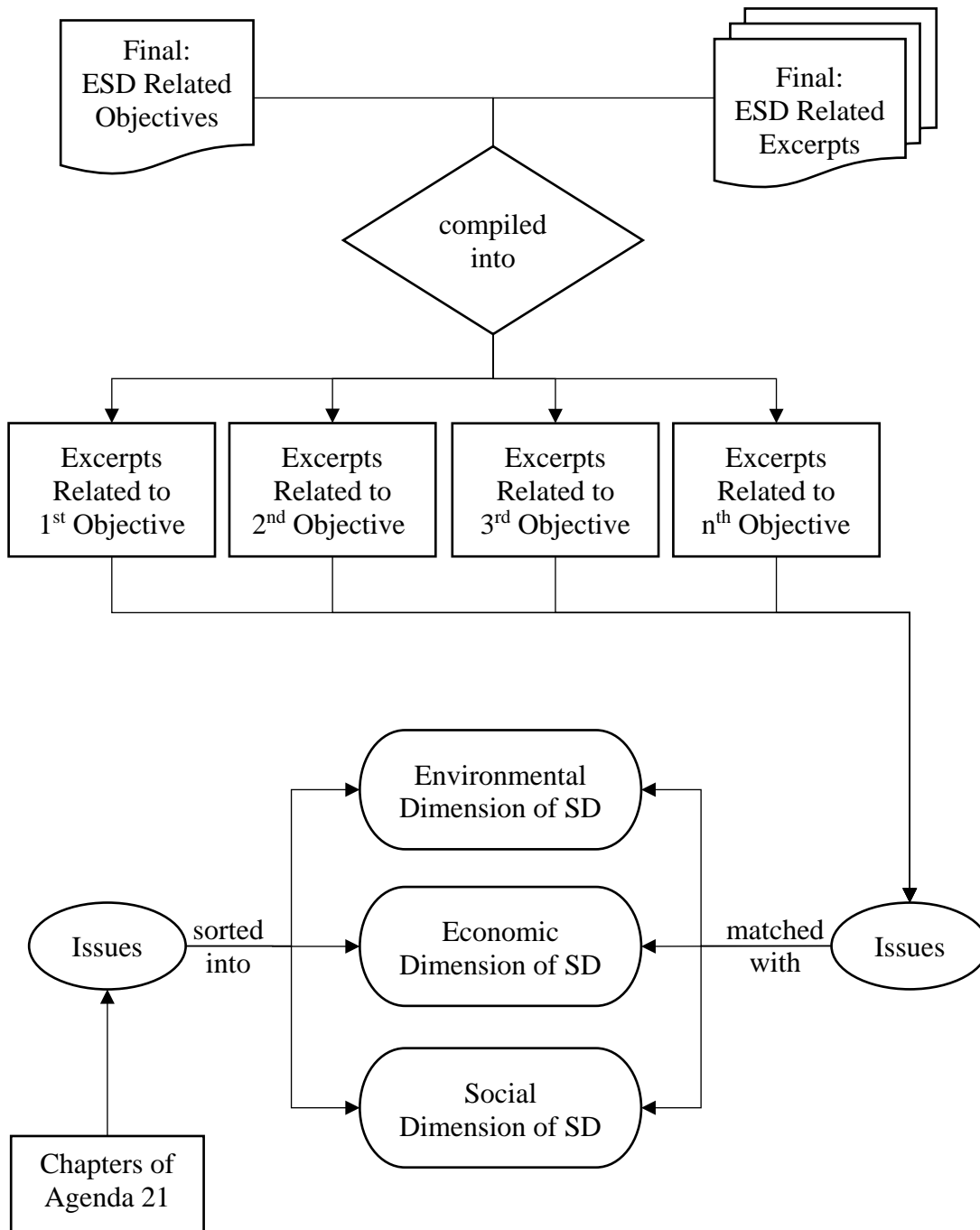


Figure 3: Coding Process into the Dimensions of SD

3.4.3. Reporting the Findings

Secondary Science Chemistry Curriculum of Turkey (2013-2018) and the chemistry course textbooks of 9th, 10th, 11th and 12th grades are in Turkish; hence the results are translated into English by the researcher and a professional interpreter. The ESD related objectives taken from curriculum and excerpts taken from the course textbooks are reported with their English translations in the findings chapter to give thick description.

3.5. Trustworthiness

The qualitative studies require a different approach to validity and reliability because of the certain dissimilarities between qualitative and quantitative research methods (Lincoln & Guba, 1986). Lincoln and Guba (1986) suggested trustworthiness of research, composed of credibility, transferability, dependability, and confirmability. The components of trustworthiness are stated as “credibility as an analog to internal validity, transferability as an analog to external validity, dependability as analog to reliability, and confirmability as an analog to objectivity” (Lincoln & Guba, 1986, pp. 76-77). The components of trustworthiness are explained and discussed in the following sections.

3.5.1. Credibility

Credibility is related to the compatibleness of the results of the study with the reality (Merriam, 2009). To increase the credibility of qualitative research, prolonged engagement, persistent observation, triangulation, peer debriefing, negative case analysis and member checks are suggested (Lincoln & Guba, 1986). In this study; data triangulation and investigator triangulation were applied to increase credibility.

Triangulation is the process of cross checking by the use of various sources, methods, and investigators (Lincoln & Guba, 1986; Onwuegbuzie & Leech, 2007). It is examined under data triangulation, investigator triangulation, theory triangulation and method triangulation (Patton, 2001).

First of all, the intent of the study was to investigate the objectives of the chemistry curriculum in terms of ESD inclusion, yet, the chemistry course textbooks were also included in the data sources to make sure that the selected objectives were indeed reflecting ESD by crosschecking them from the textbooks. Using both curriculum and textbooks for the analysis of the objectives serves as data triangulation.

Furthermore, expert opinion from different areas of expertise gathered throughout the research served as the investigator triangulation. An expert who is an experienced researcher and instructor for chemistry education and curriculum studies, and another expert who is an experienced researcher and instructor for education for sustainable development and science education, provided the investigator triangulation for the study.

3.5.2. Transferability

Transferability is us as an analog to external validity, hence it shows “the degree to which research results can be applied to a context apart from where they were gained or with different subjects” (p. 16) and it could be increased with thick description and purposive sampling (Bitsch, 2005).

According to Geertz (1973) thick description is considered as an interpretive description that is also dense and rich in detail, hence providing a comprehensive data base would contribute to the transferability of the study. The analysis of the curriculum and textbook resulted with a lengthy and detailed list of objectives and excerpt from textbook. In the findings chapter, translations of the objectives and excerpts are provided for the reader to gain access to the data that is gathered from the analysis.

In addition to thick description, purposive sampling is used to achieve relevant information for the study. Lopez and Whitehead (2013) states that “purposive sampling is designed to provide information-rich cases for in-depth study” (p. 125). Preselected criteria relevant to the study are required for this sampling technique (Lopez & Whitehead, 2013). For this research, I had chosen the criteria for curriculum by its relevancy to DESD. The selected is updated and used during DESD, hence the Secondary School Chemistry Curriculum used in between 2013-2018 was purposefully selected. The criteria for selection of the chemistry course textbooks is the approval of MoNE. Four textbooks with the approval of MoNE from each grade in secondary school were chosen for the content analysis to increase the transferability of the study.

3.5.3. Dependability

Bitsch describe dependability as “the stability of findings over time” and it seeks to examine if the results of the study would be the same if the study is replicated (2005, p. 86). Audit trail, code-recode strategy, stepwise replication, triangulation, and peer debriefing are strategies used for establishing dependability (Lincoln & Guba, 1986)

Investigator triangulation and data triangulation that are explained in the previous section provides dependability for the study. Expert opinion supplied by Prof. Dr. Yezdan Boz and Prof. Gaye Teksöz were recorded during the weekly meetings, and their comments on the draft reports for curriculum and textbooks were collected from email discussion. Interrater reliability was calculated using Miles and Huberman (1994) formula given below, and it is found as 96%.

$$\text{Reliability} = \frac{\text{Number of agreements}}{\text{Number of agreements} + \text{Number of disagreements}} \times 100$$

3.5.4. Confirmability

According to Baxter & Eyles (1997) confirmability refers to the degree to which researchers could confirm the results. Audit trail, reflexive journal and triangulation are suggested for increasing the credibility of the research (Lincoln & Guba, 1986). In this study, expert opinion gathered from two researchers serves as investigator triangulation and it helps to increase confirmability of the study. Investigator triangulation is explained in the previous section.

3.6. Limitations of the Study

Content analysis is regarded as a flexible method for analyzing data. Even though, it is useful to have this flexibility for the researcher in many areas, the lack of a concise definition and procedures pose a threat to the reliability. Including expert opinion in the design of the study contributed to the reliability of the analysis, yet further improvements could be achieved through the inclusion of chemistry teachers' opinions or instructional content developers.

In addition to this, the analysis is done only for the curriculum that was used in between 2013 and 2018, however the updated curriculum may serve latest information for the inclusion of ESD into chemistry curriculum. Hence this study provides insight only from the 2013-2018 version of the curriculum.

Finally, the study reflects the three researchers' analysis on curriculum and textbooks, even though triangulation were applied to increase trustworthiness, there may be bias resulting from the personal views of the researchers.

CHAPTER 4

FINDINGS

This chapter presents the findings of the analysis of each ESD related objective in the Secondary School Chemistry Curriculum of Turkey (2013-2018) while including the excerpts from the authorized textbooks approved by the Ministry of National Education of Turkey. The findings are divided into two sections to illuminate Fundamental and Advanced Level Chemistry Curriculum by analyzing each ESD related objective and its corresponding content from the textbooks through 9th to 12th grades. In these sections, the ESD related objectives in each grade are investigated with the corresponding content from the textbook of that grade in subsections by considering environmental, social, and economic dimensions in separate topics.

The general aim of both Fundamental and Advanced Level Chemistry Curriculum is to rise chemically literate students. According to the Secondary School Chemistry Curriculum of Turkey (2013-2018), chemically literate students;

“Acquire the basic concepts, principles, models, theories, laws, and skills concerning the science of chemistry; and use this knowledge and skills in order to explain the phenomena relating to everyday life, human health, and industrial and environmental problems.

Develop an attitude that can discriminate between the positive and negative effects of chemical technologies on human life; the students evaluate this in terms of human health, society, environment, and quality of life.” (MoNE Commission, 2013, pp. 1,23)

To be able to achieve these aims, specific objectives are included in the curriculum. Through content analysis of the curriculum and the textbooks, it is found that 14 objectives from a total of 155 are related to ESD and they represent at least one of the dimensions of SD. Fundamental Level Chemistry Curriculum of Turkey (2013-2018) consists of 9th and 10th grades. The number ESD related objectives in this level is found to be 14 from a total of 72 objectives. On the other hand, Advanced Level Chemistry Curriculum of Turkey

(2013-2018) consists of 11th and 12th grades. There are 83 objectives at this level and none of them found to be related to ESD. *Table 6* shows the distribution of ESD related objectives into the levels of the curriculum.

Table 6: Distribution of ESD Related Objectives into the levels of the Chemistry Curriculum of Turkey (2013-2018)

Levels in the Curriculum	Number of Objectives	Number of ESD Related Objectives
Fundamental Level	72	14
Advanced Level	83	0
TOTAL	155	14

The distribution of ESD related objectives into grades of the curriculum is given in *Table 7*. There are four ESD related objectives in 9th grade out of 33 objectives. The number of ESD related objectives in 10th grades is 10 out of 39 objectives. There are only two ESD related objectives in 46 objectives in 11th grade. When it comes to 12th grade, unfortunately, there is not ESD related objective to be found in 37 objectives.

Table 7: Distribution of ESD Related Objectives into the grades of the Chemistry Curriculum of Turkey (2013-2018)

Grades in the Curriculum	Number of Objectives	Number of ESD Related Objectives
9th Grade	33	4
10th Grade	39	10
11th Grade	46	0
12th Grade	37	0
TOTAL	155	14

4.1. ESD Related Objectives in the Fundamental Level Chemistry Curriculum and the Corresponding Content in the Textbooks

Fundamental Level Chemistry Curriculum (2013-2018) has 16 objectives related to ESD. They are listed with their grade, unit, and objective number in *Table 8*.

Table 8: ESD Related Objectives of Fundamental Level Chemistry Curriculum of Turkey (2013-2018)

Grade	Unit	Number	Objective
9	1	2	Explains the principal fields of activity of chemistry and chemists.
9	1	6	Recognizes the basic safety warning signs that are used in chemistry.
9	4	1	Recognizes the importance of substances being in different physical states in terms of life, industry, and environment.
9	4	4	Recognizes the vital importance of the atmosphere, which is a mixture of gases, for living beings, and acquires an awareness for protecting the atmosphere from pollutants.
10	1	6	Evaluates the beneficial and harmful effects of acids and bases on health, industry, and environment.
10	1	7	Implements the important health and safety measures and methods when working with acids and bases.
10	3	2	Examines the superiority and drawbacks of coal as a fuel.
10	3	8	Recognizes clean energy sources.
10	4	1	Acquires awareness about the limitations of usable water sources in the world.
10	4	4	Acts sensibly when selecting processed foods.

Table 8 (Cont'd): ESD Related Objectives of Fundamental Level Chemistry Curriculum of Turkey (2013-2018)

Grade	Unit	Number	Objective
10	4	7	Acquires awareness concerning the use and recycling process of polymeric materials.
10	4	10	Acquires awareness concerning the structures and proper usage of stationeries.
10	4	11	Examines the compositions, functions, and environmental effects of fertilizers.
10	4	13	Explains the causes of air, soil, and water pollution, and offers solutions.

4.1.1. 9th Grade

There are four units in the 9th grade chemistry curriculum and two of these units have ESD related objectives. There are 33 objectives in 9th grade however only four of them has qualities to represent ESD. *Table 9* shows the distribution of the ESD related objectives into the units in the 9th grade chemistry curriculum.

Table 9: Distribution of ESD Related Objectives into the units of 9th Grade Chemistry Curriculum of Turkey (2013-2018)

Name of the Unit	Number of Objectives	Number of ESD Related Objectives
Chemistry as a Science	6	2
The Atom and Periodic System	7	0
Interactions Between Chemical Species	9	0
The States of Matter	11	2
TOTAL	33	4

The objectives that are found to be related to ESD and the dimensions they contribute to are given in *Table 10*.

