EXAMINING 7th GRADE TURKISH ECO-SCHOOL STUDENTS' MENTAL MODELS OF GREENHOUSE EFFECT

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Approval of the Graduate School of Social Sciences

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I certify that this thesis satisfies all the requirements as a thesis for the degree of Master of Science.

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This is to certify that we have read this thesis and that in our opinion it is fully adequate, in scope and quality, as a thesis for the degree of Master of Science.

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ABSTRACT

EXAMINING 7th GRADE TURKISH ECO-SCHOOL STUDENTS' MENTAL MODELS OF THE GREENHOUSE EFFECT

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The purpose of this qualitative study is to examine 7th grade Eco-Schools students' mental models of greenhouse effect. The sample of this study was comprised of 109 7th grade students attending three Eco Schools in İstanbul. The data were collected by a draw-and-write survey. In this survey, students were asked to draw their understandings of the greenhouse effect and explain their drawings. Their source of information was also asked to the students in the survey. As a result of inductive analysis of students' drawings and explanations, five different mental models emerged: (1) Reasons and Results of Greenhouse Effect, (2) Misconception - Ozone Layer Depletion and Greenhouse Effect, (3) Misconception – Daily Temperature Difference, (4) Scientific Explanation of Greenhouse Effect, (5) Misconception – Greenhouse used for Agricultural Purposes.

Keywords: Climate Change Education, Education for Sustainable Developments, Mental Model, Greenhouse Effect

ÖZ

7. SINIF EKO-OKUL ÖĞRENCİLERİNİN SERA ETKİSİ ZİHİNSEL MODELLERİNİN BELİRLENMESİ

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Bu çalışmanın amacı 7. Sınıf Eko-Okul öğrencilerinin sera etkisi zihinsel modellerinin belirlenmesidir. Bu çalışmanın katılımcıları İstanbul'daki üç Eko-Okulda bulunan 109 7. sınıf öğrencisidir. Veriler yazma/çizme yöntemi ile toplanmıştır. Bu yöntemin uygulanmasında, öğrencilerden sera etkisinin onlar için ne ifade ettiğini çizmeleri ve çizimlerini açıklamaları istenmiştir. Ayrıca bu bilgileri nereden öğrendikleri de sorulmuştur. Öğrencilerin çizim ve açıklamalarının tümevarım analizi sonucunda beş farklı zihinsel model ortaya çıkmıştır: (1) Sera Etkisinin Nedenleri ve Sonuçları, (2) Kavram Yanılgısı – Ozon Tabakası ve Sera Etkisi, (3) Kavram Yanılgısı – Günlük Sıcaklık Farkı, (4) Sera Etkisinin Bilimsel Açıklaması, (5) Kavram Yanılgısı – Tarımsal Amaçlar için Kullanılan Sera.

Anahtar Kelimeler: İklim Değişikliği Eğitimi, Sürdürülebilir Kalkınma için Eğitim, Zihinsel Model, Sera Etkisi

To My Parents

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LIST OF ABBREVIATIONS

CCE	Climate Change Education
DESD	Decade of Education for Sustainable Development
DGVN	United Nations Association of Germany
ESD	Education for Sustainable Development
FAR	First Annual Report
IPCC	Intergovernmental Panel on Climate Change
NFP	National Focal Points
NGO	Non-Governmental Organization
NRDC	National Resources Defence Council
REC	Regional Environmental Center
TURCEV	Turkish Environment Education Found
UNCED	United Nations Conference on Environment and Development
UNDP	United Nations Development Program
UNEP	United Nations Environment Programme
UNESCO	United Nations Education Scientific and Cultural Organization
UNFCCC	United Nations Framework Convention on Climate Change
WCC	World Climate Conference
WCED	World Commission on Environment and Development
WMO	World Meteorological Organization
WSSD	World Summit on Sustainable Development

CHAPTER 1

INTRODUCTION

1.1 Milestones

In the late 1800s, as a consequence of the Industrial Revolution, the world had to face with extreme burning of coal; a Swedish scientist, Arrhenius predicted that the average temperature on the Earth would raise five to six degrees if the carbon dioxide (CO_2) was doubled in the atmosphere (as cited in Houghton, 2005). Thus, atmospheric pollution was started to be discussed. In 1975, Wallace S. Broecker reported that man-made greenhouse gas emissions might cause global warming. This was the first time in the world history, the term "global warming" was used and the reason and results were explained as increase in CO_2 emissions produced by the burning fossil fuels and global temperature changes, climatic fluctuations, respectively. Public was warned by the first World Climate Conference (WCC) in 1979, about activities like burning of fossil fuels, deforestation, changes in land use, increased use of nitrogen fertilizers might change climate regionally or even globally. The importance and the need for an international agreement to find a solution for future global climate change were also emphasized in the conference (DGVN, 1979).

The Intergovernmental Panel on Climate Change (IPCC) was established in 1988 by the United Nations Environment Programme (UNEP) and the World Meteorological Organization (WMO) to provide comprehensive scientific assessments of current scientific, technical and socio-economic information worldwide about the risk of climate change caused by human activity, its potential environmental and socio-economic consequences, and possible options for adapting to these consequences or mitigating the effects. The first annual report (FAR) released by IPCC stressed that the human activities which are responsible for accelerated greenhouse effect might unwittingly cause the global climate changes. Thus, announcing that, unnatural

greenhouse effect causes global warming and then it was recognized that global warming results in climate change (IPCC, 1990).

In 1990, Intergovernmental Panel on Climate Change (IPCC) released three reports on the climate change (the scientific assessment, the impacts assessment, and the response strategies) in order to raise public awareness and to get the attention of media and politicians. Similar reports were followed in 1995, 2001, and 2007 (IPCC, n.d.).

1.1.1 Greenhouse Effect, Global Warming and Climate Change

Global warming refers to negative effects on climate caused by human activities such as, burning of fossil fuels (coal, oil and gas) and large-scale deforestation and has several negative effects on human health, weather patterns, wild life and glaciers and sea levels: (1) Global warming increases ground-level ozone smog production and makes worse local air quality problems and so it causes more violent pollen allergies and asthma. (2) In the past 35 years, the Earth has been exposed to more powerful and dangerous hurricanes (e.g. Hurricane Katrina of August 2005 in U.S.). Because of more energy pumped by warmer water in the oceans, tropical storms have been stronger and also it has more destructive consequences. Increase in temperature exacerbates probability of drought and wildfire especially in summer and fall seasons. (3) Climate change damages ecosystems and triggers extinction of species. (4) Melting of glaciers caps and ice caps speeds up due to raising temperature and it increases the water level on seas, rivers and lakes (NRDC, 2008).

Therefore, global warming needs global precautions. The first international agreement, the importance and necessity of which were mentioned in the FAR, was provided in the United Nations Conference on Environment and Development (UNCED) (generally known as the Earth Summit) in Rio de Janeiro, June, 1992 by introducing the United Nations Framework Convention on Climate Change (UNFCCC). UNFCCC was signed by 154 nations in 1992 and has 194 parties today. It came into force in 1994 with the objective “stabilizing greenhouse gas

concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system" (UNFCCC, n.d.-a). In pursuit of this objective, Kyoto Protocol was adopted in 1997 in the third one of Conference of Parties (COP) which is an annual meeting of parties of convention. The Protocol which entered the force in 2005 and ended in 2012, assisted countries in adapting the reverse impacts of climate change and signatories committed reduction of greenhouse gases (GHG) emissions to promote sustainable development (UNFCCC, n.d.-b) which is "seeking to meet the needs of the present without compromising those of future generations" (UNESCO, n.d.-a).

1.1.2 Climate Change Education for Sustainability

When the sustainable development started to be perceived as a global need, education has become one of the crucial aspects. The concept of sustainable development was popularized in 1987 with the publication of the "Brundtland Report" – the Report of the World Commission on Environment and Development (WCED). This landmark report highlighted the need to conceptualize sustainable development that would "meet the needs of the present without compromising the ability of future generations to meet their own needs" (WCED, 1987).

Five years later, in 1992, Agenda 21 was declared as a guiding document for sustainable development in the United Nations Conference on Environment and Development (UNCED) met in Rio de Janeiro. It has been generally accepted that achieving sustainable development will require balancing environmental, societal, and economic considerations in the pursuit of development and an improved quality of life.

Agenda 21 viewed education as an essential tool for achieving sustainable development. Despite much effort in these and other areas, reports prepared by countries for the World Summit on Sustainable Development (WSSD) in Johannesburg in 2002, the ten-year review of Agenda 21, revealed that the goals laid out in Rio were still a long way from becoming reality. There was clearly a need to

rethink education. Education for Sustainable Development paves the way for this "rethinking" (UNCED, n.d.).

As the concept of sustainable development was discussed and formulated, it became apparent that education is a key to sustainability. For about a decade, many people were realizing that education is important to any effort that would create a more sustainable future; however, little was progress was being made under the name of Education for Sustainable Development (ESD).

In fact, many considered education the forgotten priority of Rio. The importance of ESD was confirmed to the world when in December 2002 the United Nations Education Scientific and Cultural Organization (UNESCO) declared 2005 - 2014 to be the Decade of Education for Sustainable Development (DESD).

Within the context of ESD and that of DESD, UNESCO responds to climate change through education. As is stated by UNESCO, education is an essential element of the global response to climate change. It helps young people understand and address the impact of global warming, encourages changes in their attitudes and behavior and helps them adapt to climate change-related trends (UNESCO, n.d.-b).

However, climate change education (CCE) brings with its requirements. Educational, teaching and learning programs that are already in place should be reconsidered to initiate reasons and outcomes of climate change. Educators should follow innovations and insert them in their educational programs. Besides, problem solving, creativity and social skills should be encouraged. To meet these requirements student-centered, constructivist education programs with learn-by-doing and collaborative approaches should be needed (UNESCO, 2010).

UNFCCC Article 6, which addresses the issue of climate change related education, training and public awareness, is the main vehicle through which the Convention fosters action to develop and implement educational and training programs on climate change. Thus, Article 6 of the UNFCCC was arranged to fill this gap with its

six pillars; climate change related educational programs at the primary and secondary levels, public awareness campaigns, public access to relevant information, public participation, training of encompassing experts and enhancement of international cooperation. For the implementation of Article 6 of the Convention, New Delhi Work Programme was admitted in 2002. It was a country-driven program that lasted in five years and included a list of activities that combine Article 6 activities with the old climate change strategies (UNFCCC, 2012).

Amended New Delhi Work Programme launched in 2007 (UNFCCC, 2012.) however, emphasizes that, "*In order to advance implementation of Article 6 of the Convention, it is useful to cooperate in, promote, facilitate, develop and implement education and training programs focused on climate change, targeting youth in particular*…" (Decision 11/CP.8).

In parallel with the political developments related to ESD and CCE, research in the area has been developed. In the beginning of 1900s, researchers started to investigate climate science at first. Then in 1990s, more specific research about greenhouse effect, global warming and climate change has started to be investigated. Throughout literature of a century, as in the explained in the Chapter II, it was concluded that students hold general misconceptions and EDS and CCE are inefficient eradicating their misconceptions most of the time.

1.2 Climate Change Education in Turkey

Implementing New Delhi Work Programme, ensuring its stipulations and providing communication and information exchange between national and international offices are the primary duties of National Focal Points (NFP). Regional Environmental Center (REC) Turkey was nominated as NFP for implementing New Delhi Work Programme in Turkey in 2004.

Accordingly, one of the challenges REC-Turkey stated was to develop environment and climate change in the primary and secondary school curricula. Thus, REC's first

attempt to overcome this challenge was Green Pack Project, the purpose of which was instilling sustainable development in students and making them protectors of environment (REC, 2008). However, the project could not receive support by the Turkish national curriculum.

Besides, lack of an environmental education course in Turkish primary education program, environment related objectives were mentioned in science and technology, life science and social science courses. Furthermore, these objectives concentrate on recognizing and understanding the environment, keeping it clean, understanding the relationship between the environment and people, rather than sustainability or climate change (Tanriverdi, 2009).

Furthermore, in accordance with the New Delhi Work Programme that addresses the need and importance of non-governmental organizations (NGOs) for ESD and CCE, TURCEV (Turkish Environment Education Found), has been implemented several programs related to CCE. Among these programs, Eco-Schools, Young Reporters, and Learning about Forest are the first attempts to education for sustainable development and education for climate change in Turkey (TURCEV, n.d.).

Research about ESD and CCE has been started in 2000s. For the 10 year period from 2000 to 2010, research in Turkey indicated that students and even teachers had misunderstandings and held many similar misconceptions about global warming and greenhouse effect which mainly caused by mass media and peer interaction. On the other hand, despite their misconceptions and misunderstandings, their awareness and sensitivity were high (Unlu at al., 2011).

According to First National Communication of Turkey on Climate Change report in 2007, along with the EU Acquis Communautaire and the Environmental Law which was amended in 2006 accelerated climate change activities and trainings in order to raise public awareness. In scope of the First National Communication of Turkey, painting and slogan competitions, awareness-raising workshops, forums and panels on energy, industry, impact and adaptation disciplines were performed to get young

generations' attention. Moreover, The International Meeting for Kids was organized in 2006, in which children discussed climate change with in all respects. In addition, in the academic year 2006-2007, an inter-disciplinary postgraduate programme on Climate Change was launched (UNFCCC, 2007).

1.3 Mental Models for Determining Student's Perceptions on Global Warming

Greenhouse effect causes global warming and global warming results in climate change. Therefore, students' mental models of greenhouse effect depend on their understandings of both global warming and climate change. Thus, identifying students' constructs about greenhouse effect is vital (Shepardson et al., 2011) and also sheds the light of their understandings of global warming and climate change.

There are several ways to examine mental models such as drawing, writing, or talking (Boulter and Buckley, 2000). The study conducted by Yanis (2012), for example, determined Turkish pre-service science teachers' mental models about ozone layer and ozone layer depletion via drawing. The results of the study showed that the existence of ozone layer in the atmosphere was perceived by half of the pre-service science teachers and chlorofluorocarbons (CFCs), carbon monoxide (CO), and carbon dioxide ($CO_{2)}$ was accepted as harmful chemicals for ozone layer. Moreover, Yanis (2012) showed 10 distinct mental models about role and distribution of ozone layer and 5 mental models about ozone layer depletion. However, those misconceptions were not related to the teachers' achievement and grade levels in establishing which type of mental models and ontological beliefs about the concepts. As it was stated by the author, the misconceptions were lead to misunderstandings and misconceptions about greenhouse effect, global warming and climate change. Furthermore, according to the research with 113 elementary students in the USA, students' misconstructions of mental models about ozone depletion were resulted in that global warming and greenhouse effect was increasing with ozone depletion (Somerville, 1996).

Furthermore, Andersson and Wallin (2000) sought answers to the Swedish students (grade 9 and grade 12) explanation of the greenhouse effect, thoughts on the reduction of CO_2 emission effects on society and the explain of the ozone layer depletion. The method chosen to answer these questions was to give students written tasks of the open-ended type. Five models of the greenhouse effect appeared as a result. The students' responses also indicated that they do not fully understand what fundamental societal changes would occur as a result of a drastic reduction in CO_2 emission. On the other hand, as the authors reported, the students were rather well informed about how injurious depletion of the ozone layer is to humans.