Table 10: ESD Related Objectives of 9th Grade Chemistry Curriculum of Turkey (2013-2018) with corresponding dimensions of SD

	Objective	Dimensions of SD		
		Env.	Eco.	Soc.
9.1.2	Explains the principal fields of activity of chemistry and chemists.	✓	✓	✓
9.1.6	Recognizes the basic safety warning signs that are used in chemistry.	✓	✓	✗
9.4.1	Recognizes the importance of substances being in different physical states in terms of life, industry, and environment.	✓	✓	✗
9.4.4	Recognizes the vital importance of the atmosphere, which is a mixture of gases, for living beings, and acquires an awareness for protecting the atmosphere from pollutants.	✓	✓	✓

The first unit of the 9th grade chemistry curriculum, Chemistry as a Science, aims to introduce chemistry, based on its historical development and cause-effect relationships, in order to raise students' awareness concerning career consciousness and entrepreneurship, to familiarize them with the symbolic language of chemistry and to recognize the effects of chemical substances on human and environmental health.

There are two objectives found in the first unit of the 9th grade that reflects the ESD by including at least one of the dimensions of SD; environment, society, and economy.

The first objective that reflects ESD in the first unit and its objective annotations are quoted below;

9.1.2. Explains the principal fields of activity of chemistry and chemists.

- a. The principal chemistry disciplines are introduced.*
- b. Pharmaceutical drugs, fertilizers, petrochemicals, refining, wood processing, and paints-textile processes are briefly introduced in order to contribute to [the students'] career awareness and entrepreneurship skills. (MoNE Commission, 2013, p. 6)*

It is expected to introduce the basic concepts related to SD throughout the unit. This objective would give the opportunity to briefly integrate all the dimensions of SD; environment, society, and economy, into the field of occupation of chemistry and chemists.

The textbook includes eight excerpts that are related to *Objective 9.1.2* and they are listed in *Table 11*.

Table 11: Excerpts from 9th Grade Chemistry Textbook related to Objective 9.1.2

Issue	Excerpt from the Textbook
Definition of Chemistry	Chemistry is closely related to many scientific fields such as health, energy, environment, food, agriculture, metallurgy, etc.
Green Chemistry	While providing the products and materials that constitute the basis of modern civilization, chemistry also entails secondary effects that damage the environment. For example, during their transformation to industrial products, coal and petroleum caused the contamination of water and soil. The solution to these problems is also in the domain of chemistry. New methods that are called green chemistry are minimizing the adverse effects on the environment.
Quality of Life	Pharmaceutical drugs are used in order to establish a healthy social life by protecting human health through the diagnosis, treatment, and prevention of diseases, and by increasing the quality of life.
Food Safety	One of the most important problems is, without a doubt, the problem of adequately feeding the world population. Had the nutritional capacity of the soil not been increased through artificial fertilizers, famine would disrupt the entire world. This problem was solved by chemists. The use of fertilizers and pesticides in food and agriculture saved humanity from a great risk of famine.

Table 11 (Cont'd): Excerpts from 9th Grade Chemistry Textbook related to Objective 9.1.2

Issue	Excerpt from the Textbook
Accessible Clothing	Facing a global increase in population, chemists also work on artificial fibers in order to meet the clothing requirements of people. Chemists have solved the problem of clothing millions of people, through artificial fibers that are commercially available under the names nylon, perlon, orlon, terylene and many other commercial names.
Scientific Studies	However, as these materials began to cause environmental pollution, the current direction is being rapidly orientated toward polymers that can decompose when deposited in the ground.
Job Opportunities and Local Economy	Considering the fact that the plastics industry in our country constitutes 1.6% of the global plastics industry, the importance of chemical sciences in providing employment opportunities for our people is obvious.
Job Opportunities and Industrial Applications of Science	Another industry that provides job opportunities today is the colorant manufacturing. The first artificial paint was the lilac-colored aniline paint that was obtained from coal by William Perkin in 1856. The researchers apply the developments in chemistry to the paint industry and continue to make life easier through many various products from dirt-free paints to scent-free, anti-bacterial paints.

Environmental

To begin with, green chemistry is defined as new methods that minimize the adverse effects [of chemistry] on the environment. Furthermore, while introducing green chemistry which is one of the principal chemistry disciplines, the negative effects of chemistry and its industrial applications to the environment are mentioned briefly (MoNE Commission, 2013, p. 13). Also, increasing number of studies that involve polymers that can decompose when deposited in the ground shows the efforts to reduce its effect on the environment (MoNE Commission, 2013, p. 14).

Economic

The economic effect of chemistry is reflected through mentioning global and local chemical industries, job opportunities created through developments in chemistry, and the ongoing orientation toward environmental scientific studies (MoNE Commission, 2013, pp. 14-15)

Social

The social implications of chemistry in daily life are introduced by including its use in pharmaceutical drugs to protect human health, artificial fertilizers to stop famine, and artificial fibers to supply necessary clothing to people. Hence, increasing quality of life and providing clothing and food safety are shown as an integral part of chemistry as a science (MoNE Commission, 2013, p. 14).

In the textbook, the definition and fields of activity of chemistry are given by showing the connections between related scientific fields such as health, energy, environment, food, agriculture, and metallurgy (MoNE Commission, 2013, p. 11).

This objective represents ESD in environment, society and economy dimensions successfully

One of the important concepts of the first unit is the basic safety warning signs. It is expected to include information regarding hazardous chemicals and why it is necessary to take required precautions.

The second objective that reflects ESD in the first unit and its objective annotations are about the basic safety warning signs and they are quoted below;

9.1.6 Recognizes the basic safety warning signs that are used in chemistry.

- a. The harmful effects of chemical substances on human health and the environment are examined.*
- b. Signs that represent flammable, incendiary, corrosive, explosive, irritant, toxic, radioactive, and environmentally hazardous substances are introduced. (MoNE Commission, 2013, p. 6)*

The textbook includes two excerpts related to *Objective 9.1.6* listed in *Table 12*.

Table 12: Excerpts from 9th Grade Chemistry Textbook related to Objective 9.1.6

Issue	Excerpt from the Textbook
Hazardous Waste	The wastes of these substances cannot be poured down the sink, cannot be directly deposited in the environment, and these substances cannot be placed in the same collection container with other chemical substances. These substances have to be collected in waste containers that are used by municipalities for this purpose and then delivered to specialists.
Industry	The symbol in the image is placed on the packaging labels of such substances.

Environmental

This objective is reflected in the textbook by mentioning hazardous wastes and the reason to handle them properly and explaining the disposal of hazardous waste and its effect on the environment.

Economic

Packaging labels for each safety warning signs on chemicals used in the industry are included (MoNE Commission, 2013, pp. 30-31). These packaging labels play a key role not only in the chemical industry and the factories, but also in people's daily life.

This ESD related objective represents both environmental and economic dimensions of SD.

The fourth unit in the 9th grade chemistry curriculum is The States of Matter and the aim of the whole unit is to explain the basic properties of gases, liquids, and solids. Even though the focus is mainly on the subject matter, it would be enriching to include information regarding the importance of different properties of states of matter in our life.

Accordingly, the first objective and the objective annotations of the fourth unit contributes to achieving this aim.

The first objective and the objective annotations of the fourth unit are:

9.4.1 Recognizes the importance of substances being in different physical states in terms of life, industry, and environment.

- a. For example, the natural water cycle (solid, liquid, gas) and the different functions of its different physical states are examined.*
- b. The importance of state transitions is emphasized using LPG (liquefied petroleum gas), the propellant gases in deodorants, LNG (liquefied natural gas), and gases used in coolants as examples.*
- c. The process of fixing nitrogen and oxygen from the air is examined. (MoNE Commission, 2013, p. 11)*

The textbook includes seven excerpts related to *Objective 9.4*, listed in *Table 13*.

Table 13: Excerpts from 9th Grade Chemistry Textbook related to Objective 9.4.1

Issue	Excerpt from the Textbook
Purification of Water and Water Cycle	The natural purification of water that is continuously polluted for reusability occurs through a similar process. The water on Earth evaporates due to solar energy; the water vapors that cool down in the atmosphere first transform into clouds, then return to earth in liquid (rain) or solid (snow or hail) form.
Water Cycle	<p>The Importance of the Water Cycle</p> <p>After being evaporated from the soil, rivers, lakes, and seas by solar energy, the water on the surface of the earth enters the atmosphere as vapors. This is the transition from the liquid state to the gaseous state. Water vapor returns to earth from the air as various forms of precipitation, such as rain, snow, or hail. These events signify a transition from the vapor (gaseous) state to the liquid or solid state. Rainwater, snow, and ice melt waters and underground waters on/under the ground join together to feed rivers, streams, creeks, brooks, lakes, and seas. This cycle is very important for living beings, and for the formation of the land features.</p>

Table 13 (Cont'd): Excerpts from 9th Grade Chemistry Textbook related to Objective 9.4.1

Issue	Excerpt from the Textbook
Animals and Water	<p>The Serengeti ecosystem in Africa is one of the places where dry and rainy seasons follow one another. Animals that live here try to migrate in large groups from dry areas toward areas where the rain will start.</p> <p>The animals in Serengeti actually migrate in accordance with the water cycle. What they need is liquid water, and they head toward wherever water can be found.</p>
Economic Activity	<p>The fact that water starts freezing at its surface is very important for creatures living in water. The density of water, in contrast to other substances, decreases when it freezes. Consequently, the ice that forms floats on the water and covers the surface of standing water.</p> <p>The ice on the surface of a lake acts as an insulator that prevents water below from getting colder, and thus, the underwater creatures can sustain their lives in a liquid environment that is at a suitable temperature for them. Because of this transition, fishermen can economically sustain themselves by fishing even on very chilly winter days.</p>
Industry and Human Health	<p>Nitrogen, oxygen, and argon, which are the main components of air, are very important in terms of life, environment, and industry. For example, liquid nitrogen is required as a coolant for the preservation of products that have to be stored cold. Oxygen is used in the steel industry to burn and gasify impurities in iron, such as carbon, sulfur and phosphorous. Additionally, patients with respiratory distress use an oxygen-enriched gas mixture. Pure argon is used to establish an “inert atmosphere.” Substances that are easily affected by air are stored in argon.</p>

Table 13 (Cont'd): Excerpts from 9th Grade Chemistry Textbook related to Objective 9.4.1

Issue	Excerpt from the Textbook
Industry	The transitions between different states of matter affect life and industry. For example, substances such as tetrafluoroethane, which are used for cooling in refrigerators, circulate in a closed circuit inside the device. While this substance is a liquid inside the pipes outside the refrigerator, it transitions to the gaseous state inside the refrigerator, obtaining the heat that is necessary for evaporation from the interior of the refrigerator, and the heat that is emitted while transitioning to the liquid state is dissipated into the room. Freezers and air conditioners also use similar systems.
Global Warming	It is argued that the permafrost in the poles and high altitudes acquired a tendency to melt due to global warming and that this is a threat against life since the sea level will increase for about 80 meters when all the glaciers melt. Why does the sea level increase when glaciers melt? Explain this phenomenon based on the characteristics of solids and liquids.

Environmental

Throughout the unit in the textbook, the properties of three different states of matter are explained by focusing on the subject matter. However, there are plenty of information on the properties of liquids section related to the environmental dimension of SD such as purification of water, water cycle, the effect of the water cycle on natural life, melting of permafrost in the poles and global warming (MoNE Commission, 2013, pp. 150-153). *Figure 4* and its caption are also excerpted from the textbook and they contribute to the explanation of water cycle in this unit.

Economic

In addition to these, there is information about the industrial usage of gases on the properties of gases section which represents the economic dimension of SD and a brief mention about the economic activities of fishermen (MoNE Commission, 2013, pp. 151,153).

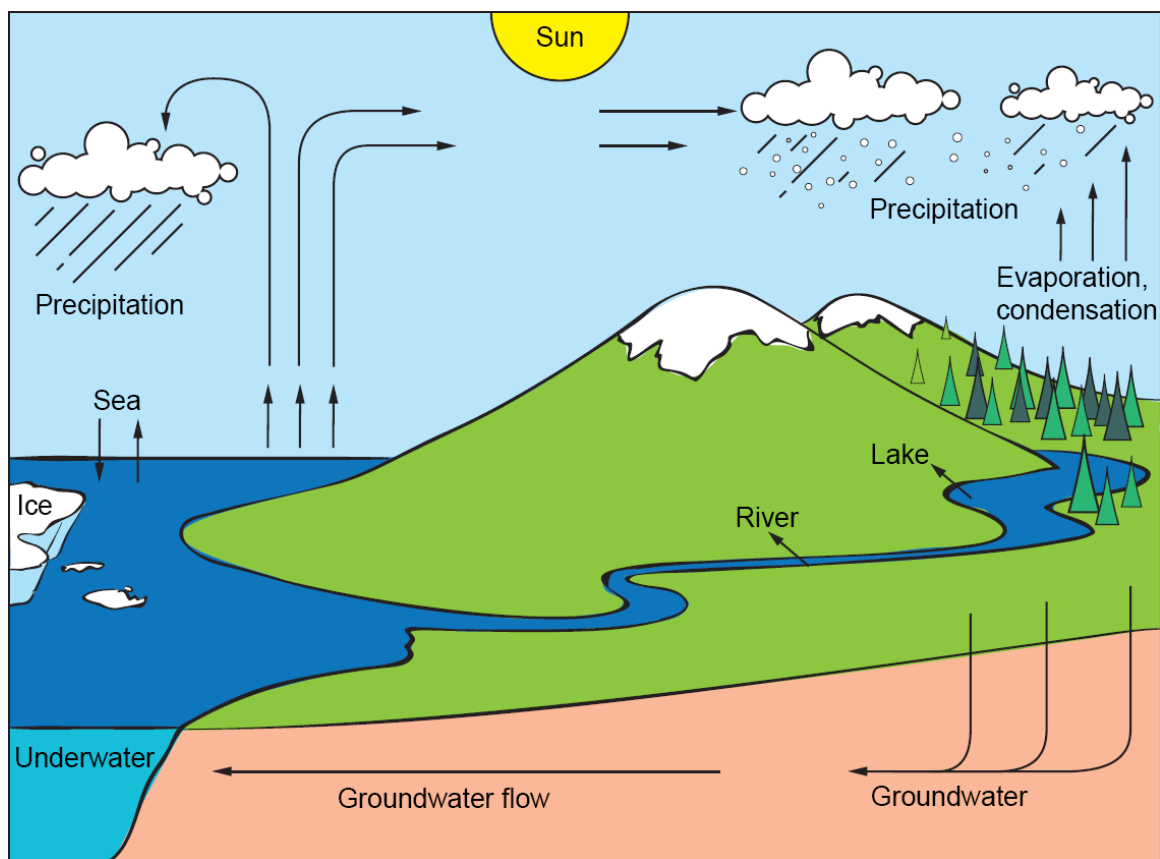


Figure 4: Depending on changes in temperature, many transitions between solid, liquid and gas states occur during the natural water cycle. (MoNE Commission, 2013, p. 150)

Herewith, this objective serves both environmental and economic dimensions of SD.

The atmosphere, which is a mixture of gases, is also included in this unit of the curriculum and its importance is expected to be taught, hence the objective requires all three dimensions of EDS to be covered.

The second objective that reflects ESD in the fourth unit is:

9.4.4 Recognizes the vital importance of the atmosphere, which is a mixture of gases, for living beings, and acquires an awareness for protecting the atmosphere from pollutants. (MoNE Commission, 2013, p. 12)

The textbook includes five excerpts related to *Objective 9.4.4* listed in *Table 14*.

Table 14: Excerpts from 9th Grade Chemistry Textbook related to Objective 9.4.4

Issue	Excerpt from the Textbook
Air Pollution	<p>The atmosphere is a mixture of gases and forms a 100 km-thick layer that encircles our world. As previously stated, it consists of 78% of N₂, 21% of O₂, 0.9% of Ar, and 0.1% of other gases. Some of the secondary gases that constitute less than 0.1% of the atmosphere are considered pollutants since they have harmful effects on living beings. Sulfurous oxides and nitrous oxides are the principal ones among these harmful gases.</p>
Ozone Layer Depletion	<p>NO (nitrogen monoxide), NO₂ (nitrogen dioxide), SO₂ (sulfur dioxide) and SO₃ (sulfur trioxide) that emerge from industrialization, heating, and motorized vehicles are the most important pollutant gases. These gases directly and adversely affect human health. While chlorofluorocarbons (CFCs) do not directly affect human health, they are very important pollutants since they damage the ozone layer in the upper layers of the atmosphere.</p>
Industrial Prevention Methods	<p>Industrial organizations install filtration systems or other refinement facilities that capture such substances that come out of their chimneys before they reach the atmosphere.</p>
Greenhouse Effect and Global Warming	<p>Although they are not considered toxic gases, the gases CO₂ and CH₄ have indirect pollutant characteristics. These gases absorb the heat-carrying infrared rays that are emitted from the surface of the earth and prevent them from getting out of the atmosphere. This causes an increase in the average temperature of our world. This is the basis of the global warming process. In conclusion, the increase in the ratios of CO₂ and CH₄ in the atmosphere is dangerous in the long-term.</p>
Sustainable Development	<p>We must strive to minimize the production of atmospheric pollutants in our daily lives and industrial activities. We must not forget that we have to keep this world clean not only for ourselves but for future generations.</p>

Environmental

The role of carbon dioxide and methane gases are explained with the mentions of the greenhouse effect and global warming, the harmful effects of sulfurous oxides and nitrous oxides on the environment are also indicated in the textbook. Likewise, the effect of chlorofluorocarbons on ozone layer depletion is specified (MoNE Commission, 2013, pp. 169-170). This information reflects the environmental dimension of SD.

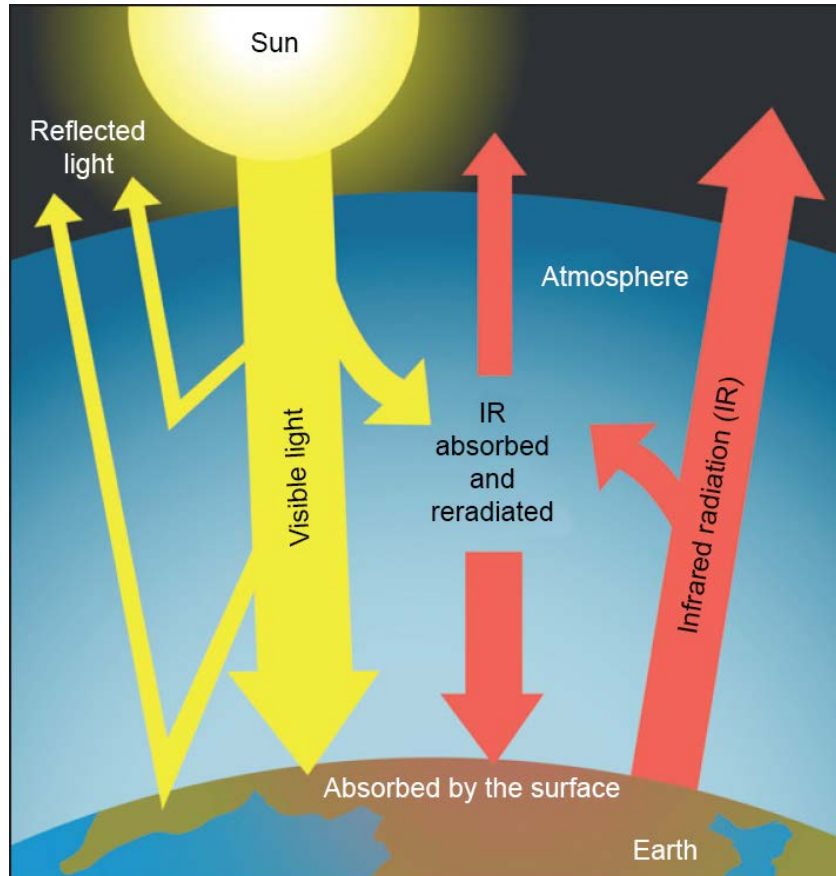


Figure 5: The gases CO₂ and CH₄ prevent the heat-carrying rays (red arrows) emitted from the Earth from spreading into space and thus cause global warming. (MoNE Commission, 2013, p. 170)

Economic

Industrialization, heating, and motorized vehicles are stated as a source of the pollutant gases (MoNE Commission, 2013, p. 170). In addition to this, the requirement for special filtration systems for industrial organizations is suggested and this reflects the economic dimension of SD on this matter (MoNE Commission, 2013, p. 170).

Social

One of the most important indications of ESD found in the textbook is in this section and it is quoted below (MoNE Commission, 2013):

We must not forget that we have to keep this world clean not only for ourselves but for future generations. (p. 170)

This quote from textbook refers to the very definition of sustainable development, hence it reflects environmental, social, and economic dimensions of SD as a whole. As a result, this objective is related to all the dimensions of SD.

The detailed investigation of 9th grade textbook shows that ESD related content of the textbook matches and supports the ESD related objectives in the curriculum. However further improvements are proposed in the discussion chapter.

4.1.2. 10th Grade

There are four units in the 10th grade chemistry curriculum and three of these units have ESD related objectives. There are 39 objectives in 10th grade and ten of them has qualities to represent ESD. *Table 15* shows the distribution of the ESD related objectives into the units in the 10th grade chemistry curriculum.

Table 15: Distribution of ESD Related Objectives into the units of 10th Grade Chemistry Curriculum of Turkey (2013-2018)

Name of the Unit	Number of Objectives	Number of ESD Related Objectives
Acids, Bases and Salts	8	2
Mixtures	5	0
Energy in Industry and Life	13	2
Chemistry is Everywhere	13	6
TOTAL	39	10

The objectives that are found to be related to ESD and the dimensions they contribute to are given in *Table 16*.

Table 16: ESD Related Objectives of 10th Grade Chemistry Curriculum of Turkey (2013-2018) with corresponding dimensions of SD

	Objective	Dimensions of SD		
		Env.	Eco.	Soc.
10.1.6	Evaluates the beneficial and harmful effects of acids and bases on health, industry, and environment.	✓	✓	✓
10.1.7	Implements the important health and safety measures and methods when working with acids and bases.	✓	✓	✓
10.3.2	Examines the superiority and drawbacks of coal as a fuel.	✓	✓	✓
10.3.8	Recognizes clean energy sources.	✓	✓	✓
10.4.1	Acquires awareness about the limitations of usable water sources in the world.	✓	✓	✓
10.4.4	Acts sensibly when selecting processed foods.	✗	✓	✓
10.4.7	Acquires awareness concerning the use and recycling process of polymeric materials.	✓	✓	✓
10.4.10	Acquires awareness concerning the structures and proper usage of stationeries.	✓	✓	✓
10.4.11	Examines the compositions, functions, and environmental effects of fertilizers.	✓	✓	✓
10.4.13	Explains the causes of air, soil, and water pollution, and offers solutions.	✓	✓	✓

The first unit of the 10th grade chemistry curriculum, Acids, Bases and Salts, aims to introduce acidic and basic substances through daily experience, to associate their known properties and their molecular structures, to establish the relations between the concepts of acid, base and salt, and to raise awareness about the uses and proper handling of these substances (Yıldız & Sümer, 2014, p. 11).

The first objective that reflects ESD in the first unit and its objective annotations are given below;

10.1.6. Evaluates the beneficial and harmful effects of acids and bases on health, industry, and environment.

- a. Examples of beneficial uses of acids in industry, cleaning, and agriculture are provided; methods and measures to protect from their harmful effects during handling, storage, and use are examined.*
- b. The development of acid rains and their effects on the environment are examined.*
- c. Awareness is raised concerning the safety warnings on acid/base packaging labels.*
- d. The effects of mineral water and acidic beverages on the digestive system are explained.*
- e. The acidic and basic secretions that are produced during digestion are emphasized.*
- f. The pH values that are specified on the packaging labels of consumer products that are used in daily life are associated with acidity/basicity.*
(MoNE Commission, 2013, p. 14)

The objective annotation 10.1.6.b. ensures that through this unit the concept of acid rains and its causes by including its effects on environment, economy, and society are examined.

Table 17 lists 15 excerpts that are related to *Objective 10.1.6* from the Acid Rains subsection in the 10th grade chemistry textbook.

Table 17: Excerpts from 10th Grade Chemistry Textbook related to Objective 10.1.6

Issue	Excerpt from the Textbook
Air Pollution	The usage of fossil fuels, such as coal and petroleum, causes carbon dioxide (CO ₂), sulfur dioxide (SO ₂) and nitrogen dioxide (NO ₂) gases to accumulate in the atmosphere. ...these gases, which cause air pollution and are also called flue gases, are acidic oxides.
Acid Rain	Chemical reactions occur when these gases combine with the water vapors in the air. These reactions produce carbonic acid (H ₂ CO ₃), sulfurous acid (H ₂ SO ₃) and nitric acid (HNO ₃). The reduced pressures and colder temperatures in the upper layers of the atmosphere cause water vapors to transition to the liquid phase and fall down on earth as rain. This rain contains significant amounts of carbon, sulfur, and nitrogen, and are called acid rains. The acid that accumulates in the atmosphere comes down to earth not only with rains, but also with mists.
Effects of Acid Rain	Well, what are the negative consequences of these acids coming down to earth? Dead lakes where no creatures can live, destroyed forests, crops that are devastated on fields, people who lose their health, damaged historical and artistic structures are consequences of acid rains.
Threat to Biodiversity	Acid rains that fall on streams and lakes increase the acidity of these waters and reduce their pH levels. The increased amount of acids causes the creatures that live in these waters to die.
Soil Quality	The minerals in the soil are the plants' source of nutrition. The acidic water that accumulates in the soil because of acid rains cause the minerals in the soil to dissolve, and the mineral content of the soil to decrease. This prevents plants from feeding off the soil, and slow or completely halt their growth. The trees' leaves fall down.

Table 17 (Cont'd): Excerpts from 10th Grade Chemistry Textbook related to Objective 10.1.6

Issue	Excerpt from the Textbook
Human Health	Acid rains also threaten human health. These harmful acid clouds that accumulate in the atmosphere cause respiratory diseases such as asthma and bronchitis, respiratory distress, and lung cancer.
Culture	Acid rains damage not only living beings, but also non-living beings. Many statues and buildings that are built of limestone or marble are damaged by acid rains. For example, Taj Mahal in India faces severe damage due to the acid rains that are caused by factories that pollute the environment.
Local Issues	The cities that are most affected by acid rains in our country are Samsun and Muğla. CO ₂ released to the atmosphere by the thermal power plant in Muğla is causing acid rains. The acid rains that ensue primarily threaten human health, in addition to the forests and historical structures.
Prevention	What can we do to prevent acid rains from occurring?
Renewable Energy	Renewable energy sources such as natural gas, solar energy or geothermal energy have to be preferred instead of fossil fuels in factories and residences.
Forests	Forest fires have to be prevented and green areas have to be increased.
Public Transportation	Public transportation has to be used in order to minimize the damages from exhaust gases.
Regulations	The use of illegal coal has to be prevented, chimneys and stovepipes have to be annually cleaned.

Table 17 (Cont'd): Excerpts from 10th Grade Chemistry Textbook related to Objective 10.1.6

Issue	Excerpt from the Textbook
Industry	Filters have to be installed on factory chimneys.
Acid Rain	Air pollutant gases such as CO ₂ , SO ₂ , NO ₂ combine with the water vapors in the air. Acid rains form due to the reduced pressure and colder temperatures in the upper layers of the atmosphere. This rain contains significant amounts of carbon, sulfur, and nitrogen, and are called (acid rains).

Carbon dioxide (CO₂), sulfur dioxide (SO₂) and nitrogen dioxide (NO₂) gases are presented as the main source of the acid rain and the process of accumulation of carbonic acid (H₂CO₃), sulfurous acid (H₂SO₃) and nitric acid (HNO₃) in the atmosphere by means of rain and mist is explained (Yıldız & Sümer, 2014, p. 42).

The consequences of acid rains are briefly mentioned by its overall effect on lakes, biodiversity, deforestation, soil quality, human health, and destruction of historical and artistic structures. Then the prevention methods and viable solutions are listed (Yıldız & Sümer, 2014, pp. 42-44). Moreover, there is a fill in the blanks question about acid rains in the evaluation step of the unit. Therefore, this subsection dedicated to acid rains successfully includes all three dimensions of SD, and they are discussed on the next page.

Environmental

First, air pollution resulting from the fossil fuels is mentioned while explaining the formation of acid rain. The harmful effect of acid rain on streams and lakes, and the living creatures in waters is described. In addition to this, the decrease in soil quality is explained with acid rain. As a solution forestation and prevention from forest fires suggested (Yıldız & Sümer, 2014, pp. 42-44).

Economic

In the prevention part of the topic, the preference for renewable energy sources over fossil fuels for the energy needs in factories or residences is stated along with the filters for

factory chimneys (Yıldız & Sümer, 2014, p. 44). The mention of alternative energy sources reflects the economic dimension of SD.