As is reported by UNESCO (2010), development of a Climate Change Education for Sustainable Development Programme needs using innovative educational approaches to help a broad audience (with particular focus on youth), understand, address, mitigate, and adapt to the impacts of climate change, encourage the changes in attitudes and behaviors needed to put our world on a more sustainable development path, and build a new generation of climate change-aware citizens. It is also noted that, simply introducing new content about climate change science, causes, consequences and solutions will not be an adequate response to climate change. New values, creative thinking and problem solving-skills need to be instilled at all school levels through teaching and learning methodologies that are participatory, experimental, critical and open-ended. In addition, it is emphasized that, science education can make an important contribution to students' awareness and competencies to adapt to climate change. The reverse also seems to hold true, namely, that climate change education can contribute to the relevance and quality of science teaching. Strong performance in science and awareness of global environmental problems tend to go hand-in-hand, and both are associated with a sense of responsibility supporting sustainable environmental management. Failure in scientific education will mean less widespread – and less informed – public debate on issues such as climate change and other sustainability challenges. Therefore, in the light of both political and scientific developments, CCE deserves much more attention among science education researchers. One of the areas to fulfill the requirements is to find out the current state of students as far as their perceptions and

misconceptions on climate change are considered. As a result of all, this study has been conducted under the above mentioned framework to add a new data and evaluations to CCE literature, by assessing Turkish students' mental models on the issue.

1.4 Purpose of the Study

The aim of the current study was to investigate 7th grade Turkish Eco-School students' mental models of the greenhouse effect. In the light of literature, it was hypothesized that students would not interrelate causes and possible effects of greenhouse effect and their mental models of greenhouse effect reflect their perceptions on the reasons and results of global warming and climate change.

1.5 Research Question

The study addressed the following research question:

What are the greenhouse effect mental models for 7th grade Turkish Eco-school students?

1.6 Significance of the Study

This study is worth to investigate because of several reasons. First of all, as mentioned above, EDS and CCE literature in Turkey is still new and developing. Therefore, any contribution to this literature is very valuable and also will be helpful for future researchers.

Second, examining students' mental model is a kind of measurement of learning. To evaluate and improve educational programmes and curriculum results of this study can be a guide because Turkish literature does not serve many research that seek students' mental model of greenhouse effect. In other words, students' greenhouse effect mental models had not been investigated frequently in Turkey.

Third, this research also shows effectiveness of Eco-schools Programme. In that respect, it will give idea to other environmental education programmes that are very poor in number and quality.

In the light of given information, the following chapter were intended to provide a deeper understanding of the concept in a causal sequence, namely, greenhouse effect, global warming and climate change.

CHAPTER 2

LITERATURE REVIEW

2.1 Greenhouse Effect

The greenhouse effect was identified by Jean-Baptiste Fourier in 1827, firstly. Fourier realized that some gases in the atmosphere play role in increasing Earth's surface temperature (Pierrehumbert, 2004). Then John Tyndall around 1860 determined gases that trap heat rays (infrared radiation) and therefore was responsible for the greenhouse effect. Tyndall found that most of the infrared radiation was absorbed by the water vapor (H_2O) and carbon dioxide (CO_2), respectively (Weart, 2011). In 1896, Svante Arrhenius focused on the question: What would happen if the concentrations of greenhouse gases changed? He concluded that temperature would increase by 5-6 ^{o}C if the carbon dioxide concentration in the atmosphere doubled (as cited in Houghton, 2005).

Today, IPCC defines greenhouse effect as follows:

> Roughly one-third of the solar energy that reaches the top of Earth's atmosphere is reflected directly back to space. The remaining two-thirds are absorbed by the surface and, to a lesser extent, by the atmosphere. To balance the absorbed incoming energy, the Earth must, on average, radiate the same amount of energy back to space. Because the Earth is much colder than the Sun, it radiates at much longer wavelengths, primarily in the infrared part of the spectrum. Much of this thermal radiation emitted by the land and ocean is absorbed by the atmosphere, including clouds, and reradiated back to Earth. This is called the greenhouse effect. […] Without the natural greenhouse effect, the average temperature at Earth's surface would be below the freezing point of water. Thus, Earth's natural greenhouse effect makes life as we know it possible. However, human activities, primarily the burning of fossil fuels and clearing of forests, have

greatly intensified the natural greenhouse effect, causing global warming (as cited in Le Treut et al., 2007).

Similar to Earth, in Mars and Venus, since CO_2 as the main constituent both of which own atmospheres similar greenhouse effects also occur on them. About the same size as the Earth, Venus, owns an atmospheric pressure at its surface of about 100 times that on the Earth. This creates a very large greenhouse effect ensuing in a surface temperature of about 500 °C. This phenomenon has called as the 'runaway' greenhouse effect. Being closer to the Sun than the Earth, water vapor (H_2O), which is one of the greenhouse gases, would have been a dominant component of the atmosphere. However, strong greenhouse effect would have used a large positive response and sent to all the water boiling away from the surface (Houghton, 2005).

2.1.1 The Natural Greenhouse Effect

Nitrogen and oxygen gases constitute the bulk of the atmosphere which does not absorb or emit thermal radiation. They are not the only atmospheric elements. If they were only atmospheric constituents, there would be no clouds and no greenhouse effect to appreciate the radiative balance, the average Earth's surface temperature would be about - 6 °C. However, average surface temperature is known as about 15 °C.

The difference between these two surfaces of 20 °C is because of the *natural greenhouse effect* due to water vapor (H_2O), carbon dioxide (CO_2), ozone (O_3), methane (CH_4) and nitrous oxide (N_2O) which are known as greenhouse gases. Water vapor provides the largest greenhouse effect and followed by carbon dioxide (Maurellis and Tennyson, 2003). It was known that 70 % of the boosted greenhouse effect was due to carbon dioxide (CO_2), 24 % due to methane (CH_4) and 6 % due to nitrous oxide (N_2O). The natural greenhouse effect is clearly vital in maintaining the Earth's climate as we know it, with its suitability for human life (Houghton, 2005).

It was well known that the concentration of methane (CH_4) in the atmosphere (less than 2 ppm) is less than that of carbon dioxide (CO_2) (about 370 ppm), however, the enhanced greenhouse effect resulted by a molecule of methane (CH_4) is about 8 times that of a molecule of carbon dioxide (CO_2) (Crutzen, & Lelieveld, 1992), therefore, the contribution of methane (CH_4) to enhanced greenhouse effect is not minor.

2.2 Global Warming

Global warming refers to negative effects on climate caused by human activities, burning of fossil fuels (coal, oil and gas) and large-scale deforestation which is emerged by the Industrial Revolution. It was known that these activities lead to release of about 7 billion tons of carbon as carbon dioxide (CO_2) into the atmosphere with extensive quantities of methane (CH_4), nitrous oxide (N_2O) and chlorofluorocarbons (CFCs) which are known as greenhouse gases. The fact that over the past century human activities, mostly by the burning of fossil fuels, have boosted the greenhouse effect by increasing the concentration of greenhouse gases in the atmosphere more than that would have occurred naturally. This increase in greenhouse gases has resulted in increment in the atmosphere's overall temperature causing global warming (IPCC, 2007).

The basic principle of global warming as mentioned above is the phenomenon that the radiation energy from the Sun that warms the Earth's surface and the thermal radiation from the Earth and the atmosphere that is radiated out of space. By the presence of greenhouse gases in the atmosphere, it acts as a blanket over the surface and the balance can be restored only an increase in the Earth's surface temperature (Houghton, 2005).

To understand global warming, it was asserted that research have to investigate last 50 years period which greenhouse gases increased significantly as did the global average temperature - by about 0.5 °C (Fu, & Johnson, 2004). And also, it was known that for the global average, this is a huge change. It was also known that for

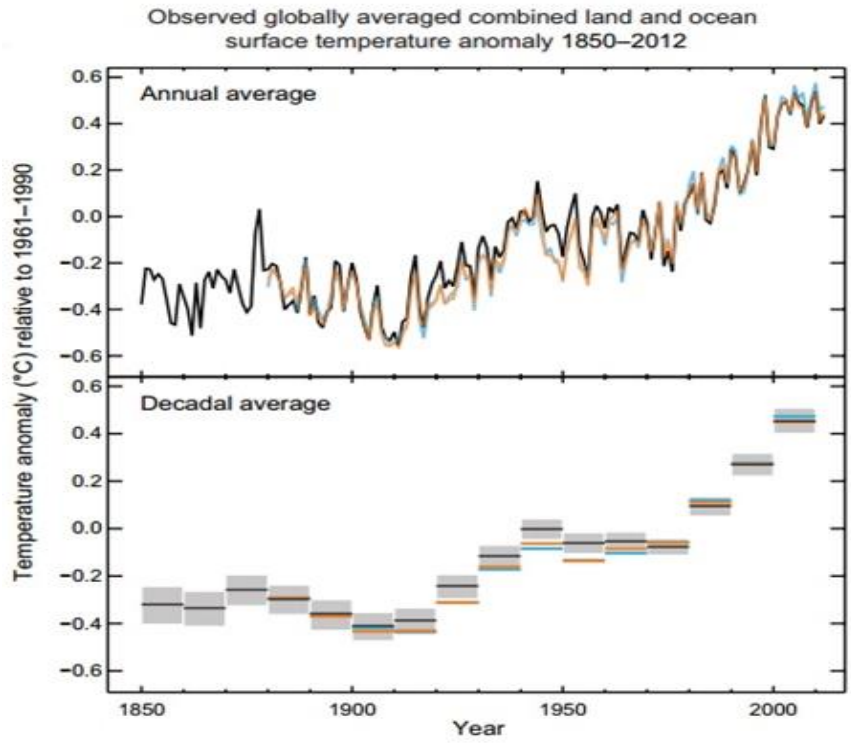
doubled carbon dioxide (CO_2) in the atmosphere under equilibrium conditions, it would be expected that a rise in global average surface temperature of about 2.5 °C. Since the preindustrial period, CO_2 has increased approximately 35 % together with other gases and these generated a rise of about 1.4 °C, about twice the rise of 0.6 °C or 0.7 °C that has actually occurred. The reason that given for this increment is the thermal capacity of the oceans that is presenting an interval in answer, with the current increment of greenhouse gases of around 30 or 40 years (Cubasch et al., 2001).

Between 1955 and 1998, measurement which showed the heat content of oceans down to 3 km depth demonstrated that oceans are warming. It was asserted that, as a result of global warming, rising the type, frequency and intensity of extreme events, such hurricanes, typhoons, floods, droughts and heavy rainfall events, are predictable even with small average temperature increases and observed all around the world today (Meehl et al., 2007).

2.3 Climate Change

Climate change is a complex and challenging environmental issue which the world faces with. According to the IPCC, human activities endures to alter landscapes' formations and atmospheric structure of greenhouse gases such as, carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O), and global temperatures are anticipated to rise, causing the Earth's climates to change. As a long-term alteration in the statistics of the weather (including its averages), climate change could show up as a change in climate normal (expected average values for temperature) for a given place and time of year, from one decade to the next. IPCC reports showed that each of the last three decades has been consecutively warmer at the Earth's surface than any earlier decade since 1850. Moreover, these reports gave the fact that among last 1400 years, 1983–2012 was the warmest 30-years period of Northern Hemisphere. As seen in Figure 2.1, the reports also demonstrated that the globally averaged pooled land and ocean surface temperature data as calculated by a linear trend,

illustrate a warming of 0.85 (0.65 to 1.06) °C, over the period 1880 to 2012 (IPCC, 2013).



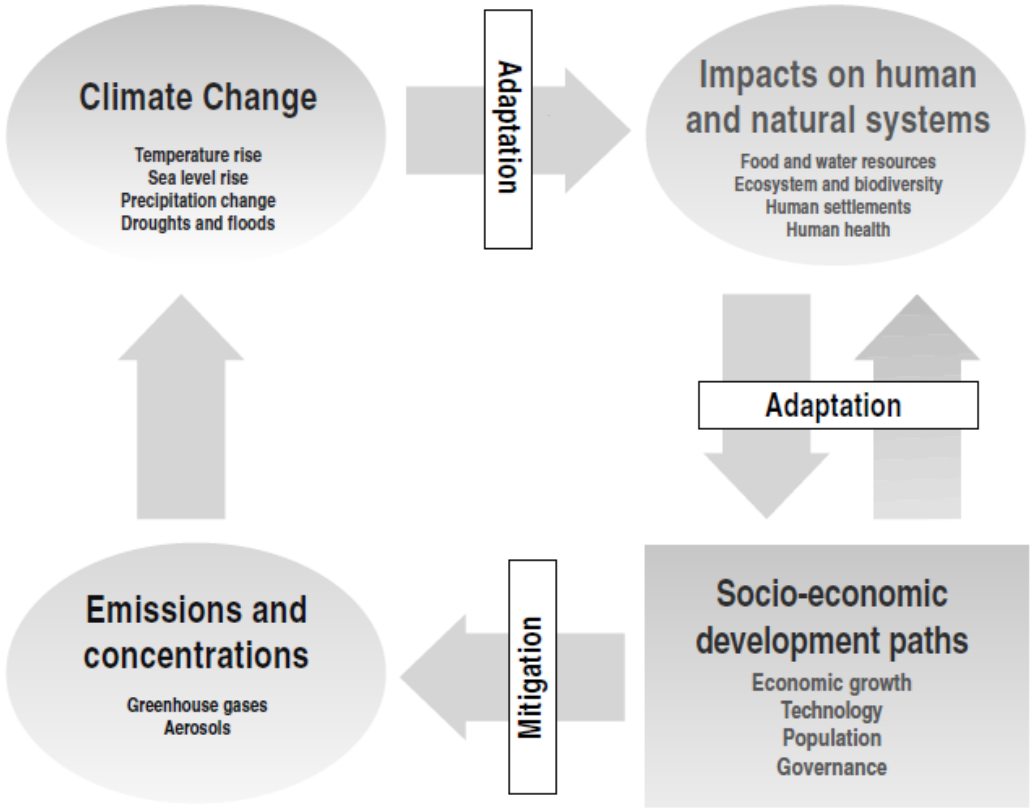
Source: IPCC, (2013). *Land and surface temperature*. Retrieved from http://treealerts.org/wp-content/uploads/2013/09/ipcc-warming-graph.jpg

Figure 2.1 Surface temperatures of oceans and lands in 1850-2012

The devastating majority of climate scientists approved that for most of the climate change currently being observed is due to human activities especially the burning of fossil fuels (coal, oil, and gases). It was well known that climate change as a normal part of the Earth's natural changeability, and this is interrelated with the atmosphere, ocean, and land, as well as changes in the amount of solar radiation reaching the Earth. However, the problem is that, there is an important evidence related to warming of the Earth surface and oceans due to human activities and accelerate the natural process (National Academies, 2008)

2.3.1 Education for Climate Change

In Figure 2.2, cycle of cause and effect is shown starting with socioeconomic development (lower right-hand corner) that leads to emissions of greenhouse gases (of which CO_2 is the most vital) and aerosols. These emissions result in changes in atmospheric composition and later to changes in climate that affect both humans and natural ecosystems and affect human life, health and development. Moreover, this figure demonstrates there is a direct relationship between natural system and socioeconomic development which means economic growth or population lead to changes in ecosystem and biodiversity, also (Figure 2.2).