Social

The effects of acid rain on human health are listed as asthma, bronchitis, respiratory distress, and lung cancer. In addition to this, the damage done by acid rain to statues, historical buildings that have cultural importance is mentioned (Yıldız & Sümer, 2014, p. 43). Offering solutions and prevention methods for acid rains show a degree of social responsibility. For these, promoting public transportation to minimize the exhaust gases and making regulations to prevent the use of illegal coals are suggested, which reflect the social dimension of SD.

In the light of the excerpts from the textbook, Objective 10.1.6 represents environmental, economic, and social dimensions of SD:

In the following part of the unit, the safety measures, and methods for using acids and bases are explained. Especially, the harmful effects of excessive use of cleaning substances are emphasized.

The second objective that reflects ESD in the first unit and its objective annotations are given below;

10.1.7. Implements the important health and safety measures and methods when working with acids and bases.

- a. Examples of domestic chemical substances that are harmful when mixed together are provided (such as bleach and hydrochloric acid).*
- b. The fact that the material that is used to manufacture the infrastructure (pipes) may be damaged when using drain openers is emphasized.*
- c. The harmful effects of the excessive use of cleaning substances on health, environment, and infrastructure are examined.*
- d. The method and substance selection for removing scales from kitchenware and rust from metal goods are investigated. (MoNE Commission, 2013, p. 14)*

Environmental

The adverse effects of cleaning substances on the environment are explained with soil, water, and air pollution. In addition to this, the chemicals in cleaning substances cause contamination and plants, they negatively affect animals and humans (Yıldız & Sümer, 2014, p. 52).

Economic

The excessive use of cleaning substances may cause damage to the infrastructure of our homes (Yıldız & Sümer, 2014, p. 53). This excerpt from the textbook reflects the economic dimension of SD.

Social

The social dimension of SD is reflected in the textbook with the health problems humans face because of the resulting pollution from the wastes of cleaning substances. The health problems are given as; chronic fatigue, allergies, liver problems, lymphatic cancers, skin cancer and eye damage (Yıldız & Sümer, 2014, p. 53).

The textbook includes nine excerpts that are related to *Objective 10.1.7* and they are listed in *Table 18*. As discussed above the objective contributes to the three dimensions of SD.

Table 18: Excerpts from 10th Grade Chemistry Textbook related to Objective 10.1.7

Issue	Excerpt from the Textbook
Damage to Infrastructure	The polluting effects of chemical substances that are used for cleaning, on the environment increase as the amount that does not biologically degrade increases. Most of these materials directly go into the sewage system. First of all, they damage the infrastructure.
Soil and Water Pollution	After the sewers, they reach underground and surface waters. Petroleum and its derivatives, which are the most important water pollutants, are the raw materials for most cleaning products. These chemical substances that contaminate the soil or water, accumulate in the water and soil in time because they cannot be degraded.

Table 18 (Cont'd): Excerpts from 10th Grade Chemistry Textbook related to Objective 10.1.7

Issue	Excerpt from the Textbook
Human Health	They are then incorporated into plant, animal and finally human bodies and cause various diseases such as chronic fatigue, allergies, liver problems, lymphatic cancers, etc.
Air Pollution	Home cleaning products not only pollute the soil and the water but also threaten the air that we breathe. Spray oven cleaners and fat solvents, disinfectants and furniture polishers remain in the air we breathe even some days after use.
Human Health	These substances pose a great hazard, especially for asthma patients.
Ozone Layer Depletion	Cleaning products that are sold in aerosol packaging in the market contain pressurized gases. These gases deplete the ozone layer. As we know, the ozone layer prevents the harmful radiation from the Sun from reaching the Earth.
Human Health	As the ozone layer is depleted, the harmful radiation that reaches the Earth adversely affect living organisms. It increases the probability of skin cancer. It damages the eyes.
Human Health	As the ozone layer is depleted, the harmful radiation that reaches the Earth adversely affect living organisms. It increases the probability of skin cancer. It damages the eyes.
Evaluation	I. Damaged infrastructure materials II. Emergence of respiratory diseases such as asthma III. Depletion of the ozone layer Which one(s) from the above is/are among the consequences of improper use of chemical substances?

There are two objectives found to be related to ESD in the third unit, Energy in Industry and Life. With this unit, it is aimed to explain the basic concepts and relationships related to the acquisition of energy in the human body and the industry and the environmental problems caused by energy use.

The first objective that reflects ESD in the third unit and its objective annotations are given below;

10.3.2. Examines the superiority and drawbacks of coal as a fuel.

- a. Nitrous and sulfuric components of coal are mentioned, in addition to its principal component; the products of side-reactions that occur alongside the main combustion reaction, and their effects on the environment are investigated.*
- b. The specific heats of combustion of various types of coal are compared.*
(MoNE Commission, 2013, p. 17)

In *Fossil Fuels* section of the unit, the formation and several types of fossil fuels are examined in detail. Moreover, a subsection named *Fossil Fuels and Environment* is dedicated specifically to explaining their effect on the environment, besides economy and society.

Environmental

The amount of carbon dioxide emission resulting from the coal plants around the world is stated as 7 billion tons which makes the 40% of the harmful gas emissions in the world (Yıldız & Sümer, 2014, p. 123). In addition to carbon dioxide emission, coal plant release sulfur dioxide and nitrogen monoxide which cause acid rains. Since acid rains damage the whole ecosystem, it is a threat to the environment. Aside from the acid rain, coal plants cause heavy metal deposition in the soil, pollutes the water and contaminates the food chain because the waste materials from the combustion of coal contain heavy metals and toxic substances (Yıldız & Sümer, 2014, p. 124).

Economic

Coal mining causes the destruction of the flora and causes erosion, that results in a decrease in the agricultural potential of the land (Yıldız & Sümer, 2014, p. 124). The economic

activities that depend on agriculture would be affected by coal mining, hence the economic dimension of the SD is included with this information.

Social

The local issues related to coal mining and using lignite coal in Turkey are stated, and its effects on the local economy and the life quality of people were mentioned briefly. In the textbook, “social dimensions of its hidden cost” is discussed with its effect on the globe, human life, and agriculture (Yıldız & Sümer, 2014, pp. 124-125).

As a result, the environmental, economic, and social dimensions of SD are embedded in the employment of the objective in the textbook, and the excerpts are given in *Table 19*.

Table 19: Excerpts from 10th Grade Chemistry Textbook related to Objective 10.3.2

Issue	Excerpt from the Textbook
Acid Rain	Using coal as fuel is one of the main causes of acid rains. Harmful gases that are produced by acid rains damage the whole ecosystem. Coal plants cause the release of sulfur dioxide and nitrogen monoxide gases, which cause acid rains.
Human Health	Using coal as a fuel for heating causes the emission of harmful particles and radiation. These particles may damage the lungs and cause asthma and are one of the causes of infant deaths.
Water Pollution	Coal use indirectly reduces freshwater sources. Toxic chemical substances that are released from coal plants pollute the freshwater sources in the area.
Heavy Metal Deposition	Waste materials from the combustion of coal contain heavy metals and toxic substances. These waste materials are harmful both to human health and the environment. Elements such as arsenic, cadmium, chromium, and lead in amounts that may harm human health and the environment are released as a result of combustion. When these pollutants reach drinking water, plants, and animals, they increase the risk to the health of all living beings.

Table 19 (Cont'd): Excerpts from 10th Grade Chemistry Textbook related to Objective 10.3.2

Issue	Excerpt from the Textbook
Soil Erosion	Coal mining causes erosion. In coal mining, the flora of the area where the coal will be extracted is destroyed first. This triggers soil erosion. Additionally, the agricultural potential of these areas decreases.
Social Dimension	While coal is cheaper compared to other fossil fuels, did you ever think about the social dimensions of its hidden costs? The true costs of coal are the ill-health problems in humans, the damages it causes on agriculture, and the pollution and reduction of water sources.
Local Issues	Most of the coal reserves in our country consist of lignite coal. Lignite is the type of coal that contains the least amount of carbon, and the most amount of moisture. It has a high pollution rate and low energy value. This coal reduces the efficiency of power plants. Additionally, it results in more expensive electricity generation and increases social costs.
Clean Energy	Natural gas is the cleanest fossil fuel that we use in our homes.

The third unit continues with the alternative energy sources. In this part, it is expected to introduce clean and renewable energy sources to the pupils in order to contribute to ESD. It is achieved with *Objective 10.3.8*, the objective and its objective annotations are given below;

10.3.8. Recognizes clean energy sources.

- a. Clean energy sources such as the sun, wind-wave, geothermal, etc.*
- b. Energy sources are compared, and their advantages and disadvantages are examined. (MoNE Commission, 2013, p. 18)*

The objective is reflected in the textbook in the *Clean Energy Sources* section. Plant-based energy sources are explained, and methanol is given as a possible clean energy source. In

the following subsection, other clean energy sources are introduced, and their advantages and disadvantages are explained while making connections to environment, economy and society dimensions of SD. *Table 20* lists the excerpts taken from the textbook.

Table 20: Excerpts from 10th Grade Chemistry Textbook related to Objective 10.3.8

Issue	Excerpt from the Textbook
Alternative Fuels	Today, the increase in the consumption of fossil fuels, especially in the transportation industry, increases the damage to the environment that is caused by fossil fuels. This is why alternative fuels are attracting more interest. Methanol is one of the alternative fuels.
Methanol	As a liquid fuel at room temperature, methanol is an alternative fuel that will gain importance in the future since it can be used both in internal combustion engines and in fuel cells. Methanol is a clean fuel product because it does not release environmentally harmful compounds after combustion. Methanol provides better combustion due to its high-octane number and causes less damage to the environment compared to other fuels. Its wider combustion range than gasoline is another advantage.
Pollution	The environmental pollution that is caused by the rapid development of industrialization in our world since the 1900s, came to threaten the natural habitats of humans and other living beings.
Biodiversity	Environmental pollution caused the extinction of some animals, and others are rapidly following suit.
Ecology	Additionally, the use of very harmful radioactive materials is causing fatal diseases in humans, habitats are being destroyed and droughts are occurring.

Table 20 (Cont'd): Excerpts from 10th Grade Chemistry Textbook related to Objective 10.3.8

Issue	Excerpt from the Textbook
Future Generations	Fossil fuels also have to be conserved and stored for producing the plastics, synthetic fabrics, oils, carbon fiber products for future generations.
Clean and Renewable Energy Sources	The reduction in the coal reserves that we are using leads us to alternative sources. These are clean and renewable energy sources such as the solar, wind, wave, and geothermal energy.
Solar Energy	Solar energy is a clean, renewable, and continuous energy source. The systems are easily transported and installed. It can be easily used in small areas. It is also used effectively in agriculture and transportation.
Wind Energy	Wind energy is a type of renewable energy that does not cause pollution, and that causes the least damage to the environment. Wind energy can be produced in many locations on Earth. Agriculture and livestock farming can also be carried out in the same area.
Wave Energy	Wave energy is a type of continuous energy. It is an energy system that can be sustained without affecting the ecology. It does not disrupt the ecological balance.
Geothermal Energy	Geothermal energy is a cheap and ready type of energy. It is used in many different areas. It provides high efficiency. It contributes to various industries such as healthcare and tourism.
Hydroelectric Energy	Hydroelectric energy is a low-cost energy type. It does not cause pollution.

Table 20 (Cont'd): Excerpts from 10th Grade Chemistry Textbook related to Objective 10.3.8

Issue	Excerpt from the Textbook
Solar Energy	Solar energy has low efficiency, its initial costs are high. It may not be present at the time and intensity that is desired.
Wind Energy	Turbines that generate wind energy generate noise and may disturb people in nearby residential areas. Although it can be installed everywhere, it requires wide areas. This energy type has low efficiency, depending on wind conditions, the production is not constant.
Wave Energy	Wave energy is not yet widely adopted. The efficiency of this energy type is not high. Its installation costs are high.
Geothermal Energy	The water that is obtained through geothermal energy takes time to fully recycle.
Hydroelectric Energy	It is highly efficient. Dams that generate hydroelectric energy are expensive. The dams change the ecology of the region.
Advantages and Disadvantages of Energy Sources	In conclusion, each type of energy has its advantages and disadvantages. However, we have to steer toward and use sustainable and alternative energy sources in order to leave a clean Earth to future generations.
Local Issues	We can produce economic gains by producing our own energy.

Environmental

The pollutive effects of fossil fuels are emphasized by the damage done to the natural habitat of animals and biodiversity through extinction of species. While introducing the viable alternative energy sources their effects on the environment are discussed with their advantages and disadvantages (Yıldız & Sümer, 2014, pp. 150-153).

Economic

The energy required in the industry and transportation are provided through fossil fuels which cause drastic negative effects in our life explained in the previous section. In this part, the need for the shift in energy sources is introduced by making connections with information provided in the previous section. Alternative energy sources are listed, and clean and renewable alternatives are recommended. Proposed energy sources such as solar, wind, wave, and geothermal energy are discussed with their availability, usability and the possible costs for the shift are briefly explained (Yıldız & Sümer, 2014, pp. 150-153). Furthermore, local economy is mentioned in the following quote from the book (Yıldız & Sümer, 2014);

We can produce economic gains by producing our own energy. (p. 153)

Social

Emphasizing conservation and storage of industrially produced plastics, synthetic fabrics, oils, carbon fiber products for the future generations shows the existence of attention to sustainability, and the need for the shift to clean energy sources reflects our generation's responsibility (Yıldız & Sümer, 2014, pp. 150-153).

The overall inclusion of environment and economy is found to be prevalent. Even though society dimension of SD is present, further improvement on its inclusion is necessary.

Chemistry is Everywhere, being the most inclusive unit when it comes to representing SD, has six objectives that are found to be related to ESD: The aim of the unit is to contribute student's growth as conscious individuals who are sensible about the protection of their own health and environment by informing them about the real-life situations that they can associate their chemistry knowledge and skills in. (MoNE Commission, 2013, p. 20).

The unit has five sections; *Water and Life*, *Chemistry at Home*, *Chemistry in School*, *Chemistry in Industry* and *Environmental Chemistry*, and all of them includes ESD related objectives.

The importance of water in our life is explained in *The Water and Life* section in the unit. It is expected to inform the students about the limitation of usable water sources and the need for raising awareness about saving water. The first objective and its objective annotations are given below;

10.4.1. Acquires awareness about the limitations of usable water sources in the world.

- a. Terrestrial waters are classified in terms of their usability.
- b. Awareness is raised about water usage through the information that saving one drop per second saves 1 ton of water per year. (MoNE Commission, 2013, p. 20)

According to the 2001 research by the United Nations Environment Programme (UNEP), only 3.5% of the water on earth are freshwaters, i.e. potable water.