Source: IPCC, (2003). *Climate change and integrated framework*. Retrieved from http://www.grida.no/publications/other/ipcc_tar/

Figure 2.2 Summary for policymakers

More specifically, according to climate change records over the 1000 to 2000 years, for the Northern Hemisphere, global surface temperatures reached the highest degree among at least the past 400 years. It was found in 2007 that 719 changes among 765 significant changes in physical system such as snow, ice and frozen ground, coastal and hydrology processes were resulted from climate change. Moreover, 25.804 changes among 28,671 significant changes in biological system such as terrestrial, marine and fresh water were resulted from climate change (UNEP, & UNESCO, 2011). The predicted natural and also social and economic negative effects of climate change will occur earlier than expected. Therefore, to take action to the climate change, education is one of the key points because of providing not only convincement but also behavioral change (Leite, 2010).

After undeniable evidences of climate change, societies, citizens and politicians regarded education as a solution for climate change. Therefore, education planners and teachers are insistently recalled to integrate climate change into their programs and curriculum to meet the needs of next generations which is responding to the climate-related challenges (UNEP, & UNESCO, 2011). However, as mentioned below, students hold many misconceptions and misunderstandings about greenhouse effect, global warming and climate change and it can be inferred that EDS and CCE can not be effective as much as intended.

2.4 Mental Models

2.4.1 Nature of Mental Models

Mental models were firstly described by Keeneith Craik in 1943. He asserted that mind needs to form small-scale models of reality to predict coming events and creates explanations. In 1991, Byrne and Johnson-Laird developed a mental model theory which based on thinking and reasoning. They claimed that mental models were formed by perception, imagination or comprehension of discourse. They can be constructed for both visual images and also abstract structures. For whatever it is, all indicates a possibility.

Mental models are kind of models that are cognitive structures of human beings (Finegold, & Smith, 1995) and accepted as demonstration of an idea, object, and event and even process (Boulter, & Gilbert, 2000). Then in 2004, mental models were described as knowledge structures which are used to describe, foresee and understand the system that they represents and help to decrease mental energy usage and working memory load and allow for interferences in a rapid way (Gilbert, Rogers, & Samuelson).

According to Coll and Treagust (2003a), there are two types of mental models; physical mental models and conceptual mental models. Physical mental models are accepted as the imagination of physical properties and conceptual ones as accepted as mental constructions of concepts, models and abstraction. Two important characteristics of all types of mental models are their subjectivity and changeability. Greca and Moreira (2000) explained this issue as follows; students form internal representations or mental models that are based on their existing knowledge, to understand the world. By these models, students can foresee the events and understand phenomena or events in a more functional way. By upcoming new ideas and knowledge about scientific phenomena, students' mental models are altered; therefore mental models are accepted as unstable and personal (Greca, & Moreira, 2000). Therefore, it is important to know if students' building models are up to their existing mental model (Greca, & Moreira, 2000; Libarkin et al., 2003). And also, poorly constructed mental models may possibly be improved with new experiences and organized mental models may help students to dispose new knowledge into their existing models (Libarkin et al., 2003).

In the literature, there are two methodologies to construct mental models. First one is related to conceptions which are described as compressions of concepts and are supposed to be developed in a theoretical framework. This kind of models are constructed as a mental model into ones that scientifically correct, it needs to change at the theory level (Brewer, & Vosniadou, 1992, 1994). The second methodology to construct a mental model is related with forming conceptions through one's experience of the external world (diSessa, 2008). In other words, there are some

factors such as educational, cultural and personal experiences that affect mental models and resulted in difference in mental models (Duit, & Glynn, 1995).

It was well known that the people by interacting the environment, obtain new information and mental models continually change (Brewer, & Vosniadou, 1994). However, if there is not a consensus with the mental model of individual and the new information about environment, there will be conflict and though the information was coherent but in the end the new information may accommodate in a wrong way. In this way, there will be a gap with mental model and the correct scientific model and can be ended up with incomplete mental model. Therefore, the mental models of the students about scientific concepts might be validated by testing how they respond the additional questions related to these concepts (Chi, 2008).

It was stated that learning involves the structuring and restructuring of detailed concepts related to existing concepts in the learner's mind, and there is a flow of a dynamic to-ing and fro-ing of ideas (Ausubel, 1968). Thus, a mental model is able to illustrate what a person comprehends about a concept at a particular time and contains their knowledge of, as well as their opinions about the concept (Byrne, 2011). As a result of these findings, to help children learning process, the research about representational nature of knowledge and mental models are growing (Greca, & Moreira, 2000). However, mental models are accepted as difficult area to do research. On the other hand, understanding mental models of human being, especially school children, may provide useful information in science of education (Coll, & Treagust, 2003b). Despite its difficulties, that is why mental models are being investigated for a long time.

To illustrate, in 1993, diSessa introduced the term phenomenological primitives (p-prims) which implies that students' explanations of phenomena are spontaneous constructions based on elements of their existing knowledge structures and used by students unconsciously and in different contexts, students may use different p-prims and, p-prims are not mental models, and accepted as isolated knowledge constructions that they use to make sense of the world. More recently, Byrne (2011)

did a study with a total of 458 children, 176 aged seven years, 174 aged eleven years, and 108 aged fourteen years, to investigated the mental models of these children about microorganism, and demonstrated that across age groups many children did not possess expected knowledge and understanding about micro-organisms and hold misconceptions about microorganisms.

Also, there are some research in science education literature which investigates the children's knowledge and point of views to scientific phenomena (Driver, Rushworth, Squires, & Wood-Robinson, 1994; Freyberg, & Osborne, 1985), and studies about how children intellectualized different biological phenomena; for example, growth (Russell, & Watt, 1990), life processes (Black, Osborne, & Wadsworth, 1992), and ecology (Driver, Leach, Scott, & Wood-Robinson, 1992).

The most inspiring study in the literature was belong to Shepardson, Charusombat, Choi, and Niyogi. They did a constructivist study which examines drawings and explanations of 225 students from 3 different schools in the Midwest in the US, to classify 7th grade students' mental models of greenhouse effect. As a result of their inductive analysis of the content of the drawings and explanations of the students, five different mental models were discovered; a 'greenhouse' for growing plants as Model 1, greenhouse gases cause ozone depletion or formation, causing the Earth to warm as Model 2, greenhouse gases, but no heating mechanism, simply gases in the atmosphere as Model 3, greenhouse gases 'trap' the sun's rays, heating the Earth as Model 4, and the sun's rays are 'bounced' or reflected back and forth between the Earth's surface and greenhouse gases, heating the Earth as Model 5 (2011).

2.4.2 The Need for Mental Models for Climate Change Education

Today, process of learning is understood more after the contribution of cognitive psychology, especially in the area of representational nature of knowledge (Brown, 1995; Gardner, 1985). With its theoretical elements, as describing mental representations, and in area of knowledge (Greca, & Moreira, 2000), it was asserted

that it has revolutionary notes that they have revolutionary inferences for science of education (Vosniadou, 1996).

It was asserted that through cohesive mental models, learners consolidates knowledge (Brewer, & Vosniadou, 1992) and it was indicated that beliefs about especially physical phenomena are constructed by how the related concepts are presented to them and more information organizes more sophisticated models (Lawson, 1988). Since most concepts about science and physical world are abstract, the learners mostly need analogues explanations and scientific models to learn the concepts about science (Park, 2006).

Ducheyne (2008) asserted that people uses the scientific models which are functional mental representations to understand the natural world. Moreover, it was asserted that there are 3 types of mental representations, namely, propositional representations, i.e. verbal representations; mental models, i.e. structural correspondents of the world; and mental images, i.e. perceptual correlates of the phenomenon being represented (Johnson-Laird, 1983).

To learn scientific concepts, people need to construct cognitive representations and related to this mental models are needed to be built (Greca, & Moreiro, 2001). Moreover, as mentioned before, Earth's climate is a complex issue and unfortunately there is no chance to observe it directly even it is possible to observe day to day weather changes (Hansen, Henriksen, & Schreiner, 2005). Thus, ambiguity of climate science (Andrey, & Mortsch, 2000) makes it difficult to provide an understanding to students' conceptualization of climate change. Therefore, students' mental models of greenhouse effect, as a complicated and abstract topic, are worth to investigate in order to determine how much students internalize the topic.

2.4.3 Research Related to Mental Models of Greenhouse Effect

Research related to greenhouse effect, global warming and climate change started in the early period of literature and mainly focused on awareness of and knowledge and beliefs about natural events such as clouds, precipitation, wind etc.

One of the very early research in the literature was in 1883. Hall (1883) did a study with 200 Boston children, age 4 to 8, and investigated their explanations of 112 different objects and concepts and demonstrated that 78 % of children stated they were ignorant of dew, 76 % of them did not know what season is, 73 % of them were ignorant of seen hail, 65 % of them were ignorant of seen rainbow and 36 % of them were ignorant of seen clouds.

In his report, Hall (1883) also shared the quotes of children as:

> *"God keeps raining heaven in a big sink, rows of buckets, a big tub or barrels, and they run over or he lets it down with a waterhole through a sieve, a dipper with holes, or sprinkles or tip sit down or turns a faucet."*

> *"God makes it in heaven out of nothing or out of water, or it gets up by splashing up, or he dips it up off the roof, or it rains up off the ground when we don't see it."*

> *"The clouds are close to the sky; they move because the Earth moves and makes them. They are dirty, muddy things, or blankets, or doors of heaven, and are made of fog, of steam that makes the sun go, of smoke, of white wool or feathers and birds, or lace or cloth."*

More than half a century after, research indicated similar results. Piaget (1926) conducted similar research but age as an independent variable at this time. He asserted that 5 to 6 years, children believed that clouds are solids made by men or God, clouds move because men or God or the clouds themselves want to, or move when we move, 6 to 9 years, they believed clouds are made from smoke, dust, Earth

or stone, and 9 to 10 years; clouds are of entirely natural origin: condensed air or moisture, or steam or heat, etc. And these developments of concepts from stage 2 to 3 are inclined by teaching (as cited in Hansen, 2009).

More recent research's results have more satisfactory results about these terms. For example, in 1996, when students were asked about their thoughts about a cloud, its content, before 13 years old, only, 15 % of 464 participants, after 13 years old, only 43 % of 358 participants, and for 15 years old, only 24 % of 354 participants could give satisfactory answers. Moreover, for the question of "why do you think it's raining from some clouds, but not from all?", the correct answer rate showed decrement and, and before 13 years old, only, 5 % of 464 participants, after 13 years old, only 11 % of 358 participants, and for 15 years old, only 8 % of 354 participants could give satisfactory answers (Hansen, 2010).

After the terms, global warming and greenhouse effect, came into our lives and started to be popular, more specific research about these topics have been started to investigate. Most of them indicated students' inadequacy and misconceptions. As an early research, Boyes and Stanisstreet (1992) did a study with 218 first-year British undergraduate students in biology, age 18-20 years, and showed that 60 % of them confused global warming and ozone layer depletion.

One year later, Boyes, Chuckran, and Stanisstreet found the status presence of students' conceptions of the problem, with a design a closed questionnaire, contained six open-form with 36 statements to be responded on a five-point scale questions about the greenhouse effect to a group of English 13-14 years old (n = 60). As a result, "The greenhouse effect is made worse by holes in the ozone layer" was declared by 64 % of first year undergraduate students. The researchers illustrated that the students think like: "Holes in the ozone layer contribute to global warming because they allow increased penetration of solar heat", "If the greenhouse effect gets bigger more people will get skin cancer" and "The greenhouse effect can be made smaller by using unleaded petrol" was declared by 51 %. Besides, it was showed that many agreed with right statements as well (1993).

Today, global warming, greenhouse effect and climate change are the terms that people encounter almost every day. However, it was stated in ABC News in 2007 that, only 41 % of the Americans believed that global warming was caused by human activities. As it was stated in the news, 33 % of the Americans declared climate change as the world's top ecological matter, and 84 % thought it was probably happening today, while, 63 % thought it could be reduced, with 62 % claiming they knew a moderate expanse about global warming, and 86 % thought global warming would become a serious environmental problem if not adjusted. Still, it was asserted that only 18 % accepted that every time coal or oil or gas was used, human beings contributed to greenhouse effect (Myers, & Nisbet, 2007).

Today's research showed that this situation is not much different for students. In the literature, numerous studies illustrated that students did not certainly have an explicit or exact conception of the greenhouse effect (Andersson, & Wallin, 2000; Pruneau et al., 2001), and also that students commonly did not make a distinction between the greenhouse effect and global warming (Andersson, & Wallin, 2000; Boyes, Chuckran, & Stanisstreet, 1993; Christidou, & Koulaidis, 1999). Additionally, research showed that most of the students mistakenly linked the greenhouse effect with stratospheric ozone depletion and believed that the Sun rays are trapped by the ozone layer (Boyes, & Stanisstreet, 1997; Christidou, & Koulaidis, 1999; Pruneau et al., 2003). Moreover, the idea about that the increased ultraviolet radiation, due to ozone depletion, results in global warming was also common among some students (Andersson, & Wallin, 2000; Boyes, & Stanisstreet, 1994, 1997; Boyes, Stanisstreet, & Kilinc, 2008; Boyes, Stanisstreet, & Papantoniou, 1999; Christidou, & Koulaidis, 1999; Osterlind, 2005; Pruneau et al., 2003; Rubba, Rye, & Wiesenmayer, 1997).

Furthermore, students believe that air pollution causes global warming and climate change are believed as the result of some form of air pollution; acid rain (Boyes, Chuckran, & Stanisstreet, 1993); dust (Pruneau et al., 2001); harmful and unnatural gases (Fox, Gowda, & Magelky, 1997); and air pollution in general (Andersson, & Wallin, 2000; Shepardson et al., 2009) and also as 'ozone depletion' is an effect of global warming (Kilinc, et al., 2008, Ozay, & Pekel, 2005; Pruneau et al., 2001;

Shepardson et al., 2009). Moreover, research showed that the ozone hole tolerates more solar energy or ultraviolet radiation to influence the Earth, causing global warming was that the commonly shared idea among students (Andersson, & Wallin, 2000; Boyes, & Stanisstreet, 1994, 1997; Boyes, Stanisstreet, & Papantoniou, 1999; Christidou, & Koulaidis, 1999; Osterlind, 2005; Pruneau et al., 2003; Shepardson et al., 2009). Global warming and climate change is a result of an increase in solar radiation (Boyes, & Stanisstreet, 1993; Boyes, Chuckran, & Stanisstreet, 1993; Pruneau et al,. 2003) or since the Earth becomes closer to the Sun (Pruneau et al., 2003; Shepardson et al., 2009), was also some ideas held by some of the students.