Table 21 lists some of the important excerpts that are related to *Objective 10.4.1* in the 10th grade chemistry textbook. The related text exceeds the excerpts in Table 21, hence they are not included in the full text for convenience.

Table 21: Excerpts from 10th Grade Chemistry Textbook related to Objective 10.4.1

Issue	Excerpt from the Textbook
Potable Water	<p>...3.4% of the potable water is in glaciers and underground waters.</p> <p>This water cannot be used. Potable water is obtained from lakes and streams that can be used.</p>
Usable Water Sources	<p>The amount of freshwater in lakes and streams today is approximately 8000 km³. The total amount of freshwater that is used in the world in a year is approximately 3800 km³. 70% of this water is used in agriculture, 20% in the industry and 10% is used in residences.</p>
Limitations of Usable Water Sources	<p>The freshwater sources on Earth are decreasing every day due to reasons such as excessive population increase, unplanned urbanization, and industrialization. Consequently, the risk of droughts is increasing. The only way to reduce this risk is to use the existing sources efficiently, and to save water. Because nature cannot produce new water. The existing water is in constant transformation.</p>

Table 21 (Cont'd): Excerpts from 10th Grade Chemistry Textbook related to Objective 10.4.1

Issue	Excerpt from the Textbook
Water Cycle	This infinite loop provides the water that is necessary for life in various freshwater environments and on land. However, population increase is causing a reduction in freshwater sources in rivers, lakes, and underground waters. This reduces the amount of water that participates in the cycle.
Urbanization	The continuous devastation of the flora and increased urbanization is also reducing the amount of water that feeds underground sources.
Raising Awareness	This is why the water, which is vitally important for living beings, has to be protected.
Water Conservation	Stopping the water that spills at a rate of one drop per second, saves one ton of water in a year.

Environmental

Harming the flora could result reduce the amount of water that feeds the underground water sources. The damage to the environment would result in damaging the water cycle. Hence protection of the environment is necessary to the preservation of water (Yıldız & Sümer, 2014, p. 188).

Economic

Excessive population increase, unplanned urbanization, and industrialization are listed as reasons for the limitation of freshwater, and the growth in these areas are shown as a risk of droughts (Yıldız & Sümer, 2014, p. 187). The concepts of population growth and industrial development reflect the economic dimension of the SD. Furthermore, the economic benefits of saving water in our homes and schools are provided in the textbook besides many tips to save water (Yıldız & Sümer, 2014, pp. 188-189).

Social

Raising awareness for the protection of water sources and promoting water conservation through informing the society is necessary for SD (Yıldız & Sümer, 2014, pp. 187-188). Providing information about positive effects of water conservation and encouraging students to save water reflects the social dimension of SD.

As a result, *Objective 10.4.1* successfully reflects the environmental, economic, and social dimensions of SD.

Next objective in this unit that reflects ESD is related to raising awareness about the issues that come with processed foods. The objective and objective annotation is given;

10.4.4. Acts sensibly when selecting processed foods.

- a. The differences between processed foods and natural foods (preservatives, colorants, emulsifiers, flavorings, pasteurization, processing of UHT milk, etc.) are briefly mentioned.*
- b. Additive codes that are used on food labels are associated with the type of additive. The importance of the manufacturing and expiration dates on the labels of processed foods is emphasized. (MoNE Commission, 2013, p. 21)*

The textbook includes four excerpts related to *Objective 10.4.4* and they are listed in *Table 22* on the next page.

Table 22: Excerpts from 10th Grade Chemistry Textbook related to Objective 10.4.4

Issue	Excerpt from the Textbook
Development Rate	Reasons such as rapid population increase, industrialization, the fact that women are more active in the business world, the heavy pace of work, and children spending more time at school increased the demand for convenience foods. Increased demand for convenience foods led us away from natural foods.

Table 22 (Cont'd): Excerpts from 10th Grade Chemistry Textbook related to Objective 10.4.4

Issue	Excerpt from the Textbook
Food Additives	The main reason for this is the fact that natural foods spoil rapidly. Additives that are included in convenience foods produce foods that have a long shelf life, with colors and tastes that are made attractive, and that contain more vitamins and nutritional value.
Regulations	It is mandatory to specify the additive contents on the labels of all pre-packaged food products.
Responsibility	We have to pay attention to the expiration dates on the packages of convenience foods. Foods that are past their expiration dates are harmful to our health. Thus, they must not be consumed.

Economic

The increase in the production and consumption of processed food is related to “*population increase, industrialization, the fact that women are more active in the business world, the heavy pace of work, and children spending more time at school*” in the textbook (Yıldız & Sümer, 2014, p. 199). This quote reflects mainly the economic dimension of SD, however, there are elements, such as the role of woman in the workforce and change in the life of school children, that can be related to the social dimension of SD.

Social

The importance of the expiration date and its possible harm to human health are stated in the textbook (Yıldız & Sümer, 2014, p. 205). In addition to this, the regulations about pre-packaged food products are emphasized and the ingredients in processed foods are explained (Yıldız & Sümer, 2014, pp. 200-202). The laws and regulations that govern our lives are related to the social dimension of SD.

Consequently, Objective 10.4.4 is found to be related to economic and social dimensions of SD.

The third objective in the fourth unit is about recycling process of polymeric materials. The objective and objective annotation is given below;

10.4.7. Acquires awareness concerning the use and recycling process of polymeric materials.

- a. The positive and negative characteristics of the use of polymers in various areas are introduced.*
- b. The importance of recycling polymers and recycling symbols are introduced. (MoNE Commission, 2013, p. 21)*

The textbook includes eight excerpts related to *Objective 10.4.7* and listed in *Table 23*.

Table 23: Excerpts from 10th Grade Chemistry Textbook related to Objective 10.4.7

Issue	Excerpt from the Textbook
Pollution	Polymeric materials cause some harmful toxic effects on human health, in addition to causing environmental pollution.
Regulations	Plastic materials that are used in food packaging may cause interactions between the food and the plastic packaging. This is why the food-contacting plastic material must not leak the food, must not change its color, odor, and taste, and has to have the proper physical and mechanical properties for the storage and handling conditions. Food-contacting plastic materials have to have a structure that does not break, tear, or deform easily. Some plastics that contain vinyl chloride are carcinogens. Thus, their contact with foods has to be avoided.
Ecology	Environmental pollution caused by plastic waste materials also cause adverse effects on humans and other living beings.
Greenhouse Effect	The dioxin gas that is released when plastic materials are combusted is a hazardous material and causes the greenhouse effect.

Table 23 (Cont'd): Excerpts from 10th Grade Chemistry Textbook related to Objective 10.4.7

Issue	Excerpt from the Textbook
Awareness	Do people know that a plastic bottle that is left in nature does not degrade for a thousand years?
Recycling	Recycling prevents waste materials from polluting the environment, reduce raw material requirements, and allow energy savings.
Waste	Plastic materials degrade at very high temperatures. Additionally, they are quite resistant to UV radiation. Natural microorganisms degrade plastic materials only very difficultly. This is why each plastic material that is left in nature pollutes the environment. The production of plastic materials is increasing every day. This substantial increase parallels the consumption. This, in turn, causes the polymer waste material problem. This is why it is necessary to recycle polymer waste materials that pollute the environment.
Regulations	The numbers in the logos of plastic materials indicate the polymer that constitutes the plastic. They also provide information about the recycling method of the plastic material.

Environmental

The plastic materials that are thrown into the ground will not disappear for many years and it causes environmental pollution. The pollution resulting from the polymers affect the ecosystem as a whole. Additionally, the combustion of these materials would result in greenhouse gases (Yıldız & Sümer, 2014, p. 219).

Economic

The consumption of polymers increased with the industrialization, however, there are attempts to control and reduce the production of polymers. This is done through recycling; hence the plastic materials must carry a logo to represent its recycling properties.

Furthermore, the decomposition times of some materials are listed in the textbook. (Yıldız & Sümer, 2014, p. 222).

Social

The social dimension of SD is represented in the textbook with the responsibility to recycle the polymer and awareness to the recycling labels of the polymers (Yıldız & Sümer, 2014, p. 222).

As a result, this objective represents all the dimensions of SD.

The fourth objective in this unit is about the stationeries such as paper, pen, ink, and adhesives that we use in the school environment and in our daily life.

10.4.10. Acquires awareness concerning the structures and proper usage of stationeries.

- a. Paper, pens, erasers, inks, chalks, and adhesives are emphasized as examples of stationeries.*
- b. A performance homework about paper manufacturing is assigned.*
- c. The fact that old papers may generate degradation products that are harmful to health is mentioned.*
- d. The compositions of inks that are used in printing are associated with their harmful effects.*
- e. The compositions of other stationeries are associated with their potentially harmful effects. (MoNE Commission, 2013, p. 22)*

Table 24 lists the excerpts that found to be related to *Objective 10.4.10* taken the textbook.

Table 24: Excerpts from 10th Grade Chemistry Textbook related to Objective 10.4.10

Issue	Excerpt from the Textbook
Forests	Given the fact that forests take a long time to grow, even just the paper industry may cause the forests to be depleted. This is why the worldwide paper industry is increasingly steering toward non-wood sources every day.

Table 24 (Cont'd): Excerpts from 10th Grade Chemistry Textbook related to Objective 10.4.10

Issue	Excerpt from the Textbook
Alternative Sources	These sources include the stems of annual plants such as hay, reeds, hemp, tobacco, and sunflower. Among a very wide variety of plants, only hay, reeds, and hemp succeeded in being economically used.
Forests	We need trees for paper production. Trees carry out photosynthesis and contribute to the energy conversion between living beings. This maintains life.
Pollution	The liquid and gaseous waste materials that are released during production that affect environmental pollution also have to be considered for the reuse of old papers.
Recycle	We have to be aware that we are contributing to the energy conversion in nature through our recycled paper production project homework. Raw materials are decreasing due to paper production. Factories in the paper production industry recycle old and waste papers and obtain paper pulp from these papers. This provides an economical solution for the market.
Recycling	However, we must not forget that if old and waste papers are not used through paper pulp recycling, the trees that are our source of oxygen have to be used for raw materials.
Water Pollution	This white wastewater is causing water pollution in the area, albeit in a small amount.
Air Pollution	The excessive use of chemical substances that are used to degrade old papers may cause air pollution and unpleasant odors.
Petroleum Based Solvents	Petroleum-based solvents are used in printing, just like in almost all industries today. Solvents that may be harmful to human health and to nature, are restricted in almost all developed countries.

Table 24 (Cont'd): Excerpts from 10th Grade Chemistry Textbook related to Objective 10.4.10

Issue	Excerpt from the Textbook
Quality of Life	These effects are ill-health effects that disrupt the people's quality of life and sometimes reduce the length of life.
Human Health	It is known that materials that are treated with azo dyes can cause diseases in humans after prolonged contact with the body.
Human Health	Prolonged contact with nickel-containing substances causes skin irritation and allergies.
Regulations	Toluene, acetone, benzene, halogenated solvents, and similar substances, that are used to dilute dyes in the industry, and that can evaporate very quickly, and adhesive substances are still being sold and used, despite being prohibited by the Ministry of Health. Therefore, it is important to pay attention to the presence of at least one of TSE or CE signs on the product.

Environmental

The consumption of trees in the production of paper and the deforestation problem are found to be the problems that reflect the economic dimension of SD: Besides production, the recycling process of paper is explained and the polluting effects of using excessive use of chemicals on the quality of air and water are mentioned (Yıldız & Sümer, 2014, pp. 235,240,241).

Economic

Alternative sources for paper production are being investigated and hay, reeds, hemp, tobacco, and sunflower are listed as alternatives in the paper production industry (Yıldız & Sümer, 2014, p. 240).

Social

Quality and length of life are mentioned in the explanation of the effects of solvents used in the production of some stationaries which reflects the social dimension of SD (Yıldız &

Sümer, 2014, p. 241). Furthermore, the production and marketing of stationaries, especially the halogenated solvent-based adhesives, are regulated by the Ministry of Health. Allergies and skin irritation are listed as some of the health problems resulting from the usage of azo dyes (Yıldız & Sümer, 2014, p. 242).

The excerpts that are taken from the textbook support that *Objective 10.4.10 successfully* represents environmental, economic, and social dimensions of SD.

Following objective in the fourth unit is about the effects of fertilizers on the environment and it is expected to include not only environmental dimension but also economic and social dimensions of SD. The objective and objective annotations are given below;

10.4.11. Examines the compositions, functions, and environmental effects of fertilizers.

- a. Macro-micro nutrients are explained with examples.*
- b. Ammonium sulfate and diammonium phosphate (DAP) fertilizers are investigated as examples of chemical fertilizers.*
- c. The effects of chemical fertilizers on the environment are examined.*
(MoNE Comission, 2013, p. 22)

Table 25 list the excerpts found to be related to *Objective 10.4.11* in the textbook.

Table 25: Excerpts from 10th Grade Chemistry Textbook related to Objective 10.4.11

Issue	Excerpt from the Textbook
Soil Quality	The most vital component of soil quality for agriculture is the number of organic materials and microorganisms in the soil. Scientists emphasize that the living beings in the soil are important for soil fertility. Soil microorganisms need nutrition and energy to stay alive. The primary source of nutrition for soil microorganisms is organic materials. The amount of organic materials in a soil is proportional to its agricultural production capacity.