Moreover, in these studies, it was asserted that except carbon dioxide (CO_2), students had little knowledge about greenhouse effect. Shepardson et al. (2009, 2011) showed that students suggested that there was a layer in the atmosphere which consists of greenhouses gases and bounces the heat from the Earth back toward the Earth or traps the Sun's energy. Moreover, these studies also showed that some students do not know even the greenhouse effect exists (Shepardson et al., 2009; Andersson, & Wallin, 2000; Pruneau et al., 2001). Students did not differentiate even water vapor (H_2O) as a greenhouse gas and also some of them also do not reflect even carbon dioxide (CO_2) as a greenhouse gas (Boyes, & Stanisstreet, 1993; Boyes, & Stanisstreet, 1997; Pruneau et al., 2001).

Another research showed that students had also difficulties the differentiate greenhouses gases, carbon dioxide (CO_2) (Boyes, Chuckran, & Stanisstreet, 1993; Pruneau et al., 2001), methane (CH_4), water vapor (H_2O), or nitrogen oxides (NO_x) (Boyes, Chuckran, & Stanisstreet, 1993; Shepardson et al., 2009). Also, it was believed that carbon dioxide (CO_2) or greenhouse gases constitutes a thin 'layer' or 'cover' in the Earth's atmosphere that snares the sun's rays or heat (Christidou, & Koulaidis, 1999; Kilinc et al., 2008; Pruneau et al., 2003). Lastly, it was declared that students fail to comprehend the energy balance of the Earth as a whole and they are lack of understanding the concept of terrestrial radiation (Christidou, & Koulaidis, 1999).

Therefore, it is possible to infer as a result of the above summary of the literature that, considering undeniable evidences of climate change, education is regarded as a solution and as a result, education planners and teachers are insistently recalled to integrate climate change into curriculum to meet the needs of next generations. On the other hand, effective CCE education has not been confronted yet. Although UNESCO's attempts to fulfill the gaps in CCE and there are several theoretical documents available related to issue, the major reason for ineffective CCE seems as not having reasonable verification on the students' way of perceiving the issue. One of the indications for this idea is the students' misconceptions and misunderstandings about greenhouse effect. Besides, as was mentioned above, CCE and science education compensate each other in several terms and therefore, CCE is one of the issues to be tackled especially by science educators. Thus, one of the ways to support ESD and CCE to be as effective as intended is to research on the students' mental models on greenhouse effect.

CHAPTER 3

METHOD

This chapter covers details about research design, context of the study, sample, data collection, data analysis, trustworthiness of qualitative analysis, assumptions and limitations of the study.

3.1 Research Design

The aim of this study is to investigate 7th grade students' mental models of greenhouse effect. The research design of this study is a survey research in which qualitative data were collected via draw and write survey.

According to the nature of qualitative study, qualitative research is based on looking a phenomenon with the participants' eyes (Merriam, 2002). Therefore, this research comprises the sample to reflect their understanding of a natural event with their drawings, qualitative analysis of the drawings by means of tagging driving codes and determining the mental models based on the codes. The researcher's further target is to discuss 7th grade students' understandings, misconceptions and thus the current status of climate change education in the current Turkish elementary school program through the determined mental models.

3.2 Context of the Study

There are four major issues that describe the context of this study: Mental models, greenhouse effect, Eco-Schools and 7th grade elementary school students.

Seventh grade primary school students' mental models related to greenhouse effect is the focus of this study. Although there is not a single definition, mental representation of an idea, an object, an event, a process or a system is perceived as

mental model in this paper (Gilbert, & Boulter, 1998). Therefore, within the context of this study, to document students' mental models, they were asked to draw their understanding of greenhouse effect and explain their drawings by writing. In order not to impact students' own representation, they were given a blank A4 paper and were only asked to draw what they think about greenhouse effect. They were not asked any questions, and no questions were answered during the drawing sessions. The students, however, were also asked to write/explain the idea in the picture they drew and their source of information (Appendix A).

The issue that students were asked to draw a picture is "greenhouse effect". Students of the study were asked to draw about "greenhouse effect" but not global warming or climate change. The reason for designing the research on the mental models of 7th grade students' on "greenhouse effect" comes from the scientific explanation of the issues: Global warming is the phenomenon that causes the average temperature of the Earth's atmosphere and the oceans rise. Greenhouse effect is the retention of the heat by the greenhouse gases on the surface of the Earth, allowing the planet's temperature to rise. Thus, greenhouse effect is a natural phenomenon that explains the atmospheric temperature of the Earth being 15 ºC. Global warming, however, is the problem that is related to increase in atmospheric temperature due to human impact, which in turn causes changes in climate. That is to say, as discussed detailed in Chapter II, having a mental model on climate change requires a background on "greenhouse effect. Therefore, the idea behind asking students to draw "greenhouse effect" is to find out if students' have background on greenhouse effect and if they can use this background to make a relation with global warming and climate change.
One of the other issues in the context of this study is Eco-Schools. The study was realized with Eco-School students. The reason for Eco-Schools students decided as sample of this study is that, climate change is one of the topics covered in Eco-Schools programme, but not in the national curriculum in Turkey, except a section in the 6th grade textbook. Therefore, the idea behind working especially with Eco-School students is to strengthen the situation, in such a way to make it clear that the students have an idea about greenhouse effect. In other words, it is more meaningful to investigate mental models on the issue that is already taught. Furthermore, this

situation (having a sample who already taught about greenhouse effect) is more convenient to discuss educational implications.

The last issue that comprises the context of this study is related to the grade level. According to the nature of Eco-Schools Programme, all grade levels take part in the programme activities because all teachers should integrate the working theme into their lessons. However, in Turkish National Science and Technology Curriculum, greenhouse effect issue is covered only in "Matter and Heat" unit at 6th grade program (MEB, 2011). To make sure that students have learnt the topic "greenhouse effect" both national curriculum and programme were took into account and 7th grade students were selected as a sample. Because, whether 6th grade students had covered this topic or not was ambiguous before the data collection process and 8th grade students were absent most of time during the data collection process because of Level Determination Exam (SBS). Therefore, 7th grade Eco-School students in Turkey were identified as the target population of this study.

The more detailed information about the programme and its applications will be given in the next section below:

3.2.1 Eco-Schools Programme

Eco-Schools Programme was developed in 1994 in reply to UNCED and has been implemented in Turkey until 1995. It is an international non-profit programme and performed in 53 countries. The primary goal of the programme is to provide environmental conscious and ESD to elementary and preschool students. The programme was designed so that compatible with the objectives of ESD. This means that students actively engage in maintaining the program and also incorporate public (parents, surroundings, local authorities, other NGOs etc.) into the program by their informative, attention getting, cooperative activities. According to 2012-2013 academic year data, 638 schools in 51 cities are registered in the program in Turkey. 251 of them are public schools and 387 of them are private schools. There are 278

primary schools, 219 secondary schools and 141 preschools in the programme. (1) Litter, waste & recycling, (2) energy, (3) water, (4) climate change and global warming, (5) biodiversity, (6) air pollution, (7) noise pollution, (8) organic agriculture, (9) healthy living, (10) transportation are the themes on which Eco-Schools work. Each of these themes should be studied during 2 academic years. After two years the schools have a right to apply for the Green Flag award which is an internationally valid eco-label (TURCEV, n.d.).

The programme also serves as climate change education for sustainable development. From 2004 to now, the number of schools that had worked or has been working on climate change and global warming is 29 in 7 cities. All the subjects of the programme are interconnected not only to each other but also to climate change. One of the goals of the program is to make students understand the connection between them. Within the framework of programme goals, students should realize how to make contributions to prevent climate change by recycling, energy or water saving, organic agriculture, eco-friendly transportation etc. Understanding climate change and its cause, global warming, requires understanding the greenhouse effect process.

3.3 Sample

The accessible population of this study is 7^{th} grade students of Eco-Schools that had been worked on global warming and climate change (according to the records of 2011-2012 academic year).
In the first step of sampling procedure, the participant schools were determined by means of purposeful sampling method. The criteria used for deciding about the schools were;

1. Being an Eco-School (according to the records of the year 2012).
2. Working on climate change and global warming theme for 2 years.

As a result, three elementary schools were found to meet with the criteria (Figure 3.1). The sample of this study were comprised of the three schools which are placed

in İstanbul. Eco-Schools of this study and the themes they had realized until the year 2012 are presented in Table 3.1.

Table 3.1 Eco-Schools of the study.

Schools	**Working Topic**	**Durations**	**Number of students in the School**	**Number of Participants**
A	Climate Change & Global Warming	2010 - 2012	248	33
	Recycling	2004 - 2006		
	Energy	2006 - 2007		
	Water	2004 - 2007		
	Biodiversity	2007 - 2010		
		2005 – 2006		
B	Climate Change & Global Warming	2010 - 2012	345	35
	Recycling	2005 - 2006		
	Energy	-		
	Water	2005 - 2008		
	Biodiversity	-		
		2008 – 2010		
C	Climate Change & Global Warming	2010 - 2012	386	41
	Recycling	2005 - 2008		
	Energy	-		
	Water	2008 - 2010		
	Biodiversity	-		
		-		
		TOTAL		109

During the data collection period (spring semester of 2011-2012 academic year), three Eco-Schools of this study had been working on global warming and climate change topic for almost two years. Schools A, B and C have been participated in Eco-Schools Programme since 2004, 2005, and 2005, respectively and working themes of the schools so far were waste & recycling, energy, water, biological diversity, and global warming and climate change (Table 3.1). All these three schools are located in the European side of İstanbul and have both primary and secondary levels.

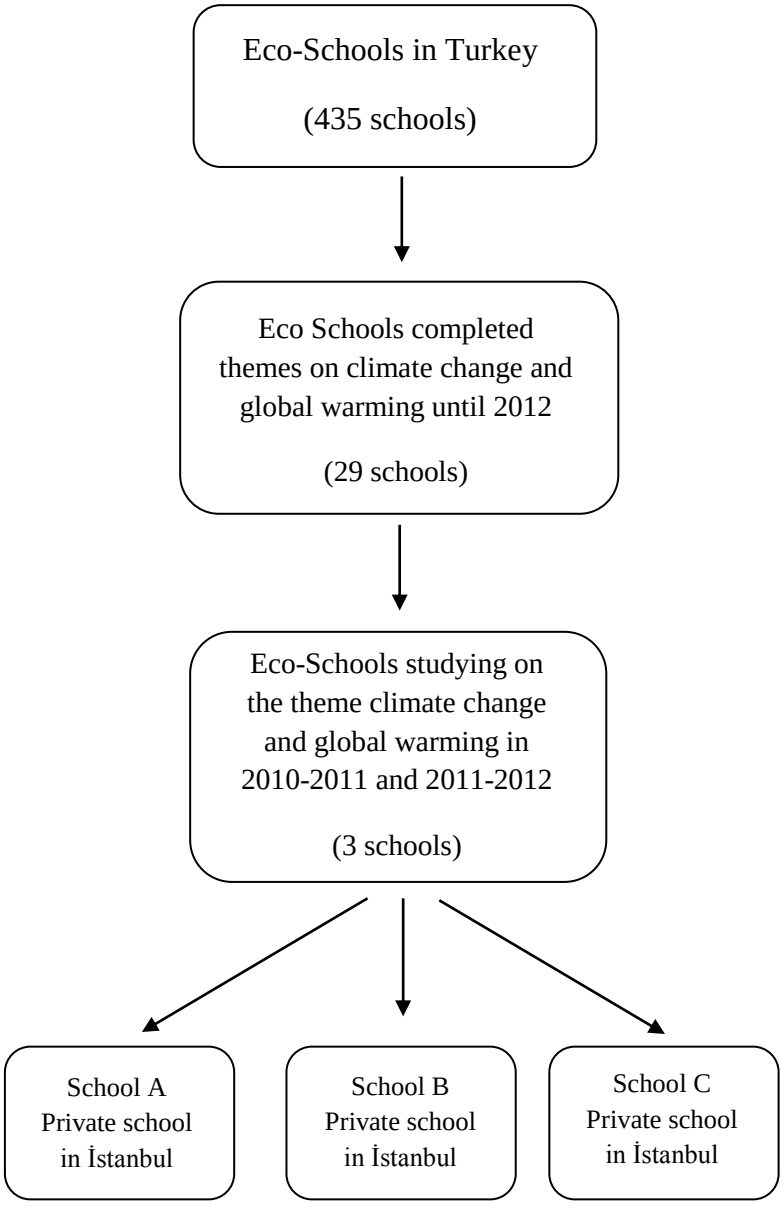


Figure 3.1 Criteria for selecting purposeful sample

As a result, the sample of the study are comprised of 109 7th grade students attending three Eco-Schools (A, B, C) in İstanbul. The number of students participated the study are 33 from School A, 35 from School B, and 41 from School C. The age range of the students was 12-14 and female and male students constituted 43 % (n = 47) and 57 % (n = 62) of the sample respectively (Table 3.2).

Table 3.2 The sample

Eco-School	Number of 7th grade students	Number of Participants	
		Boys	Girls
A	33	17	16
B	35	17	18
C	41	28	13
Total	109	62	47

3.4 Data Collection

External representation of a mental model about a concept or scientific phenomenon can be reached by through drawing, writing, or talking (Boulter, & Buckley, 2000). It was stated that drawings represents a child's expressed model of a particular phenomenon (Reiss et al., 2002) and they can deliver a useful guide to explore the children's ideas by providing a rich data (Hayes, Martin, & Symington, 1994; Reiss et al., 2002). Furthermore, using draw and write task provides attaining extensive amount of students' conceptions with varying sophistication levels than a small-case study and it helps to identify students' conceptions patterns (Shepardson et al., 2011). Therefore, the data were collected by a draw-and-write survey.

Students were asked to draw their understanding of the greenhouse effect in the survey. The students were informed during the data collection process that they can label the drawings if they find it necessary. Besides, the students were also asked to explain their drawings and information sources (Appendix A).

During data collection process, no information, further explanation or clues were offered to the students in order not to interfere with their drawings. Also, it was clearly stated that the results of the study would nothing to do with the process of Green Flag award evaluation. Data collection was realized six times in March and April of 2012 and it took about 25 minutes, in average, for the students to draw the pictures.

3.5 Data Analysis

Data were analyzed by basic inductive qualitative method, in which data is gathered to build concepts, hypothesis or theories rather than deriving postulates or hypothesis to be tested. In this kind of study, findings derived from the data inductively are in the form of themes, categories, typologies, concepts, tentative hypotheses and even substantive theory where observation and intuitive understanding form the basis of the research (Merriam, 2002).

The data analysis of this study can be described as translation of students' greenhouse effect drawings into mental models. Content analysis of drawings was enabled inductive determination of students' understanding of greenhouse effect.

The translation of students' greenhouse effect drawings into mental models had been realized in 3 steps:

1. Initial reading of drawings,
2. Determining basic codes and common codes, and
3. Constructing mental models.

To begin with, all the drawings were analyzed for their content without making any codes and basic points were recorded by the researcher.

Afterwards, the drawings were translated into codes/core concepts one by one by the researcher. Furthermore, by another coder analysis, an inter-rater reliability coefficient was calculated for 22 (20 %) randomly selected tasks for the sake of being consistent.

Lastly, resulted 15 codes were categorized as mental models, based on their content and the relevant literature.

As a result 5 different mental model categories were determined, representing students' understanding of greenhouse effect, based on codes typology (Figure 3.2).

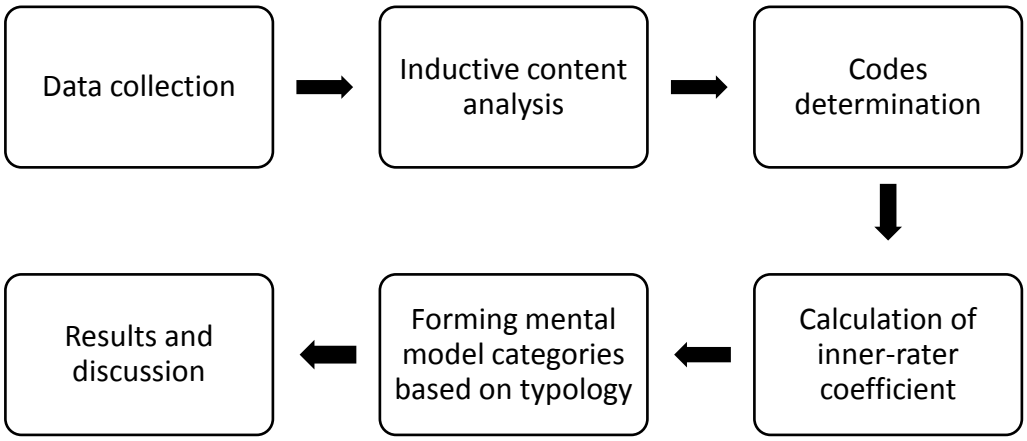


Figure 3.2 Data analysis process

3.6 Trustworthiness of the Qualitative Analysis

The validity of qualitative research is often referred to as trustworthiness of qualitative research. Unlike internal validity, external validity/generalizability, reliability and objectivity in quantitative analysis; credibility, transferability, dependability, and confirmability are the trustworthiness constructs in qualitative research (Shenton, 2004).

In the following sections, information about these constructs in the context of the current study will be presented.

3.6.1 Credibility

Credibility in qualitative research corresponds to internal validity in quantitative research. Credibility seeks the answer of this question: How much do the results of the study equal with the reality? (Guba & Lincoln, 1989). Adoption of research methods, the development of an early random sampling, triangulation, tactics to help ensure honesty in informants, iterative questioning, negative case analysis, frequent debriefing sessions, peer scrutiny of the research project, the researcher's "reflective

commentary", background, qualifications and experience of the investigator, member checks, thick description of the phenomenon under scrutiny and examination of previous research findings are the strategies that promote credibility (Shenton, 2004). To verify credibility following steps were taken:

1. Tactics to help ensure honesty in informants: Every participant has right to reject or leave off data collection process. Therefore, it was guaranteed that data were collected independently from the participants who were really volunteer to take part in. It was emphasized in the top of the draw-and-write survey of this study (Appendix A). Participants were completely free to draw and wright anything they wanted. Therefore; they were not restricted in any way and free to contribute any idea and experiences.

2. Examination of previous research findings: The value of a qualitative research mainly depends on the researcher's contributions to the literature and to what extent researcher relates his/her findings to existing knowledge (as cited in Shenton, 2004). This study results are congruent with the related literature and allow comparison with similar studies.

3.6.2 Transferability

Transferability in qualitative research corresponds to external validity /generalisability in quantitative research. It is based on to what extent study can be conducted another context. Therefore, qualitative research should include detailed description of study, sample and method to provide readers to transfer or compare the study under their circumstances (Shenton, 2004). Thus, description of sample (number, age, gender, and parents' educational levels), the number and length of the data collection sessions, the data collection method, and the time period over which the data was collected were given in detail.

3.6.3 Dependability

Dependability in qualitative research corresponds to reliability in quantitative research. It refers to obtaining similar results after repeating the study with same method, participants and context (Shenton, 2004). Therefore, the research design and its implementation and the operational detail of data gathering were explained in detail. Moreover, inter-rater reliability coefficient was calculated in order to verify dependability.

3.6.4 Confirmability

Dependability in qualitative research corresponds to objectivity in quantitative research. Dependability means that findings of the study do not result from researcher's beliefs, biases or other characteristics (Shenton, 2004). To evaluate participants' ideas and verify confirmability, two experts, the researcher and the second coder, evaluated the data.

3.7 Assumptions of the Study

3.7.1 Assumptions

The following assumptions for this study are made by the researcher:

1. There was no interference by data collector during data collection process.
2. There was no interaction between students while drawing requested task.
3. Data were collected in standard conditions.

3.7.2 Limitations

1. Identifying and analyzing codes may permit different interpretations of the results or fatigue. To eliminate this instrument decay limitation, researcher's codes were compared with another expert's coding of 20 % (n = 22) of the data (inter-rater reliability) and data collection and scoring were scheduled.

2. Data gatherers of current research which are teachers may unwittingly cause change in students' responses. The probable reason of that they may try to ingratiate themselves with operators/inspectors of the Eco-Schools programme. This limitation tried to be removed by standardizing the data collection procedure. Lack of a relationship between study and programme or Green Flag award was explained persistently to the teachers. They also were asked not to comment about the study, give explanatory information or answer students' questions. They were clear about their duty, providing transfer of the surveys.

CHAPTER 4

RESULTS

Results of this study are comprised of 7th grade elementary school students' mental models of greenhouse effect as derived from basic inductive qualitative data analysis. The results are presented to answer the research question of the study. Therefore, this chapter is presented as to answer the questions: "What are the greenhouse effect mental models for 7th grade Turkish Eco-school students?" The answer for the question was sought through the drawings of 109 elementary students and the results will be presented in line with the steps followed during the research.

Accordingly, the first section of this chapter gives a general view of the drawings and the results obtained within the steps through determining the models.

The models resulted from the analysis are presented in the second section of this chapter.

4.1 The Nature of Eco-School Students' Drawings about Greenhouse Effect

According to the design of the study, the outcome of the data analysis was the translation of 7th grade students' drawings on greenhouse effect into mental models. The translation, on the other hand, had been realized in three steps as; 1. Initial reading of drawings; 2. Determining basic codes and common codes and 3. Constructing mental models.

The results for each corresponding step are presented in the following sections.

4.1.1 Initial Reading of Drawings

Content analysis of drawings was the major tool for inductive determination of students' understanding of greenhouse effect. First step of the content analysis, however, was the "initial reading of drawings" and had been realized by means of translating the drawings into codes/core concepts.

At a first glance, before the translation process, the researcher's comments about the drawings were as follows:

Most of the drawings reflect the idea that greenhouse effect is a problem, instead of a natural phenomenon.

Most of the drawings contain emissions from both domestic and industrial sources as well as automobile exhausts and deodorants and perfumes.

Many of the drawings have the most famous figures related to global warming, such as a desperate polar bear.

Many of the drawings have explanations and figures related to ozone depletion.

Several of the drawings contain the scientific explanation of the greenhouse effect.

Only a few of the drawings has a clue about greenhouse gases, only CO_2.

Accordingly, codes/core concepts and corresponding frequencies resulted by initial reading of the drawings were presented in Table 4.1.

As displayed in the table, inductive determination of students' understanding of greenhouse effect resulted with 15 codes/core concepts. Among the determined codes the ones with the highest frequencies are emissions from industrial and domestic sources (C1; appeared in 40 drawings), deodorants and perfumes (C2;

appeared in 35 drawings), exhaust gases (C3; appeared in 31 drawings) and indicators of environmental impacts – penguins/polar bears on melting glaciers, raise in temperature, droughts, endangered species, injured or dead organisms, deforestation, changes in seasons, floods, migrations of birds – (C4; appeared in 31 drawings). Twenty four of the 7th grade students of this study mentioned about scientific explanation of greenhouse effect (C5) in their drawings. However, as far as their drawings displayed, 20 of the students mentioned about greenhouse effect-global warming relationship (C6). Frequency of drawings containing CO_2 was 11 and that for holes in ozone layer as a reason for rising temperature on Earth (C7) was 12. The frequency that ozone layer was mentioned as an explanation for greenhouse effect (C13) was 7. Although low in frequency, greenhouse used for agricultural purposes (C14) was one of the codes determined in the drawings (in 2 drawings).

Table 4.1 Codes/core concepts appeared in 7th grade students' drawings related to greenhouse effect.

Code Number	**Code**	**Frequency (no. of drawings)**
C1	Gaseous emissions of industrial and domestic sources	40
C2	Deodorant/perfume	35
C3	Exhaust gases	31
C4	Indicators of environmental impacts (penguins/polar bears on melting glaciers, raise in temperature, droughts, endangered species, injured or dead organisms, deforestation, changes in seasons, floods, migrations of birds)	31
C5	Scientific explanation of greenhouse effect	24
C6	Greenhouse effect - global warming relation	20
C7	Holes in ozone layer as a reason for increasing Earth's atmospheric temperature	12
C8	CO_2	11
C9	Causes for ozone depletion (deodorant, perfume, exhaust gases, gaseous emissions of industrial and domestic sources)	11
C10	Explanation of greenhouse effect with daily temperature differences	10
C11	Natural greenhouse effect	9

Table 4.1 (continued)

C12	Other sources of greenhouse effect (air conditioner, wastes, smoking)	7
C13	Ozone layer as an explanation for greenhouse effect	7
C14	Greenhouse used for agricultural purposes	2
C15	Miscellaneous (unidentified, shuttling monoxide gases between Sun and Earth, evaporated water from natural sources between Earth and Sun)	4

Then, the researcher and an outside coder, a science educator, reviewed randomly selected 20 % (n = 22) of the whole data and determine their codes, independently. Based on frequency of codes that both researcher and science educator identified, inter-rater reliability coefficient was computed.

Inter-rater correlation was assessed using a two-way mixed, absolute agreement, single-measures intraclass correlation (ICC) to assess that a subset of drawings were coded by two raters and the reliability of their ratings is meant to generalize to the subjects rated by one coder, the researcher. The resulting ICC was .76 with a 95 % confidence interval ranging from .448 to .907. This indicates that coders had a substantial degree of agreement and suggesting that codes were rated similarly across coders. The ICC value suggests that a minimal amount of measurement error was introduced by the independent coders, and therefore statistical power for subsequent analyses is not substantially reduced. Coding was therefore deemed to be suitable for use in the hypothesis tests of the present study (Hallgren, K. A., 2012).

4.1.2 Determining Basic Codes and Common Codes

Fifteen codes/core concepts determined as a result of initial readings of the drawings were grouped into typologies so as to construct students' mental models. Mental models were constructed according to the concepts reflected by the codes. Codes related to causes and results of greenhouse effect (C1, C2, C3, C4, C12), for example, are defined as to make Model 1 and defined as "Reasons and Results of Greenhouse Effect" (Table 4.1).

While constructing the models, on the other hand, codes/core concepts were treated as 2 types; being *basic codes* and *common codes*. *Basic codes* for each model are defined as the basic indicators of the model and these are special for that model. That is to say, basic codes for Model 1, for example, are deterministic only for Model 1, but not for any other model (Table 4.2). However, although "C1 (Gaseous emissions of industrial and domestic sources)", for example, is the basic code for the Model 1, it is common code for the other models. Because, in the drawings that are defined as Model 1, emissions from industrial and domestic sources (C1) is seen as the major source of greenhouse effect (Figures 4.1a, 4.1c, 4.5, 4.7). Whereas, those sources (C1), in the drawings for Model 2, for example, do not make up the core of that model, instead they are appeared as just side/supportive actors (Figure 4.9b).

Common codes, on the other hand, are not specific for the models; instead they appear in several of the drawings in addition to basic codes. Therefore, the basic codes determined for the Model 1, for example, may be appeared as a *common code* in other drawings of other models (Table 4.2).

The reason for defining 2 types of codes, therefore, is for the sake of being more representative and realistic for constructing the models. Defining Model 1, for example, with only its basic codes (C1, C2, C3, C4, C12), would cause the meaning that the drawings of this model contain only those codes/core concepts, which is not the real case. The reality is, the drawings of the model reflect mainly the concepts of the main codes, but although not being as strong as the concepts defined by the basic codes, drawings also reflect additional concepts that are shown by the common codes.

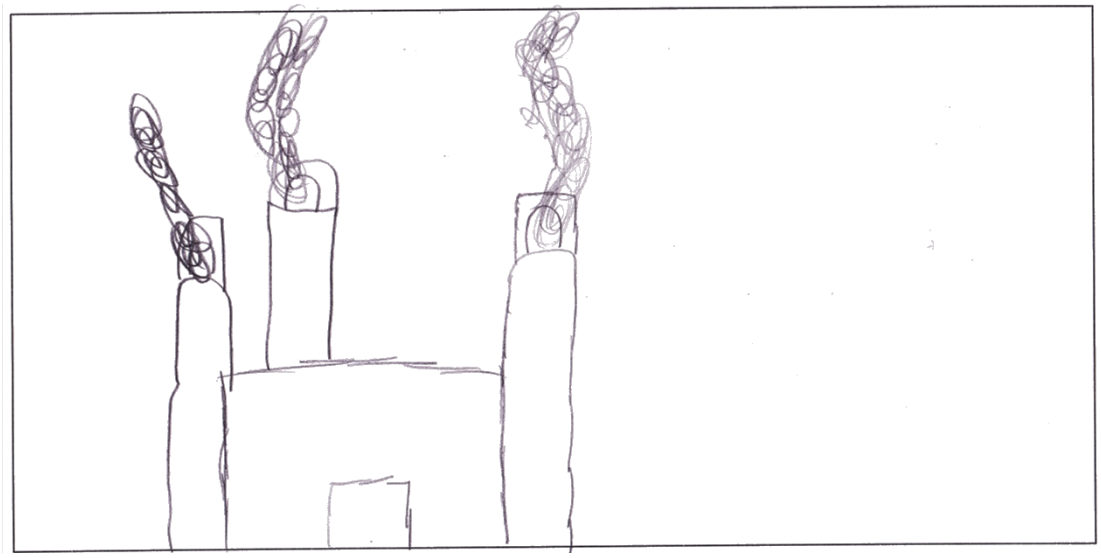
4.1.3 Constructing Mental Models

Mental models were constructed based on the basic codes, determined in the former step. As a result of categorizing basic codes and according to the concepts they deliver, 5 mental models were constructed and numbered and sequenced, without any value judgment, in Table 4.2.