Table 25 (Cont'd): Excerpts from 10th Grade Chemistry Textbook related to Objective 10.4.11

Issue	Excerpt from the Textbook
Sustainability and Continuity	<p>Sustainability and continuity are essential in agriculture. Ensuring that the productivity of agricultural lands do not decrease depending on weather conditions, and climate and soil types of the region, and to increase the quality of the crops that are grown give rise to different nutritional requirements. The fact that organic fertilizers take a long time to form, the transportation of the existing fertilizers, the fact that their structures vary, and that their effect is not permanent led people to seek novelties.</p>
Water Conservation	<p>The fact that the Earth's water sources are at a critical level and the rise in people's environmental awareness made using conventional irrigation and fertilization methods inevitable. These practices are monitored in order to preserve natural resources and life.</p>
Responsibility	<p>Insensible use of economically cheaper chemical fertilizers without carrying out detailed research cause some adverse consequences. Chemical fertilizers have to be used with care due to the fact that they threaten human health, cause environmental pollution especially due to chemicals that contaminate the waters, and consequently disturb the natural balance of animals.</p>
Environmental Issues	<p>The harmful effects of chemical fertilization on the environment may be classified as direct and indirect effects. Excessive and prolonged use of chemical fertilizers cause environmental problems such as salification of the soil, accumulation of heavy metals, disruption of the micro-macro nutrient balance, disruption of microorganism activity, eutrophication, nitrate accumulation in waters, release of nitrogen- and sulfur-containing gases into the air, depletion of the ozone layer, the greenhouse effect, etc. The practices that are necessary to eliminate these problems require a lengthy process and significant economic investment.</p>

Table 25 (Cont'd): Excerpts from 10th Grade Chemistry Textbook related to Objective 10.4.11

Issue	Excerpt from the Textbook
Pollution	<p>Chemical fertilizer-induced nitrate pollution in waters, is the subject that requires the most attention. This is because nitrate accumulates due to excessive fertilizer use and descends to deep waters. Excessive nitrate in the waters causes the number of living beings to decrease, stillbirths, miscarriages, many infant diseases and even death.</p>
Eutrophication	<p>Eutrophication is the disruption in the water habitat due to the increase in nitrous and phosphorous compounds in waters. It prevents microorganisms that increase the soil quality from living and reaches deep into the soil to reduce the quality. Additionally, it causes potable water to be contaminated, and odor problems. Another environmental effect of chemical fertilizer use is the accumulation of heavy metals. When chemical fertilizers are used in agriculture, they cause the accumulation of cadmium, lead, nickel, arsenic, and copper in the soil.</p>
Soil Salinity	<p>The salinity of the soil is the amount of soluble salts in a unit volume. The salinity of the soil accumulates through long years of irregular chemical fertilizer use, and it cannot be dissolved. This accumulation converts fertile soils to arid deserts.</p>
Ozone Layer Depletion	<p>Precipitation on soils where high levels of nitrous chemical fertilizers are used cause the formation of ammonia and nitrous oxide gases. The increased amount of these gases in the atmosphere is causing the depletion of the ozone layer. The use of chemical fertilizers is killing worms and other earth grubs.</p>

Table 25 (Cont'd): Excerpts from 10th Grade Chemistry Textbook related to Objective 10.4.11

Issue	Excerpt from the Textbook
Ecosystem	The destruction of these living beings prevents these creatures to move under the soil and aerate the soil and contribute to regulation by eating some of the natural nutrients in the soil.
Regulations	If chemical fertilizers are applied under the supervision of experts, based on analysis results, their adverse effects on the environment and the natural life will decrease.
Organic Fertilizers	Fertilizers with high organic material contents have to be used in order to achieve high productivity while maintaining the quality and vitality of the soils, maintaining the balance of natural life, avoid causing environmental pollution and affecting human health. In conclusion, while chemical fertilizers contribute to production, their improper use damages the environment and the people. The amount and time of application are considered crucial factors in the occurrence of these adverse effects. Since it is not possible to avoid the use of chemical fertilizers, it is obvious that insensible consumption has to be eliminated, and their use has to be supplemented with organic fertilizers.

Environmental

The problems that may arise from using inordinate amount of fertilizers in long periods may cause “such as salification of the soil, accumulation of heavy metals, disruption of the micro-macro nutrient balance, disruption of microorganism activity, eutrophication, nitrate accumulation in waters, release of nitrogen- and sulfur-containing gases into the air, depletion of the ozone layer, the greenhouse effect, etc.” (Yıldız & Sümer, 2014, p. 249). The mentioned problems are discussed in detail however quoted text is enough to understand that the environmental dimension of SD is prevalent in this objective.

Economic

In the textbook, the required practices to eliminate and overcome the environmental problems quoted above depend upon time and economic investment (Yıldız & Sümer, 2014, p. 249). The cost of transitioning from synthetic fertilizers to organic fertilizers is also mentioned in the textbook and it reflects the economic dimension of SD.

Social

The problems caused by the excessive and incorrect usage of fertilizers are explained and our responsibility to shift to organic fertilizers is emphasized. Furthermore, the regulations about using fertilizers under supervision and control are mentioned (Yıldız & Sümer, 2014, pp. 249, 251).

The overall explanations provided in this section related to *Objective 10.4.11* reflects the environmental, economic, and social dimensions of SD.

The last objective in the fourth unit is about air, water, and soil pollution. The objective and objective annotations are given below;

10.4.13. Explains the causes of air, soil, and water pollution, and offers solutions.

- a. Nitrous oxides and sulfurous oxides are examined as air pollutants.*
- b. The greenhouse effect and ozone depletion in the atmosphere are examined.*
- c. Organic liquids, heavy metals, and industrial waste materials are examined as examples of water pollutants.*
- d. Plastics, batteries, and industrial waste materials are examined as examples of soil pollutants. (MoNE Commission, 2013, p. 22)*

Environmental Chemistry section has a subsection called *Air, Water and Soil Pollution* and each pollution is explained in detail by including environmental, economic, and social dimensions.

Some of the texts that are excerpted from the *Environmental Chemistry* section in the fourth unit of the 10th grade textbook are listed in *Table 26*. There is more content related to ESD in the textbook since the section is dedicated to ESD, however, complete texts are not included for convenience.

Table 26: Excerpts from 10th Grade Chemistry Textbook related to Objective 10.4.13

Issue	Excerpt from the Textbook
Pollution	Environmental pollution is a term that people frequently encounter today. Since the phenomenon that lends this term its meaning can be constantly observed, every person has an image associated with this term in their minds. What do you think of when you hear the term ‘environmental pollution’?
Environment	For some people, this term means the clouded color of the sea and the garbage that floats over it; for others, it is the air that they have difficulty inhaling in winter; for some it is the garbage on the ground, for others it is the depletion of the ozone layer and the climate changes that may be caused by the carbon dioxide that is accumulated in the atmosphere. Sadly, it is possible to multiply these examples.
Human Activity	As a general definition, the environment means the space in which living and non-living beings coexist, interact, and communicate. While the activity of humans is a factor that affects the environment in all its aspects, the soil, water, and air that is polluted due to human activities will threaten humans and will not allow them to live.
Policy Making	Environmental problems begin with air, water and soil pollution and extend to climate changes, and caused countries to sign agreements that obligate them to comply with various environmental regulations such as the Kyoto Protocol.
Industrialization	The main reason of today's environmental problems is based on the desire to produce and consume more in order to respond to the needs that increase in parallel to advances in science and technology.

Table 26 (Cont'd): Excerpts from 10th Grade Chemistry Textbook related to Objective 10.4.13

Issue	Excerpt from the Textbook
Air Pollution	Air pollution in our country can be examined in three groups, based on its source:
Improper Use	Air pollution due to residential heating is mainly due to the widespread use of low-calorie and high-sulfur coals for heating. Improper combustion techniques and incomplete combustion cause a high level of air pollution, especially in winter.
Industry	Air pollution due to industrial activity is caused by improper location selection for establishing industrial facilities, not taking the necessary measures to protect the environment (lack of flue filters, treatment facility, etc.), and the fact that the fuels used for energy in production have a high sulfur content.
Transportation	The exhaust fumes from motorized vehicles, the numbers of which rapidly increase in line with the increase in population and income levels, are a crucial factor in the air pollution due to motorized vehicles.
Prevention	What may be the measures that can be taken to reduce the factors that cause air pollution? First of all, solar energy, wind energy, and geothermal energy sources have to be given priority instead of fossil fuels. Increasing green areas has to be included in plans while establishing industrial facilities. Industrial waste materials have to be prevented from being released into the air without being adequately filtered. Inspections in urban areas have to be increased in order to reduce pollution due to vehicle exhausts, and the use of public transportation has to be encouraged. The destruction of forests has to be prevented, and the speed of forestation efforts has to be increased.

Table 26 (Cont'd): Excerpts from 10th Grade Chemistry Textbook related to Objective 10.4.13

Issue	Excerpt from the Textbook
Greenhouse Effect	<p>Carbon dioxide, methane, water vapors and some other gases in the atmosphere retain the heat that is reflected from the Earth and maintain the Earth's temperature. Just like the glasses in a greenhouse keep plants warm, these gases keep the Earth warm. This natural phenomenon is called the greenhouse effect. If these gases were not present, the Earth's temperature would be 30 °C lower than it is today. The consumption of fossil fuels in various areas increases the amount of carbon dioxide and other greenhouse gases (methane, ozone, nitrous oxides) in the atmosphere. This, in turn, increases the greenhouse effect.</p>
Global Warming	<p>Consequently, global warming, the increase in the average temperatures of the Earth's atmosphere and oceans, occurs. Global warming has caused significant changes in the Earth's climate. As observed in recent years, when there are excessive droughts in one-part, excessive precipitation and natural disasters occur in other parts. The exhaust fumes that interact with sunlight, transform into ozone and nitrogen dioxide within clouds of smoke that consist of polluted air.</p>
Ozone Pollution	<p>Consequently, an ozone pollution occurs in parts of the atmosphere that are closer to the surface. Ozone's contribution to the greenhouse effect in global warming is approximately 7%.</p>
Ozone Layer Depletion	<p>Chlorofluorocarbon (CFC) gases that are used in refrigerators, air conditioners, deodorants and in plastic production interact with ozone in the atmosphere and cause the depletion of this layer</p>
Ecology	<p>The depletion of the ozone layer causes harmful radiation from the sun, such as ultraviolet radiation, to reach the earth. This radiation that reaches the Earth's surface adversely affects all living being, particularly the humans. For example, it damages plant leaves and phytoplanktons. It causes skin cancers and cataracts and reduced immune resistance in humans.</p>

Table 26 (Cont'd): Excerpts from 10th Grade Chemistry Textbook related to Objective 10.4.13

Issue	Excerpt from the Textbook
Future Generations	<p>What is important here is to hand over our water resources to future generations in a usable form. The main goal is not to pollute the water and clean it afterward, but to use water without polluting it or by minimizing pollution.</p>
Development	<p>The rapid population increase and the continuous growth of industry in our country result in a need for more clean and high-quality water. The most effective use of water sources is only possible through planned action.</p>
Human Activity	<p>When all three factors are considered, humans are the most crucial factor that causes the ecological balance of water to be disrupted.</p>
Responsibility	<p>What measures can we take in order to protect our water sources, which are vitally important?</p>
Industry	<p>First of all, the number of wastewater treatment plants have to be increased. The areas that feed spring waters and the springs have to be protected. Industrial facilities have to be relocated away from residential areas, and industrial waste materials have to be dumped in the environment only after passing through treatment facilities.</p>
Responsibility	<p>As individuals, we have to increase our awareness for environmental protection, and we have to warn people around us not to pollute waters. Agricultural pesticides have to be used according to the recommendations of authorized institutions.</p>
Water Conservation	<p>Water sources have to be protected in a manner that will prevent the entry of people and animals from outside.</p>

Table 26 (Cont'd): Excerpts from 10th Grade Chemistry Textbook related to Objective 10.4.13

Issue	Excerpt from the Textbook
Heavy Metal Deposition	<p>Industrial organizations prefer plains where transportation is better and water sources are plentiful. This causes industrial pollution. Harmful effects such as cyanide, arsenic, salification are observed in underground waters near industrial facilities. Additionally, the chloride, sodium, and bicarbonate concentration in well waters near industrial organizations increase. Solid and liquid waste materials from industrial organizations cause a change of odor and color in waters.</p>
Soil Pollution	<p>Soil is the general name given to the combination of solid, liquid, and gaseous substances at certain ratios, that contain the wide variety of creatures, and that is the nutrition source of plants. 1 cm thick soil may be formed in centuries. It is very difficult to recover the soil that is lost.</p>
Reasons of Soil Pollution	<p>Factors causing soil pollution are the following:</p> <p>Excessive and insensible use of agricultural pesticides and synthetic fertilizers disrupt the soil structure and decrease plant productivity. A significant amount of cultivable land is disappearing due to land erosion. Waste materials from industrial facilities that are dumped on the soil pollute the environment. Radioactive waste materials, which are waste materials from nuclear energy, are causing environmental problems in the world. Gases such as sulfur dioxide, etc. harm the soil and soil creatures due to the acid rains they form in the atmosphere. In recent years, residential wastes are being collected in landfills, mixed with the soil, and consequently cause pollution. Municipalities must establish waste disposal units.</p>
Prevention	<p>What are the practices that can be implemented in order to prevent soil pollution?</p>

Table 26 (Cont'd): Excerpts from 10th Grade Chemistry Textbook related to Objective 10.4.13

Issue	Excerpt from the Textbook
Responsibility	The awareness of individuals and organizations has to be raised in order to recycle residential waste materials. The destruction of forest, prairie and pasture areas has to stop, forestation has to speed up, and the necessary measures have to be taken against forest fires. Improper cultivation of the soil, excessive use of agricultural pesticides and fertilizers have to be prevented. Soils that have a high erosion risk must not be used for agriculture and have to be protected.
Development	Researching the root cause of environmental problems reveals the people's ambition and desire to consume, and to produce as they consume. Polluted air that cannot be inhaled, water that is so polluted that it cannot be drunk or used, soil that is so polluted that it is not possible to live upon, adversely affect the lives of humans and other creatures.
Soil Pollution	Plastics have some advantages over metal, wood, and paper. These advantages are the versatility, lightness, durability, cheapness, and water-resistance of plastics. However, their durability causes them to accumulate in the soil. This accumulation causes soil pollution. Most plastics are not sustainable because they are manufactured from fossil fuels. PET bottles, which are the most common plastic materials, can continue existing in the soil even after 100 years, if they are not recycled. Thus, using degradable bioplastic materials prevents this pollution in the soil.
Ecology	Ecological balance is like a chain, it connects all living creatures. If a link is broken, both the first and the last link are affected. The most important reason for the disruption of the ecological balance is, doubtless, humans. The ecological balance that is disrupted more every day is causing environmental problems.
Responsibility	Raising awareness in new generations about environmental pollution may prevent this. It is up to us to clean the world, as we have polluted it.

Environmental

Throughout the *Air, Water and Soil Pollution* subsection, air, water, and soil pollution are discussed consecutively. Definitions for the environment and environmental pollution are given, and causes of air, water and soil pollution are extended. Greenhouse effect, global warming, ozone pollution, ozone layer depletion are the main subjects reviewed in air pollution part of the subsection. In the water pollution part, heavy metal deposition, water cycle, water conservation, and biodiversity are discussed. The environmental pollution and its effects on ecology are explained (Yıldız & Sümer, 2014, pp. 262-271).

Economic

Industrialization, population growth, and unsustainable development are introduced as the main reasons for environmental pollution, and their effects on air, water and soil pollution are explained in detail. Consumption and production patterns in energy, agriculture, and industry are explained and efficient usage of sources are promoted (Yıldız & Sümer, 2014, pp. 262-271).

Social

The effect of pollution on human health is mentioned throughout the subsection. Human activity on the planet and the results of these activities stated as one of the main reasons of the global problems we face. Our responsibility to prevent these pollutions from occurring and to find solutions to fix the current pollution in the environment are emphasized. Taking global action through policymaking is exemplified by the Kyoto Protocol. The concept of sustainability is explained by the mention of future generations. (Yıldız & Sümer, 2014, pp. 262-271).

Hence, *Objective 10.4.13* reflects the environmental, economic, and social dimensions of SD.

The detailed investigation of 10th grade textbook shows that ESD related content of the textbook matches and supports the ESD related objectives in the curriculum and the objectives in the 10th grade is condensed in the fourth unit, *Chemistry is Everywhere*.

4.2. ESD Related Objectives in the Advanced Level Chemistry Curriculum and the Corresponding Content in the Textbooks

Secondary School Chemistry Curriculum of Turkey (2013-2018) has ESD related general aims in the curriculum, however, there is not any ESD related objective in the Advanced Level Chemistry Curriculum (2013-2018) that could support the general ESD related aims of the Secondary School Chemistry Curriculum. Nevertheless, the 11th and 12th grade textbooks include brief information that is related to ESD. The excerpts taken from the textbooks are analyzed separately.

4.2.1. 11th Grade

11th grade has six units and a total of 46 objectives, however, there is not any ESD related objective or objective annotation in the curriculum for 11th grade and it is reflected in *Table 27*.

Table 27: Distribution of ESD Related Objectives into the units of 11th Grade Chemistry Curriculum of Turkey (2013-2018)

Name of the Unit	Number of Objectives	Number of ESD Related Objectives
Modern Atom Theory	8	0
Stoichiometry	4	0
Gases	5	0
Solutions	7	0
Chemistry and Energy	8	0
Rate and Equilibrium in Reactions	14	0
TOTAL	46	0

Even though there is not any ESD related objective in 11th grade, the textbook includes brief information and they are listed in *Table 28*.

Table 28: Excerpts from 11th Grade Chemistry Textbook related to ESD

Issue	Excerpt from the Textbook
Harmful Gases	<p>However, due to the toxic effect of NH_3, and after it was understood that CCl_2F_2 is damaging the ozone layer, the use of these substances as coolant fluids was discontinued.</p>
Coolant Fluids	<p>Some of the desired features of substances that are used as coolant fluids in many devices, particularly refrigerators and vehicle and home air conditioners are:</p> <p>It must not damage the environment, it must not be toxic and flammable. Its energy consumption must be low.</p>
Greenhouse Gases	<p>How does the change of the composition of some gases (such as CO, CO_2, SO_2) in the atmosphere due to industrial and technological advances affect human health and nature? Research. Share the information you acquired with your friends.</p>
Water Pollution	<p>A polluted water sample was found to contain 1.8 ppm of KCN. Based on this, how many mg of KCN does a 5 liters sample of polluted water?</p>
Water Distillation	<p>The reverse osmosis method, which was initially very expensive was only used to obtain potable water from seawater. Newly developed manufacturing methods reduced the cost of water that is produced through reverse osmosis, and the technology entered our homes, under the sink.</p>
Thermal Pollution	<p>Thermal pollution means the harmful effects of the heat that is produced and released into the environment during industrial processes. Oxygen is less soluble in the warm water that is ejected from power plants. Additionally, since warm water is less dense, this water ascends to the surfaces of rivers and prevents oxygen's absorption, and transfer to cool water. Thus, the water acts like a suffocating blanket for its creatures. Consequently, water creatures (especially fish) may die.</p>

Table 28 (Cont'd): Excerpts from 11th Grade Chemistry Textbook related to ESD

Issue	Excerpt from the Textbook
Solar Energy	The image to the side shows that some of a residence's energy requirements can be provided by solar energy. Research other energy sources that do not disrupt the ecological balance and that may provide alternatives to fossil fuels. Arrange your research into a poster and post it in a suitable area in your classroom.
Energy Sources	Graph 5.1 displays the types of energy that have been used on Earth in the time period between 1950 and 2010 (Data from the international energy agency).
Efficiency	Based on this, the heat that is released when carbon monoxide is formed by carbon's combustion with inadequate air. The heat that is released when carbon dioxide forms by its complete combustion with adequate air. Since the heat that is obtained from fossil fuels is very important, it is imperative to establish the conditions that will allow these fuels to be fully combusted.
Human Health	Furthermore, the fact that carbon monoxide gas that forms in an incomplete combustion environment is very harmful to human life must not be forgotten. It is well known that carbon monoxide gas causes poisoning.
Water Cycle	The natural balance of water is very important for life.

In the third unit, *Gases*, NH_3 and CCl_2F_2 are stated as harmful gases for the environment, and the damaging effect of CCl_2F_2 on the ozone layer is mentioned (Bilenler, 2016, p. 168). The effects of CO , CO_2 , and SO_2 which are greenhouse gases are not directly given but presented as a research homework for students to work on by themselves (Bilenler, 2016, p. 171).

In the fourth unit, *Solutions*, there is an example about finding part per million concentration for a solution containing KCN with the information that it is a water pollutant

substance (Bilenler, 2016, p. 205). In addition to this, thermal pollution and its effect on ecology and animals are explained while explaining the solubility of gases (Bilenler, 2016, p. 220).

In the fifth unit, *Chemistry and Energy*, solar energy and its advantages over fossil fuels are asked as a research homework (Bilenler, 2016, p. 258). The same unit has information related to inefficient consumption of fossil fuels are given with a graph displaying the types of energy that have been used in between 1950 and 2010. The graph is given in *Figure 6* on the next page. In the same part, CO that result from the incomplete combustion of fuels is given as a harmful gas for human health (Bilenler, 2016, p. 263).

In the last unit, *Rate and Equilibrium in Reactions*, the water cycle is very briefly mentioned (Bilenler, 2016, p. 327).

The analysis of 11th grade chemistry textbook resulted in ESD related information, however, the curriculum does not have ESD related objectives in the 11th grade.

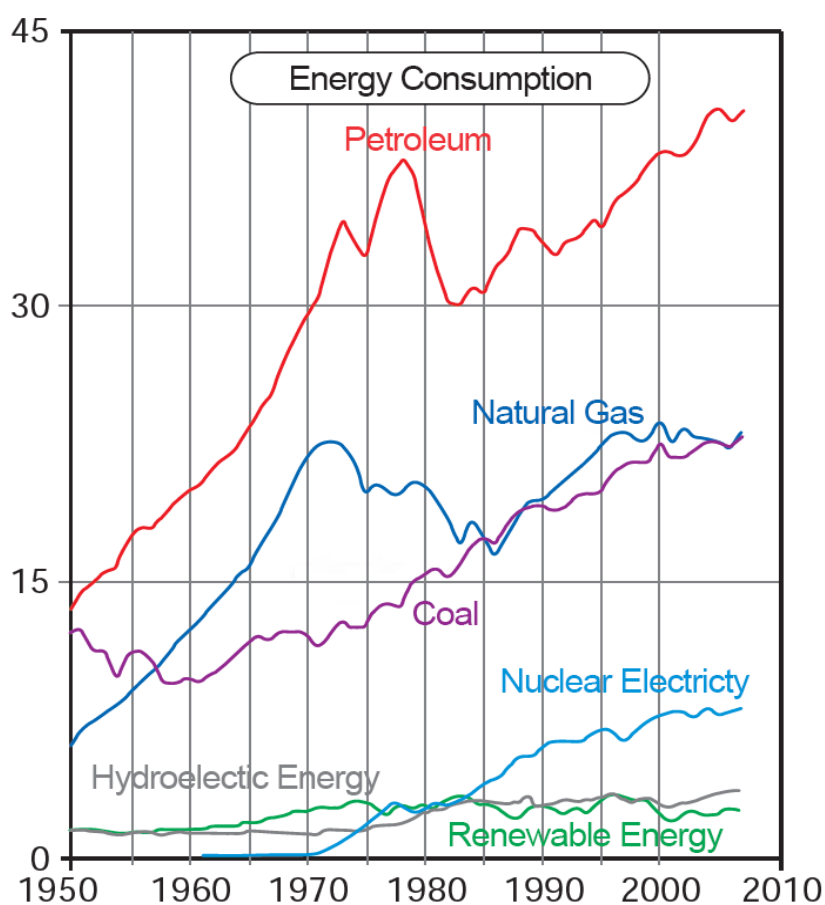


Figure 6: Consumption of different energy types (Bilenler, 2016, p. 327)

4.2.2. 12th Grade

12th grade has four units and a total of 37 objectives, however, there is not any ESD related objective or objective annotation in the curriculum for 12th grade and it is reflected in *Table 29*.

Table 29: Distribution of ESD Related Objectives into the units of 12th Grade Chemistry Curriculum of Turkey (2013-2018)

Name of the Unit	Number of Objectives	Number of ESD Related Objectives
Chemistry and Electricity	9	0
Introduction to Carbon Chemistry	7	0
Organic Compounds	14	0
Chemistry in Everyday Life	7	0
TOTAL	37	0

Even though there is not any ESD related objective in 12th grade, the textbook includes brief information and they are listed in *Table 30*.

Table 30: Excerpts from 12th Grade Chemistry Textbook related to ESD

Issue	Excerpt from the Textbook
Regulations	The use of the compound dichloromethane in the food industry is discontinued because it is a harmful substance.
Methanol	Methanol is one of the substances that are under consideration for use as an alternative fuel in the future. Studies are carried out in order to use methanol, which is not yet widely adopted as a fuel, as an alternative fuel in the future.

Table 30 (Cont'd): Excerpts from 12th Grade Chemistry Textbook related to ESD

Issue	Excerpt from the Textbook
Ethanol	Ethanol is also used as a biofuel due to its adequate energy efficiency. The fuel that is obtained from ethanol is called bioethanol. The raw materials for bioethanol are sugar-, starch-, and cellulose-containing agricultural products such as corn, sugar cane, and wheat. Ethanol is formed when these plants are fermented. The ethanol that forms is mixed with gasoline in certain amounts to obtain bioethanol fuel.
Bioethanol	Bioethanol may be of particular use in the transportation industry, it allows the fuel to which it is added to be combusted more efficiently and reduces the release of harmful gases. It is predicted that bioethanol will become one of the important fuels in the future.
Limited Sources	Petroleum is without a doubt one of the most important energy sources today. It is not only an energy source but also a very important raw material that is used to produce many industrial products. Unfortunately, this valuable resource that takes thousands of years to form is diminishing each passing day. However, it is still brought up from underground at full speed.
Petroleum Reserves	While we have enough petroleum for our current demand, the amount of petroleum diminishes every year because it is not a renewable resource. Recent data indicate that the petroleum resources will be depleted in approximately 50 years.

In the third unit, Organic Compounds, while explaining the properties of alkanes with examples, dichloromethane is given as an example. An information box is included right next to this topic with dichloromethane's limitation to use in the food industry since it is a harmful substance (Yıldız M. , 2017, p. 134). In the same unit, there is information about both methanol and ethanol, and Bioethanol is stated as cleaner alternatives to fossil fuels (Yıldız M. , 2017, pp. 170,171).

At the end of the third unit, a reading text titled *Sweet Sorghum the Carbohydrate Warehouse: A Clean Fuel Source* introduces sweet sorghum plant as a cleaner alternative to fuel. In the text, the increase in population, unsustainable development and drastic harm done on the environment are mentioned (Yıldız M. , 2017, p. 213). *Figure 7* on the next page shows the complete text of the reading at the end of the third unit.

The analysis of 12th grade chemistry textbook resulted with ESD related information, however, the curriculum does not have ESD related objectives in the 12th grade.

**SWEET SORGHUM THE CARBOHYDRATE WAREHOUSE:
A CLEAN FUEL SOURCE**

Due to the increasing population and the advancing technology, the number of vehicles in our world is increasing daily. The fuel demand is increasing accordingly. While electric vehicles were introduced in recent years, they are not yet widely adopted. Thus, most of the fuel that is used for motorized vehicles is petroleum-based. Which means that they are fossil fuels. Considering the fact that fossil fuels are not an unlimited resource, and the damage that they inflict on the environment, it is obvious that we have to steer toward alternative clean fuel sources. Sweet sorghum has many varieties, and it is an annual plant that is suitable for Turkey's climate conditions. Its rich carbohydrate content allows it to be used in the production of ethyl alcohol. Ethyl alcohol is a biofuel that is considered as an alternative to gasoline. While it is possible to obtain fuel by producing ethyl alcohol from the sweet sorghum plant, which is also used as food, it is also possible to obtain energy by combusting this plant. The plant contains high amounts of sugar in its stem. Approximately 70% of this sugar is sucrose, and the rest consists of glucose and fructose. The fermentation of these substances results in ethyl alcohol, and it is used as a fuel. The remaining pulp of the plant can be used in various areas in the industry, in addition to electricity generation. Using the fuel that is obtained from sweet sorghum will significantly reduce the amount of carbon dioxide that is released into the atmosphere. In line with its wide production in Brazil, its use in vehicles in Brazil is much more widespread than other countries. The sweet sorghum production in our country is not adequate, and we cannot yet benefit from this plant as a fuel (Written for this book.)

Figure 7: Reading text (Yıldız M. , 2017, p. 213)

CHAPTER 5

DISCUSSION & CONCLUSION

This chapter presents a discussion of and conclusions drawn from the study findings in the first section, followed by the implications of these findings in the following section. Recommendations for further studies and suggestions to policymakers and content developers can be found in the last section.

5.1. Discussions & Conclusions

The discussion and conclusion of the content analysis of Secondary Science Chemistry Curriculum of Turkey (2013-2018) for the objectives and the objective annotations are presented in first subsection with reference to the *Research Question 1*. The conclusions of the content analysis of ESD related objectives of the curriculum in the light of environmental, economic and social dimensions of SD are stated by discussing the need for implementation of all the dimensions into the curriculum in light of *Research Question 2* in the following subsection. The conclusions of the content analysis of chemistry course textbooks of 9th, 10th, 11th and 12th grades are stated in this section by discussing the lack of ESD related objectives in Advanced Level Chemistry Curriculum with reference to *Research Question 3* in the third subsection.