Table 4.2 Mental models of greenhouse effect of 7th grade elementary students

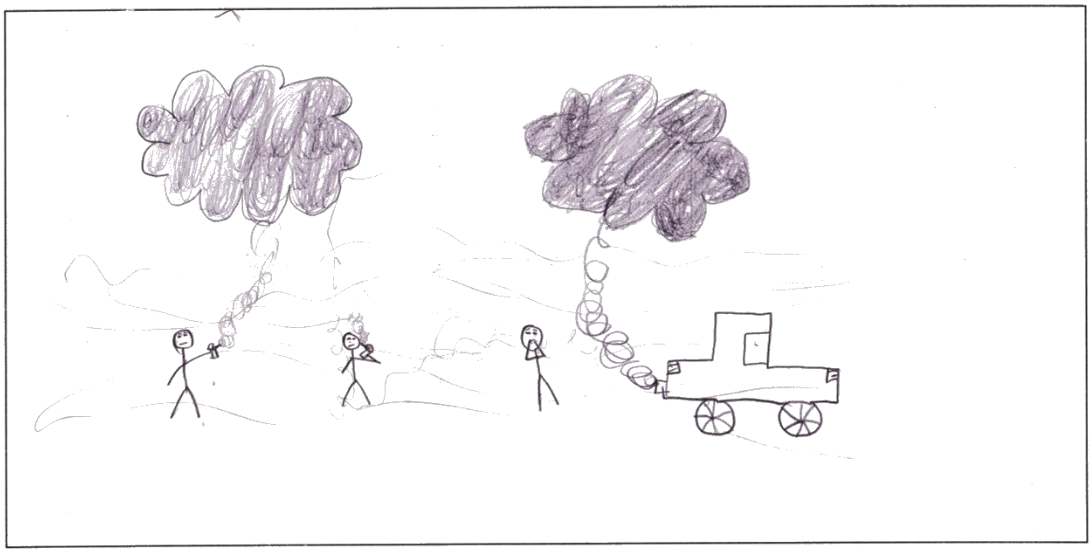
Model	Frequency	Basic Codes	Common Codes
1: Reasons and Results of Greenhouse Effect	39	C1, C2, C3, C4, C12	C6, C8, C11
2: Misconception - Ozone Layer Depletion and Greenhouse Effect – *Model 2/a: Holes in ozone layer as a reason for greenhouse effect(12)* – *Model 2/b: Ozone layer as a layer of greenhouse gases (7)* – *Model 2/c: Sources causing ozone layer depletion and/or global warming(11)*	30	C7, C9, C13,	C1, C2, C3, C4, C6, C8, C11
3: Misconception – Daily Temperature Difference	10	C10	C1, C2, C8, C11
4: Scientific Explanation of Greenhouse Effect	24	C5	C1, C2, C3, C4, C6, C8, C11, C12
5: Misconception – Greenhouse used for Agricultural Purposes	2	C14	-

As presented in Table 4.2, Mental Models 1 and 2 were constructed by more than one basic code, whereas others (models 3, 4, and 5) were constructed by one basic code. This result is parallel to the distribution of the determined codes: Five of the codes out of 15 in Table 4.1 are related to the model "reasons and results of the greenhouse effect". Besides, 3 of the codes, out of 15, are related to ozone layer depletion problem. Therefore, the resulted mental models 1 and 2, which are related to reasons and results of greenhouse effect and misconception related to ozone layer, reflect this distribution as having more than one code (Figure 4.1). There is only 1 code related to scientific explanation, thus the related model has a single code. Similarly, there is only 1 code determined for greenhouse used in agriculture and daily temperature difference, thus corresponding models are described by only 1 code.



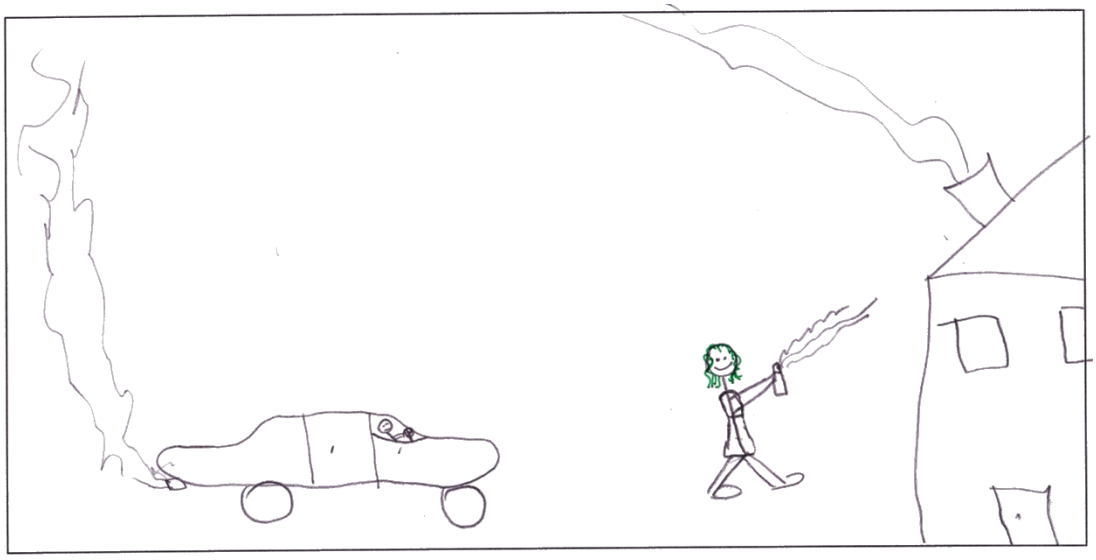
a. C1 as a basic code: industrial and domestic emission

Student's explanation: *"I explained industrial emission of factory in my drawing." (Student 2)*



b. C2 and C3 as basic codes: deodorants, perfumes and exhaust gases

Student's explanation: *"Many people damage the environment by cars and deodorants." (Student 45)*

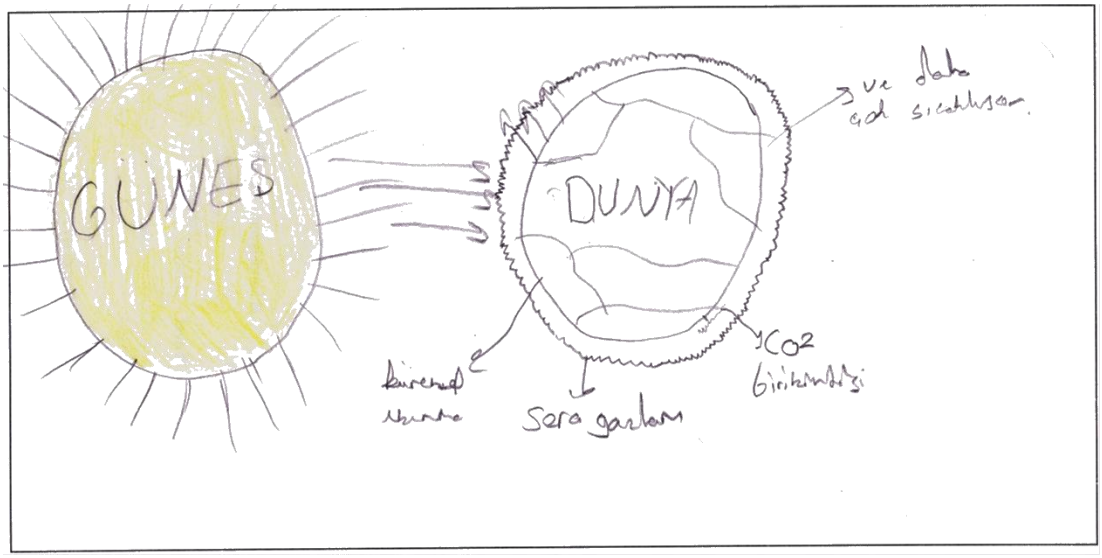


c. C1, C2, C3 as basic codes: “industrial and domestic emissions, deodorants and perfumes and exhaust gases”
Student’s explanation: *“I drew greenhouse gases in the environment.” (Student 36)*

Figure 4.1 Student drawings representing ‘basic codes’ of Model 1

The most prevalent “common codes” determined for the mental models are; industrial and domestic emissions (C1), deodorants and perfumes (C2), exhaust gases (C3), indicators of environmental impact (C4), greenhouse effect and global warming relation (C6), CO_2 (C8), and natural greenhouse effect (C11). Four of the mental models contain at least one of these common codes. CO_2 (C8) and natural greenhouse effect (C11), for example, exist in four mental models (Models 1, 2, 3 and 4) and greenhouse effect and global warming relation (C6) exist in three mental models (Models 1, 2 and 4).

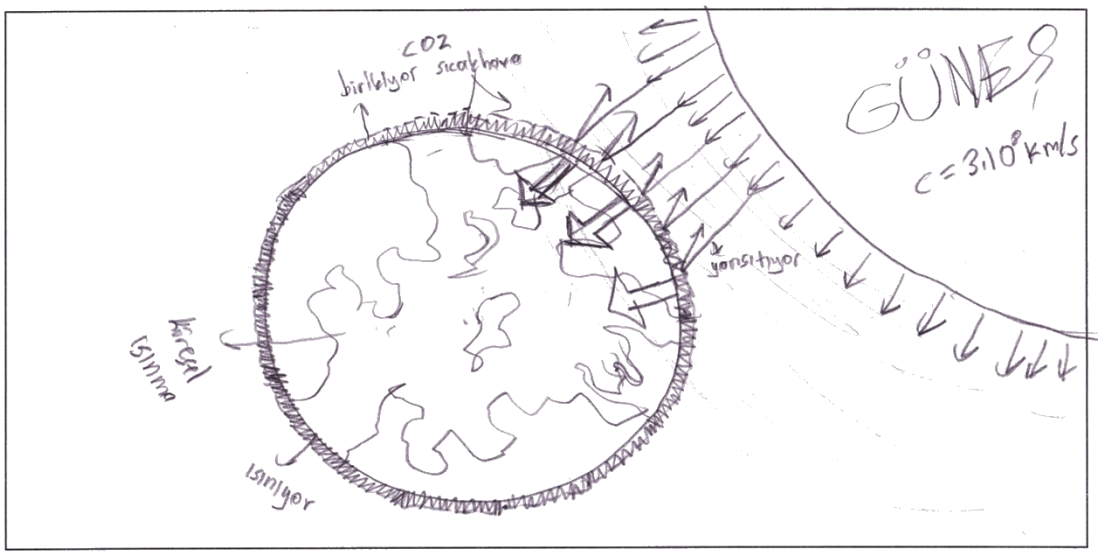
Among these frequently mentioned common codes, “greenhouse effect and global warming relation (C6)” was mentioned as a common code by 7 students in Model 1, 8 students in Model 2, 1 student in Model 3 and 4 students in Model 4. The drawing in Figure 4.2 below belongs a student who held Model 4 – scientific explanation of greenhouse effect – and it serves as an example of “greenhouse effect and global warming relation (C6)” as a common code (Figure 4.2, 4.3).



Student's explanation: *"Sun lights are reflected back by the Earth. However, CO_2 producers such as factories and exhausts cause global warming." (Student 103)* (Basic code: C5; common codes: C6, C8)

Figure 4.2 Student drawings representing C6 as a common code

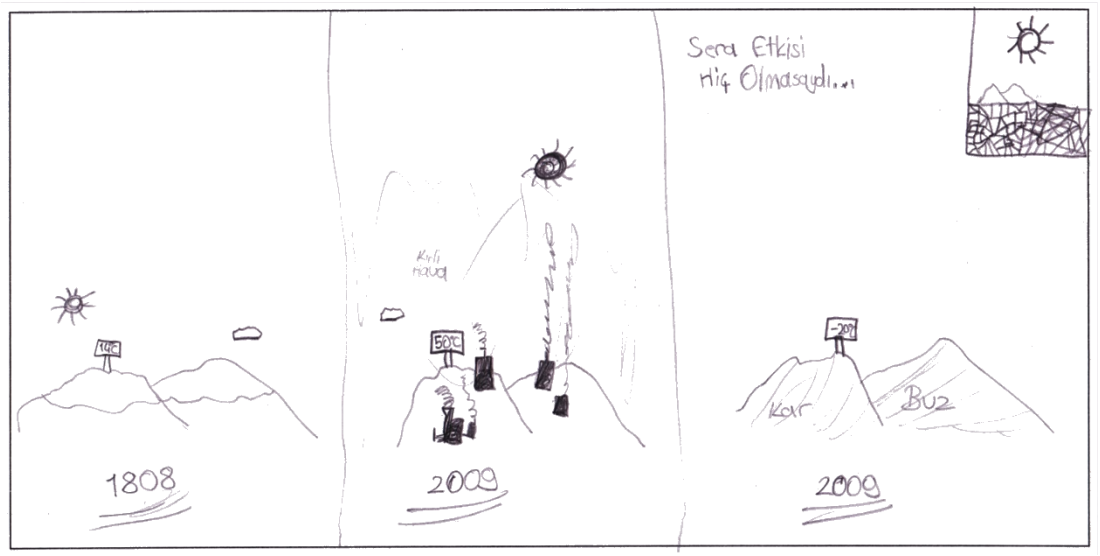
Another frequently used common code, CO_2 (C8) was mentioned as a common code, by 5 students in Model 1, by 2 students in Model 2, and by 4 students in Model 4. Figure 4.3 illustrates a drawing for Model 2/a, holes in ozone layer as a reason for greenhouse effect. Besides C7 as a basic code, it also includes C6 and C8 as common codes.



Student's explanation: *"Sun rays are reflected back in my drawing. This was good but poisonous gases in the Earth cause ozone depletion and more Sun lights to come in. Therefore, global warming occurs and both the Earth and people are affecting negatively." (Student 107)* (Basic code: C7; common codes: C6, C8)

Figure 4.3 Student drawings representing C8 as a common code

Another frequently drawn common code, "Natural greenhouse effect (C11)" was mentioned as a common code by 1 student in Model 1, 1 student in Model 2, 6 students in Model 3 and by 1 student in Model 4. The drawing in Figure 4.4 is an example of Model 1 – results of greenhouse effect – and it includes two common codes that are "natural greenhouse effect (C11)" and "greenhouse effect and global warming relation (C6)" beside of one common code, "indicators of environmental impacts (C4)".



Student's explanation: *"The Earth encounters global warming because of greenhouse effect. If greenhouse effect did not exist, the Earth would be mass of ice, Turkey become a glacier, 10 meters high snow would be in Europe, and USA would have hard times etc." (Student 100)* (Basic code: C4; common codes: C6, C11)

Figure 4.4 Student drawings representing C11 as a common code

Industrial and domestic emissions (C1) and deodorants and perfumes (C2) exist in 3 mental models (Models 2, 3, 4) as a common code. Industrial and domestic emissions (C1) were mentioned by 22 students as a basic code in Model 1. Whereas, it was mentioned, as a common code, by 12 students in Model 2, by 1 student in Model 3 and 4 students in Model 4. Deodorants and perfumes (C2) were mentioned by 12 students as a basic code in Model 1. However, C2 was mentioned, as a common code, by 19 students in Model 2, by 1 student in Model 3 and by 3 students in Model 4.

The results about frequencies (number of drawings) of basic and common codes are worth of attention, because this may be an implication that, although students have a major perception in their minds that they reflect in their drawings, they may have thoughts of several other issues which are not as clear as the major perception. This may be attributed either to students not having enough knowledge on greenhouse

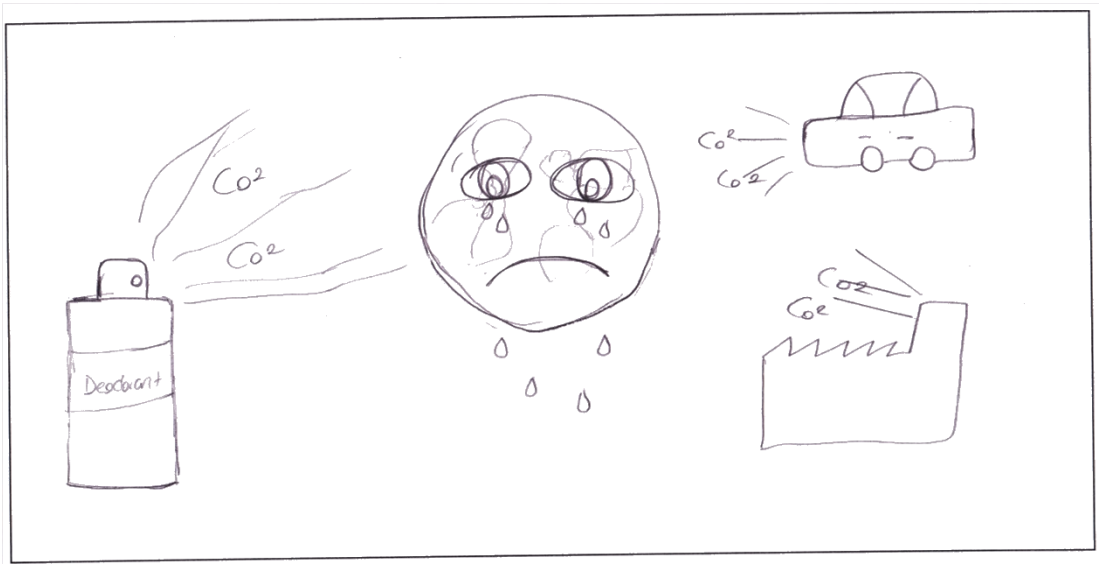
effect or they have difficulties in making relations between what they have learnt so far.

In the pending sections, therefore, the results on the mental models of 7th grade elementary students on greenhouse effect will be given in more details, according to each model.

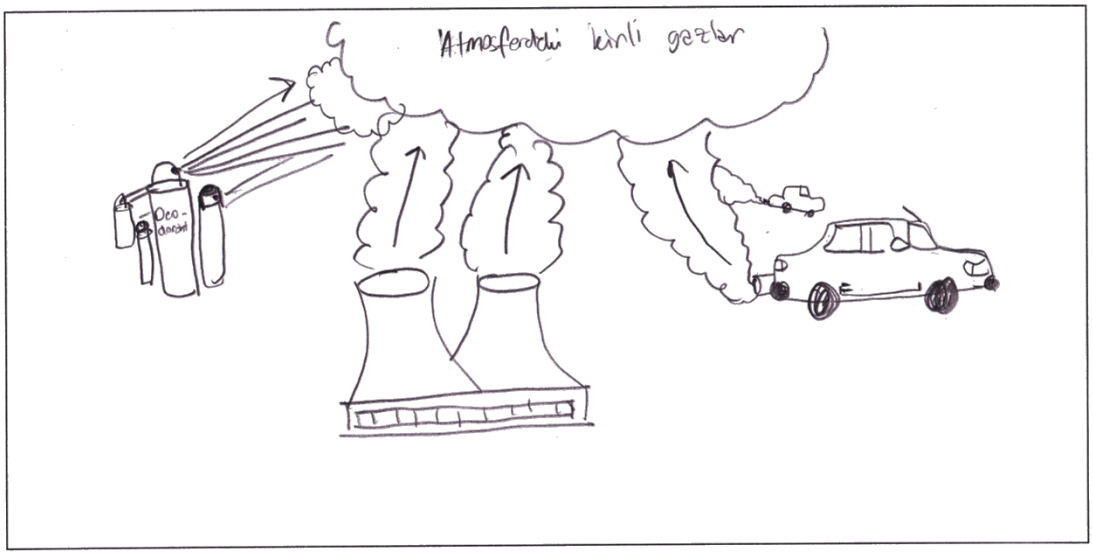
4.2 Mental Models of 7th Grade Elementary Students on Greenhouse Effect

4.2.1 Model 1: Reasons and Results of Greenhouse Effect

Greenhouse effect mental models of 39 elementary students of this study are defined by Model 1. This is the most common mental model determined and number of students of this model represents 36 % of the whole sample. Almost 80 % (n = 31) of the students of this group focused, in their drawings, on the reasons of greenhouse effect and the rest (20 %, n = 8) focused on results of greenhouse effect (Figures 4.5, 4.6).



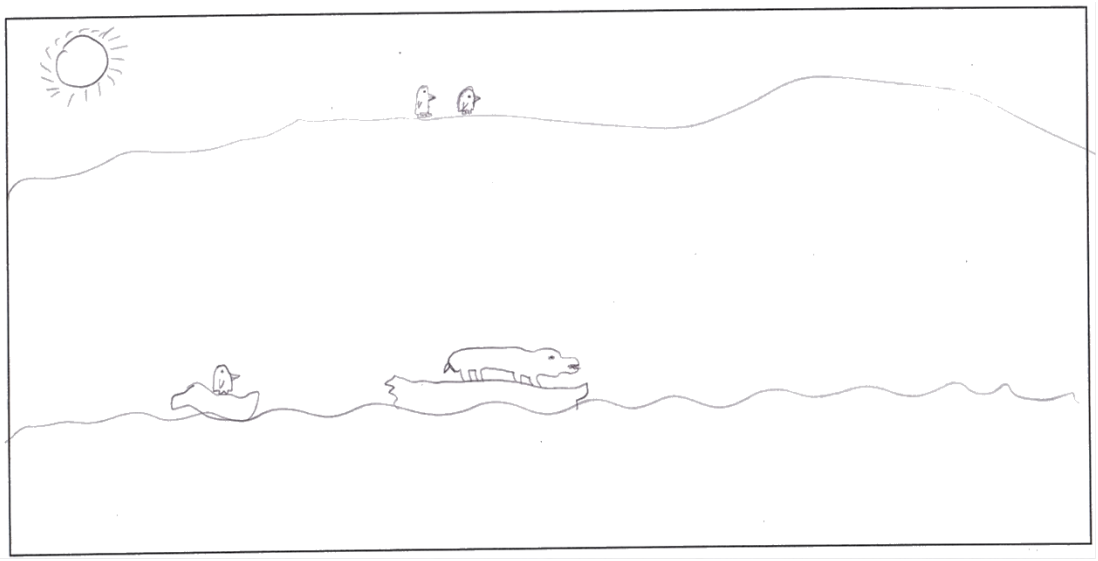
a. Student's explanation: *"In fact, a lot of things that become part of our daily lives, cause damage to the Earth and human beings. We should give up and replace them. Deodorants, emissions from factories and exhaust gases are the examples of greenhouse effect." (Student 73)* (Basic codes: C1, C2, C3; common code: C8)



b. Student's explanation: "*In the lower part of my drawing, I drew reasons of deposition of pollutant gases in the atmosphere. In the upper part, I drew gases that cause global warming." (Student 16)* (Basic codes: C1, C2, C3; common code: C6)

Figure 4.5 Student drawings: Mental Model 1 (Reasons of greenhouse effect)

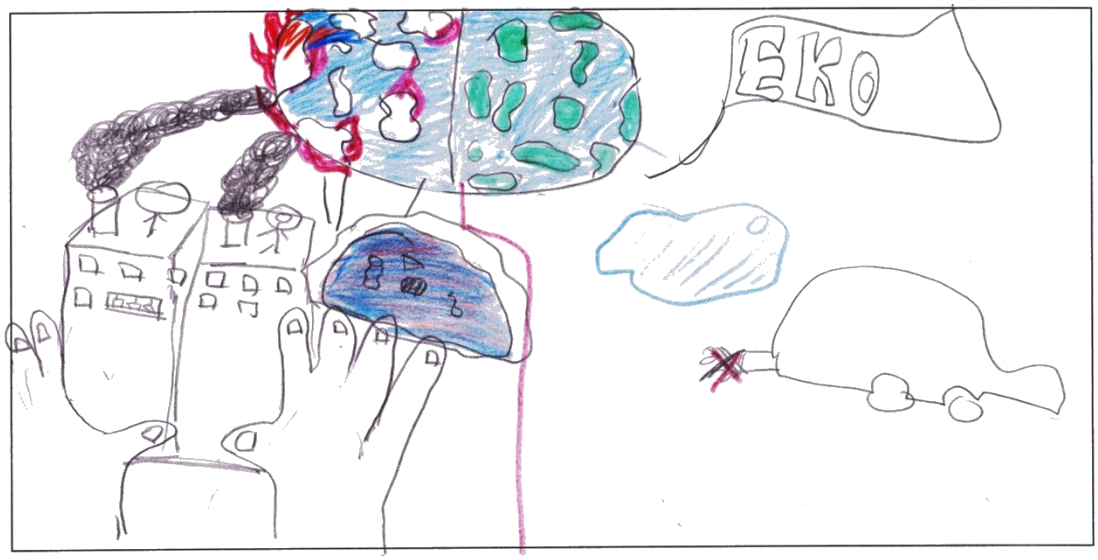
a. Student's explanation: "*The Earth is getting hotter by greenhouse effect. CO_2 is increasing. Therefore, poles are melting which causes floods and other natural disaster, which means global warming." (Student 97)* (Basic code: C4, Common Codes: C6, C8)



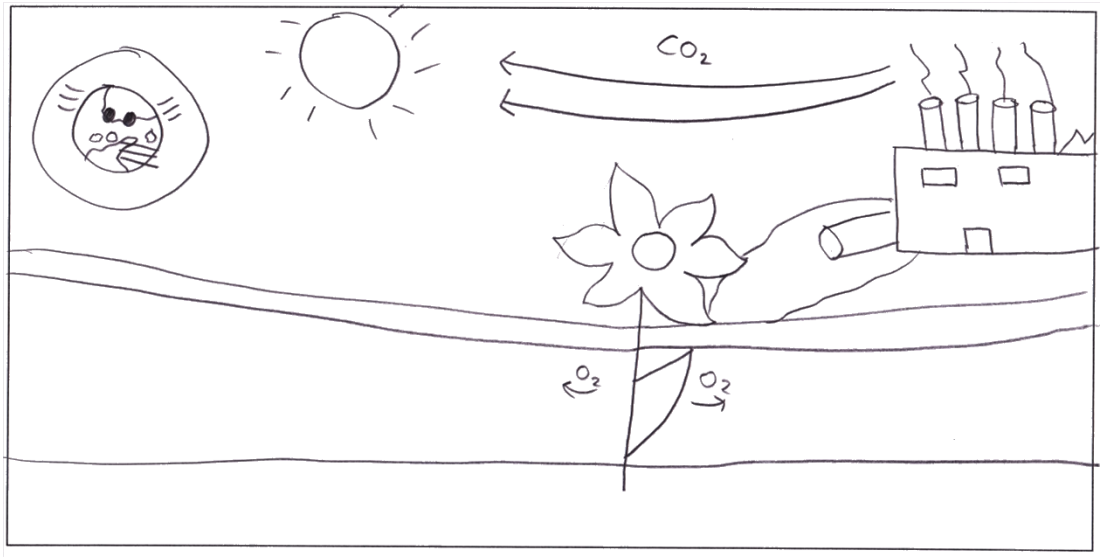
b. Student's explanation: "*In my drawing, I tried to emphasize glaciers that are melting because of global warming. This causes puddle and most of the animals live in the North Poles suffocate. Sea levels are increasing, lands are decreasing. We made it to the Earth and still we are doing it. " (Student 108)* (Basic code: C4, common code: C6)

Figure 4.6 Student drawings: Mental Model 1 (Results of greenhouse effect)

At least one of the basic codes for Model 1 (C1, C2, C3, C4, C12) appears in the students' drawings. However, although they are mentioned as frequently as the basic codes, it is also possible to find common codes (C6, C8, C11) in the drawings of this model (Figure 4.7).



a. Student's explanation: *"In my drawing the Earth has two parts. One includes the elements that pollute the environment and cause global warming. Second one includes the elements that provide sustainability and deserve the word 'eco'." (Student 3)* (Basic code: C1, C3, C12; common code: C6)



b. Student's explanation: *"A factory emits CO_2 and this cause air pollution. Flower produces O_2. As to, the Earth becomes polluted because produced CO_2 is more than produced O_2. Consequently, some environmental problems such as global warming and greenhouse effect appear." (Student 13)* (Basic code: C1; Common codes: C6, C8)

Figure 4.7 Examples of common codes for Model 1

By the basic codes of Mental Model 1, 80 % (n = 31) of the students of this model told that, the major reasons of greenhouse effect are gaseous emissions from industrial and domestic sources (C1), exhaust gases (C2), and/or deodorants/perfumes (C4) (Table 4.3; Figures 4.1, 4.5, 4.7). In addition, 8 (20 %) of the students based their drawings on the results of greenhouse effect, by means of desperate penguins or polar bears on melting glaciers (n = 1), rise in atmospheric temperature (n = 4), droughts (n = 1), injured or dead animals (n = 3), deforestation (n = 2), changes in seasons (n = 2), floods (n = 1), migrations of birds (n = 1) (Table 4.3; Figure 4.6). By just looking at this result, one can say that students with Mental Model 1 had an idea that, greenhouse effect is a problem and is caused by gaseous emissions and the results are seen in various areas.

However, common codes of Model 1 (C6, C8, C11) have been seen in just very few of the drawings, 1 of the students, for example, drew greenhouse effect as a natural phenomenon, 5 of the students mentioned about CO_2 emissions as a source of greenhouse effect, other 7 students stated greenhouse effect as a global problem known as global warming (Table 4.3). Thus, the students have difficulties integrating natural greenhouse with that of the artificial one, instead they use two concepts (greenhouse effect and global warming) as the place of other.

Table 4.3 Mental Model 1: The frequencies for the basic and common codes

Code Number	Code	Frequency	Percentage
C1	**Emissions from industrial and domestic sources**	**22**	**56**
C3	**Exhaust gases**	**17**	**44**
C2	**Deodorant/perfume**	**12**	**31**
C4	**Indicators of environmental impacts (penguins/polar bears on melting glaciers, rise in temperature, droughts, , injured or dead organisms, deforestation, changes in seasons, floods, migrations of birds)**	**11**	**28**
C12	**Other sources of greenhouse effect (air conditioner, waste)**	**4**	**10**
C6	Greenhouse effect - global warming relation	7	18

Table 4.3 (continued)

C8	CO_2	5	16
C11	Natural greenhouse effect	1	3

Note. Percentages are based on the total group sample, n = 39.

That is to say, although most of the students with Mental Model 1 perceive greenhouse effect mainly by the reasons, such as emissions from various sources, and by the results, such as desperate polar bears, some of them have, although not very frequent, an idea in their mind about the relation between greenhouse effect – causes – results – and – global warming.

Thus, the following description of Mental Model 1 of 7th grade elementary students has been developed in line with the above results (Figure 4.8).