5.1.1. ESD Related Objectives in the Chemistry Curriculum

The list of ESD related objectives found in the Secondary Science Chemistry Curriculum is given in *Table 8* and this answers to the *Research Question 1*. The number of objectives present in the whole curriculum is 155 and the total number of ESD related objectives of the curriculum is found to be 14. *Table 6* illustrates the distribution of ESD related objectives into the two levels of the chemistry curriculum being Fundamental and Advanced Level. The findings show that all of the ESD related objectives are placed in the Fundamental Level of the curriculum. On the other hand, the general aim of Advanced Level includes ESD related knowledge and skills, yet there is a lack of ESD related objectives to reach the stated aims. Hence, ESD related objectives and general aim of

Advanced Level are not in accordance with each other. Considering the fact that both levels have general aims that are in alignment with ESD, either the general aims of Advanced Level need to be reconsidered or the inclusion of ESD related objectives in Advanced Level needs to be improved.

The models proposed by Burmeister et al. (2012) besides Jegstad and Sinnes (2015) could be considered when deciding the ESD implementation route for the Advanced Level. However, improving the inclusion of ESD related objectives in Advanced Level is suggested by integrating of ESD related objectives in Advance Level while considering the availability of chemistry content, the dimensions of SD and knowledge and skills required for ESD.

The distribution of ESD related objectives into the grades of the curriculum is present in *Table 7*. According to our findings, four out of 16 ESD related objectives are in 9th grade, while the remaining 10 objectives are in 10th grade. Hence the inclusion of ESD in 10th grade outweighs 9th grade in number, while there is not any ESD related objectives in 11th and 12th grade. The predominance fourth unit of 10th grade in terms inclusion of ESD becomes evident when the *Table 15* is examined. It shows the distribution of ESD related objectives into the units of 10th grade. As reported in *Table 15*, fourth unit, *Chemistry is Everywhere*, has six ESD related objectives. In light of this findings, it is clear that *Chemistry is Everywhere* operating as a thematic unit that focuses on ESD within Secondary Science Chemistry Curriculum.

Studies recommend holistic approach for the integration of environmental problems into the curriculum (Tilbury, 1995; Berglund, Gericke, & Chang Rundgen, 2014; Burmeister, Rauch, & Eilks, 2012) instead of a thematic unit to cover the ESD related subjects (McKeown & Hopkins, 2003).

Considering that current study is a qualitative analysis of the inclusion of ESD related objectives in the curriculum with respect to the dimensions of SD, it does not provide a concise analysis of the effectiveness or the quality of ESD integration in chemistry education, this is to say, further analysis of the curriculum and objectives are required. The list of ESD related objectives found in the Secondary Science Chemistry Curriculum is given in *Table 8* and it could serve as a data source for further researches. Extending the scope of this research to assess the quality of ESD related objectives could provide a sound

base in the process of establishing ESD in chemistry education in national level. Yet analyzing in-service teachers' classroom applications of the existing ESD related objectives could give insight about the actual ESD relevancy of the curriculum.

5.1.2. Dimensions of Sustainable Development

Before the analysis, my expectation was to find significantly fewer objectives in the curriculum and content in the textbooks that contribute to the economic and social dimensions of SD, based on my preexisting knowledge on chemistry curriculum in Turkey as a recent graduate of chemistry education department. In contrast, the findings uncovered the multidimensional approach to SD, mainly resulting from the comprehensive content of the textbooks.

In order to code the objectives into the dimensions of SD, the issues addressed in Agenda 21 are used to complement the dimensions of sustainable development represented by the interconnected Venn diagram in *Figure 1* and on *Table 1*, *Table 2*, and *Table 3*. The issues addressed in the textbook under each ESD related objectives are discussed in terms of environmental, economic, and social dimensions, and then the objectives were coded with the reflected dimensions. The framework constructed from Agenda 21 is practical yet useful in analyzing complex integration of three dimensions.

Table 10 and *Table 16* lists the ESD related objectives with the dimensions of SD they contribute to, and from the tables it can be concluded that the objectives achieve to address environmental, economic, and social dimensions of SD. However, the degree of reflecting environmental, economic, and social issues in the textbook is discussed in the following section. Yet, there is a need for studies that focus on classroom experiences of teachers and students to assess the relevancy of the curriculum to instruction.

design of the study does not allow us to make any interpretations on the degree of reflecting the dimensions of SD: Hence any comparisons on the integration of dimensions of SD based on *Table 10* and *Table 16* would be baseless, unless the excerpts from the textbooks coded with another research design to answer that particular question.

To get back to the issue at hand, current design of the study answers to *Research Question 2*, and each ESD related objective reflects the environmental, economic, and social dimensions of SD; except for three objectives that reflect at least two dimensions of SD

Implementation of ESD requires a holistic view of environmental, economic, and social dimensions and interplay between these dimensions play a key role in effective implementation (Summers & Kruger, 2003). This is also true for the chemistry education (Burmeister, Rauch, & Eilks, 2012). In the end, the findings of this study represent an integrated approach to the dimensions of ESD in the curriculum and textbook.

5.1.3. Reflections of ESD in the Textbooks

The analysis of the textbooks, in light of ESD related objectives and three dimensions of SD, provide valuable information about the current understanding of economic and social issues besides environmental issues, particularly in secondary school chemistry courses.

According to our findings, 9th grade and 10th grade textbooks are rich in content that address the ESD related objectives of the Fundamental Level Chemistry Curriculum. The highlights of environmental issues addressed in 9th grade textbook are green chemistry, global warming, greenhouse effect, air pollution. The role of chemistry in industry, scientific studies that promotes SD, local economy and job opportunities reflect the economic dimension, while quality of life, food safety, accessible clothing reflect the social dimension. Even though the inclusion of ESD in 9th grade is few in number of objectives in the curriculum, the issues reflected in the textbook is quite diverse in its scope.

When it comes to 10th grade, the inclusion of ESD increases significantly because of the existing ESD related objectives in the 10th grade, especially in the fourth unit. Acid rain and its effects on environments, greenhouse gasses, global warming, ozone layer depletion, pollutant effects of fossil fuel, deforestation, heavy metal deposition on soil and water, biodiversity, ecology, water quality and usable water sources, eutrophication, air, water and land pollution are the issues that reflect the environmental dimension. Soil quality, agriculture, renewable energy sources, energy efficiency, consumption patterns, urbanization, water conservation, development rate, waste management constitutes the economic dimension of SD. Cultural heritage, public transportation, future generations, responsibility, awareness rising, human health, quality of life, policy making, prevention reflects the social dimension in the first three unit of the 10th grade. Even though the textbook is rich in terms of ESD related content, the overemphasis on ESD in the fourth unit reflects the thematic unit approach to ESD instead of holistic approach.

The results of the analysis of 11th and 12th grade is somehow surprising. Since there is not

any ESD related objectives to be found in Advanced Level, it is not expected to see ESD relevant information or remarks to be found in the textbooks. The chemistry content of the 11th and 12th grade shows factual/scientific information, yet the writers of the textbooks included ESD relevant information. Even though both curriculum and the textbook are grounded on advanced chemistry subjects, inclusion of such remarks on ESD related topics and issues reflects the progress that is made towards ESD.

The general ESD related issues addressed in 11th grade are harmful gases, use of coolant fluids, greenhouse gases, water pollution and thermal pollution, solar energy, energy sources, efficiency, and human health. Regulations, alternative energy sources, biogas, limited sources, and petroleum reserves are reflected in 12th grade.

The results of this study show that there are existing structures in 9th grade and 10th grade chemistry curriculum and textbooks that would provide a sound base for further improvement, however inclusion of ESD into Advanced Level of the curriculum is necessary in order to achieve a holistic approach to ESD in the chemistry curriculum.

5.2. Implications

In the following two subsections, implications of conclusion made in the previous section are presented. First subsection deals with the thematic vs. holistic approach to ESD, while the second subsection reemphasizes the need for further improvements in the advanced Level chemistry curriculum.

This study concludes that the current state of Secondary Science Chemistry Curriculum implements ESD through a thematic unit in 10th grade, even though there are other relevant content in 9th grade and other units of 10th grade, the prevailing impressions about ESD inclusion is thematic rather than holistic.

In agreement with Burmeister, Rauch, & Eilks (2012) and UNESCO (2006), ESD for chemistry education should;

Be interdisciplinary and holistic: ESD should be embedded in the entire chemistry curriculum and not merely be presented as a separate topic. (p. 62)

In addition to this, existing objectives in the curriculum are not sufficiently addressing the ESD related aims of the curriculum since there is not any ESD related objectives in the Advanced Level, yet the results of the textbook analysis show that there is a viable ground

in Advanced Level where ESD related content could be placed. As a result, current state of curriculum requires a change in approaching ESD by employing holistic approach as a means for implementation.

5.3. Recommendations

This section presents recommendation for further studies and policy makers.

Secondary Science Chemistry Curriculum of Turkey has been updated at the end of 2017 school year. Starting from 2018 school year, updated curriculum and the renewed textbooks are being used. By employing the similar research design for the analysis of updated curriculum and renewed textbook, a comparative research of the two curricula could be studied. The framework constructed from Agenda 21 is practical yet useful in analyzing complex integration of three dimensions in the curriculum as well as in the textbooks. Considering that current study is a qualitative analysis of the inclusion of ESD related objectives in the curriculum with respect to the dimensions of SD, it does not provide a concise analysis of the effectiveness or the quality of ESD integration in chemistry education, this is to say, further analysis of the curriculum and objectives are required. The list of ESD related objectives found in the Secondary Science Chemistry Curriculum is given in *Table 2* and it could serve as a data source for further researches. Extending the scope of this research to assess the quality of ESD related objectives could provide a sound base in the process of establishing ESD in chemistry education in national level. Yet analyzing in-service teachers' classroom applications of the existing ESD related objectives could give insight about the actual ESD relevancy of the curriculum.

Implementation of ESD is a complex yet rewarding process in order to achieve quality education (Kadji-Beltran, et al., 2017) ESD makes education relevant, hence the education system as a whole would benefit from the progress toward ESD. Initiations towards ESD, by policy change should include all levels and actors of the education system to be considered.

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APPENDIX A

BOARD'S DECISION ON CHEMISTRY CURRICULUM IN ENGLISH

REPUBLIC OF TURKEY
MINISTRY OF NATIONAL EDUCATION
Board of Education and Morality

NUMBER: 11 **DATE:** 01.02.2013
PREVIOUS RULING
NUMBER: 169 **DATE:** 11/10/2007 **SUBJECT:** Secondary School Chemistry Course
 136 03/06/2008 (9th, 10th, 11th and 12th Grades) Curriculum
 289 26/12/2008
 182 20/10/2009

It was decided to accept the Secondary School Chemistry Course (9th, 10th, 11th, and 12th Grades) Curriculum, which was prepared by our Ministry and discussed in our Board, to be implemented in stages according to the attached example, beginning from 9th class,

According to the program;

1. A course textbook shall be prepared,
2. The first review applications for the 9th grade draft course text books shall be made between June 10-17, 2013, those that are approved as course text books by the Board until the end of business day July 31, 2013 Wednesday shall be announced in the Announcements Journal that is published in August 2013,
3. The first review applications for the 10th grade draft course textbooks shall be made between January 16-February 03, 2014, those that are approved as course textbooks by the Board until the end of business day May 30, 2014 Wednesday shall be announced in the Announcements Journal that is published in June 2014,

The Secondary School 9th, 10th, 11th and 12th Grade Chemistry Course Curriculum that were approved with our board's rulings dated and numbered 11/10/2007-169; 03/06/2008-136; 26/12/2008-289; 20/10/2009-182 shall be removed from practice, beginning in the 2013-2014 academic year, and beginning from the 9th grade.

Prof. Emin KARİP

Director of the Board

Nabi AVCI

Minister of National Education

Hüseyin ŞİRİN

Member

Prof. Mehmet BAYYİĞİT

Member

Assoc. Prof. Hatice DURAN

Member

Abdülkadir YILMAZ

Member

Prof. Cengiz ALACACI

Member

İbrahim BÜKEL

Member

İbrahim DEMİRÇİ

Member

Assoc. Prof. Güray KIRPIK

Member

APPENDIX B

BOARD'S DECISION ON CHEMISTRY CURRICULUM IN TURKISH

T.C.
MİLLİ EĞİTİM BAKANLIĞI
Talim ve Terbiye Kurulu Başkanlığı

SAYI: 11 **TARİH:** 01.02.2013
ÖNCEKİ KARARIN
SAYISI: 169 **TARİHİ:** 11/10/2007
136 03/06/2008
289 26/12/2008
182 20/10/2009

SUBJECT: Ortaöğretim Kimya Dersi
(9, 10, 11 ve 12. Sınıflar)
Öğretim Programı

Başkanlığımızca hazırlattırılan ve Kurulumuzda görüşülen Ortaöğretim Kimya Dersi (9, 10, 11 ve 12. Sınıflar) Öğretim Programının, 2013-2014 Öğretim Yılından itibaren 9'uncu sınıflardan başlamak ve kademeli olarak uygulanmak üzere ekli örneğine göre kabulü,

Söz konusu programa göre;

1. Ders kitabı hazırlanması,
2. Hazırlanacak 9'uncu sınıf taslak ders kitaplarının incelenmek üzere Başkanlığa ilk başvurularının 10-17 Haziran 2013 tarihleri arasında yapılması, bunlardan 31 Temmuz 2013 Çarşamba günü mesai bitimine kadar Kurulca ders kitabı olarak kabul edilenlerin, 2013 yılının ağustos ayında yayımlanacak Tebliğler Dergisinde duyurulması,
3. Hazırlanacak 10'uncu sınıf taslak ders kitaplarının incelenmek üzere Başkanlığa ilk başvurularının 16 Ocak-03 Şubat 2014 tarihleri arasında yapılması, bunlardan 30 Mayıs 2014 Cuma günü mesai bitimine kadar Kurulca ders kitabı olarak kabul edilenlerin, 2014 yılının haziran ayında yayımlanacak Tebliğler Dergisinde duyurulması,

Kurulumuzun 11/10/2007-169; 03/06/2008-136; 26/12/2008-289; 20/10/2009-182 tarihli ve sayılı kararları ile kabul edilen Ortaöğretim 9, 10, 11 ve 12. Sınıf Kimya Dersi Öğretim Programlarının 2013-2014 Öğretim Yılından itibaren 9'uncu sınıflardan başlamak üzere kademeli olarak uygulamadan kaldırılması kararlaştırıldı.

Prof. Emin KARİP

Kurul Başkanı

Nabi AVCI

Minister of National Education

Hüseyin ŞİRİN

Üye

Prof. Mehmet BAYYİĞİT

Üye

Assoc. Prof. Hatice DURAN

Üye

Abdülkadir YILMAZ

Üye

Prof. Cengiz ALACACI

Üye

İbrahim BÜKEL

Üye

İbrahim DEMİRCİ

Üye

Assoc. Prof. Güray KIRPIK

Üye