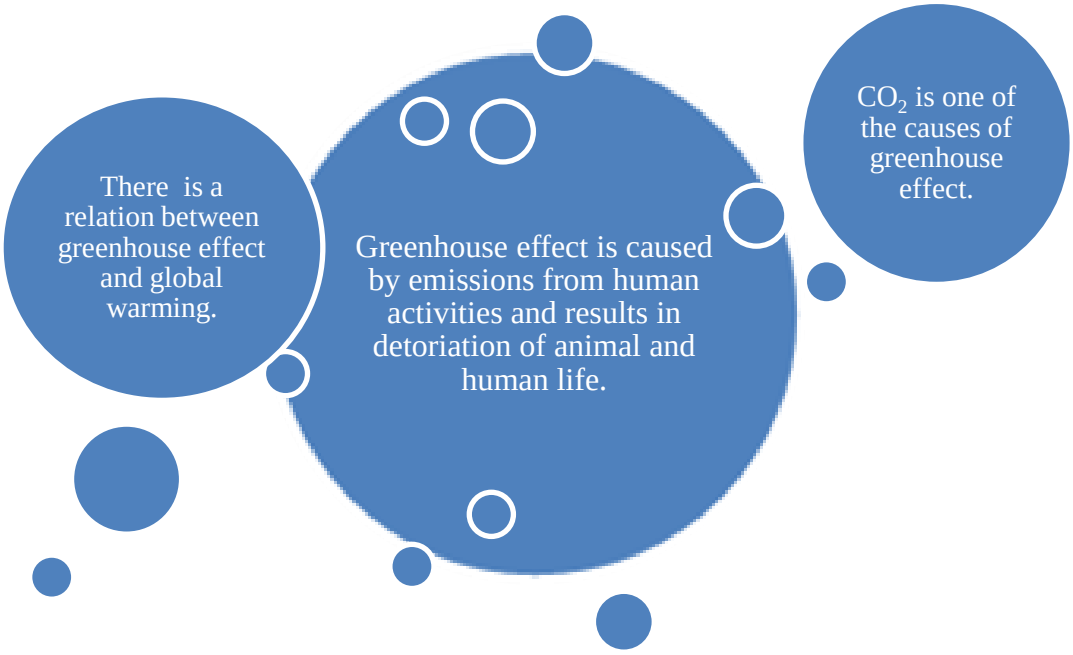


Figure 4.8 Mental Model 1: Reasons and result of greenhouse effect

4.2.2 Model 2: Misconception - Ozone Layer Depletion and Greenhouse Effect

Model 2 explains 28 % (n = 30) of the students' mental models for greenhouse effect. The basic and common codes for this model are C7, C9, C13 and C1, C2, C3, C4, C6, C8, C11 respectively (Table 4.2).

Model 2 reflects students' misconceptions related to ozone layer depletion and greenhouse effect. As is obvious from the basic codes of the model presented in Table 4.4, there are 3 modes of misconceptions, reflected through the basic codes C7, C9, C13, in the students' mental models. The first mode of misconception is related to thought about the holes in ozone layer as the reason for increasing Earth's atmospheric temperature. The second misconception is related to thought about just the sources without making connections with the phenomenon. The third, however, is related to replacing/confusing ozone layer with greenhouse gas layer.

Table 4.4 Mental Model 2: The frequencies for the basic and common codes

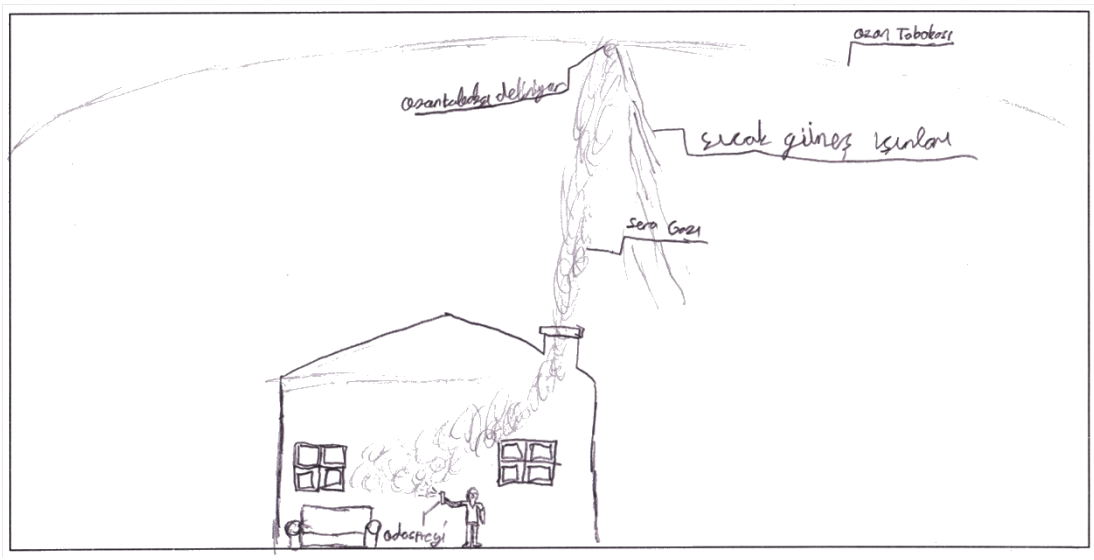
Code Number	Code	Frequency	Percentage
C7	**Holes in ozone layer as a reason for increasing Earth's atmospheric temperature**	**12**	**40**
C 9	**Causes for ozone depletion (deodorant, perfume, exhaust, gases, gaseous emissions of industrial and domestic sources)**	**11**	**37**
C13	**Ozone layer as an explanation for greenhouse effect**	**7**	**23**
C2	Deodorant/perfume	19	63
C1	Emissions from industrial and domestic sources	12	40
C3	Exhaust gases	10	33
C4	Indicators of environmental impacts (penguins/polar bears on melting glaciers, rise in temperature, droughts, endangered species, injured or dead organisms)	8	27
C6	Greenhouse effect - global warming relation	8	27
C8	CO_2	2	7
C11	Natural greenhouse effect	1	3

Note. Percentages are based on the total group sample, n = 30.

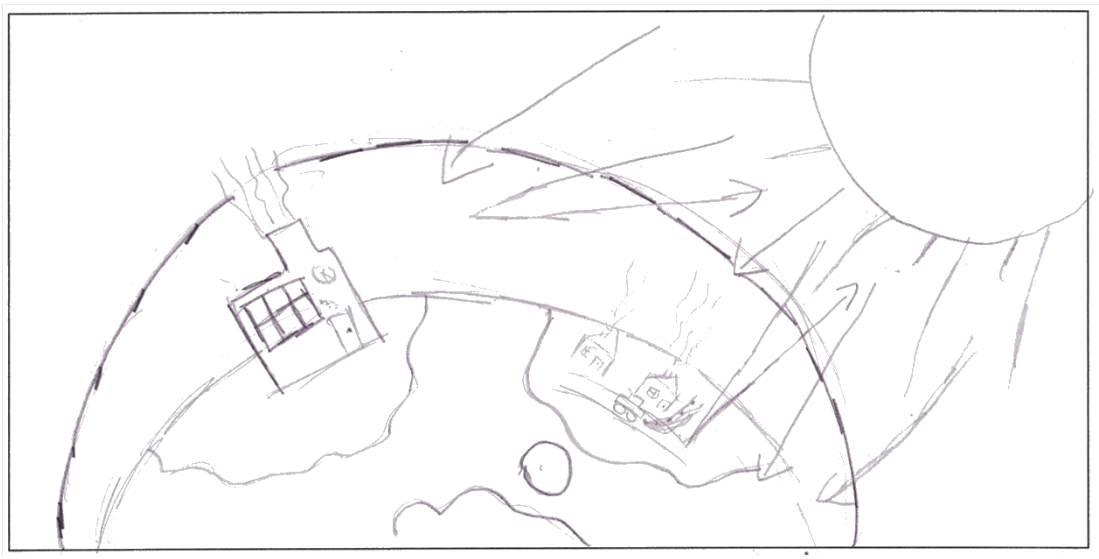
Therefore, these 3 modes of misconception that were identified under Model 2 were defined as sub-models and are explained below:

4.2.2.1 Model 2/a: Holes in Ozone Layer as a Reason for Greenhouse Effect

Twelve of the students (40%), out of 30, explained the holes in ozone layer as the reason for rising temperature on Earth's atmosphere. The first group of explanations indicated that, sun rays/sun's harmful rays/ultraviolet rays reach the Earth by means of the holes in ozone layer (Figure 4.9).



a. Student explanation: *"In this drawing, a men uses air freshener that destroys the ozone layer and thus harmful rays of the Sun reach to the Earth." (Student 54)* (Basic code: C7; common code: C2)

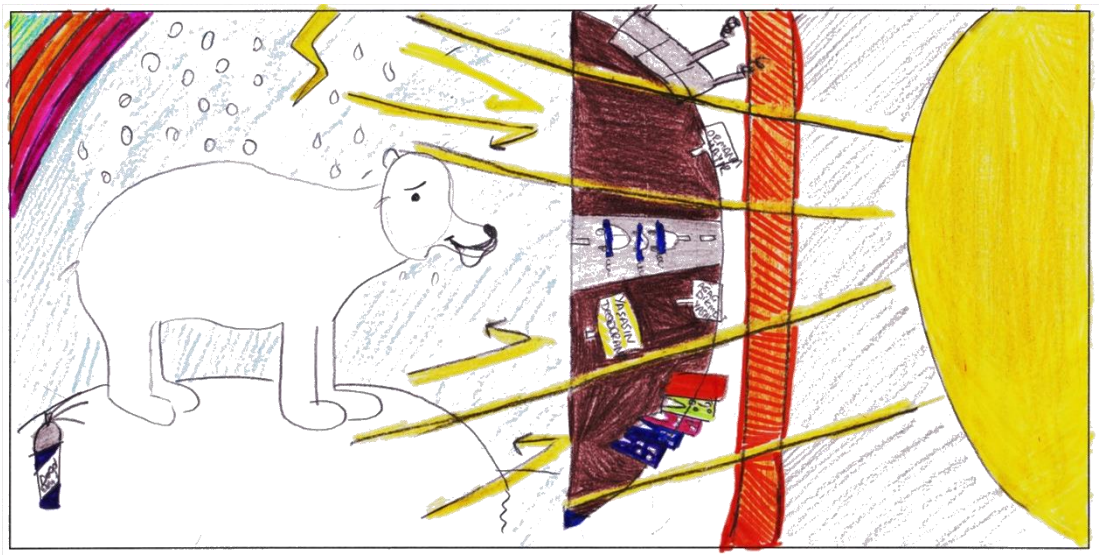


b. Student explanation: *"Sun's rays that reach the ozone layer are reflected back by the ozone layer. This prevents many Sun's rays from reaching the Earth and the world stays in balance. Various gases from factories, exhausts, perfumes and deodorants (with greenhouse gases) deplete the ozone layer and then more Sun's rays come into the Earth." (Student 99)* Basic code: C7; common codes: C1, C2, C3)

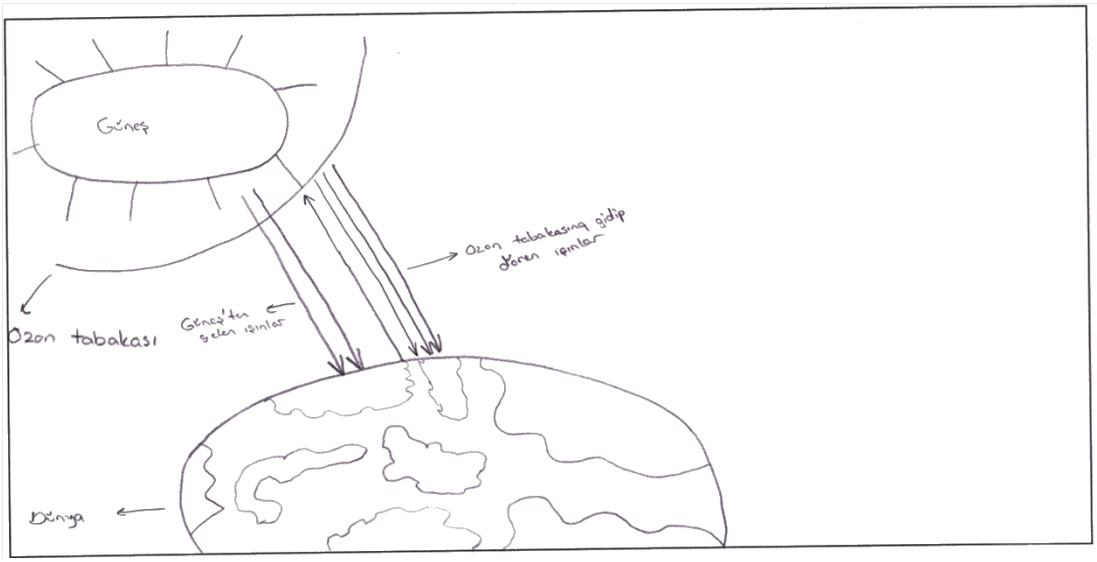
Figure 4.9 Student drawings: Mental Model 2/a

4.2.2.2 Model 2/b: Ozone Layer as a Layer of Greenhouse Gases

Seven of the students (23 %) out of 30, drew and explained greenhouse effect through defining the layer of greenhouse gases as the ozone layer (Figure 4.10).



a. Student's explanation: *"Sun's rays that come to the Earth reflected back to the Earth by ozone layer because of thickness of ozone layer and warm the Earth. It results from factories and urbanization and cause that living organisms suffer." (Student 75)* (Basic code: C13; common codes: C1, C2, C3, C4)

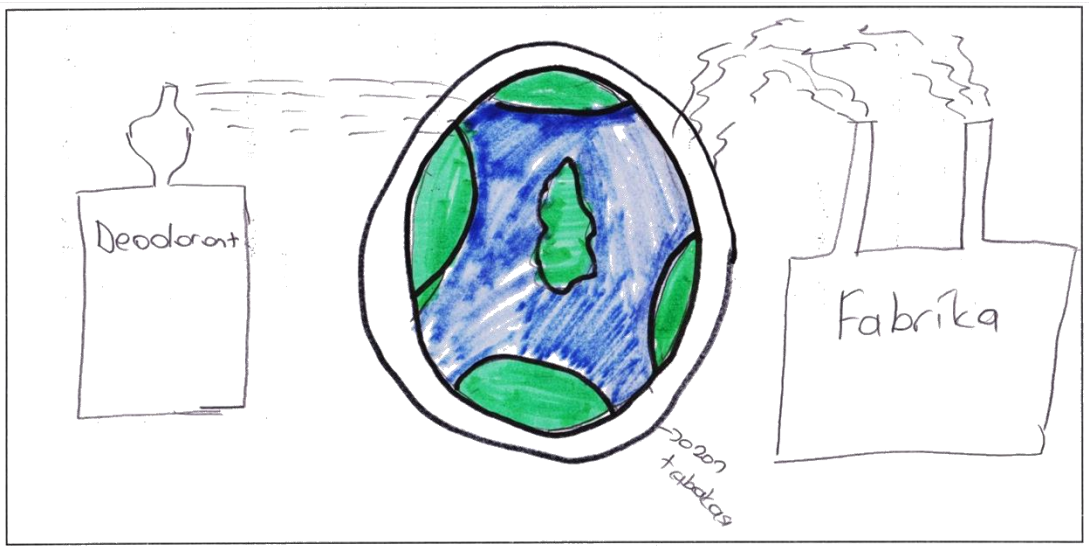


b. Student's explanation: *"Earth reflects Sun's rays to the space but ozone layer reflects these rays back to the Earth. These rays overheat the Earth and the Earth is exposed to global warming." (Student 37)* (Basic code: C13; common code: C6)

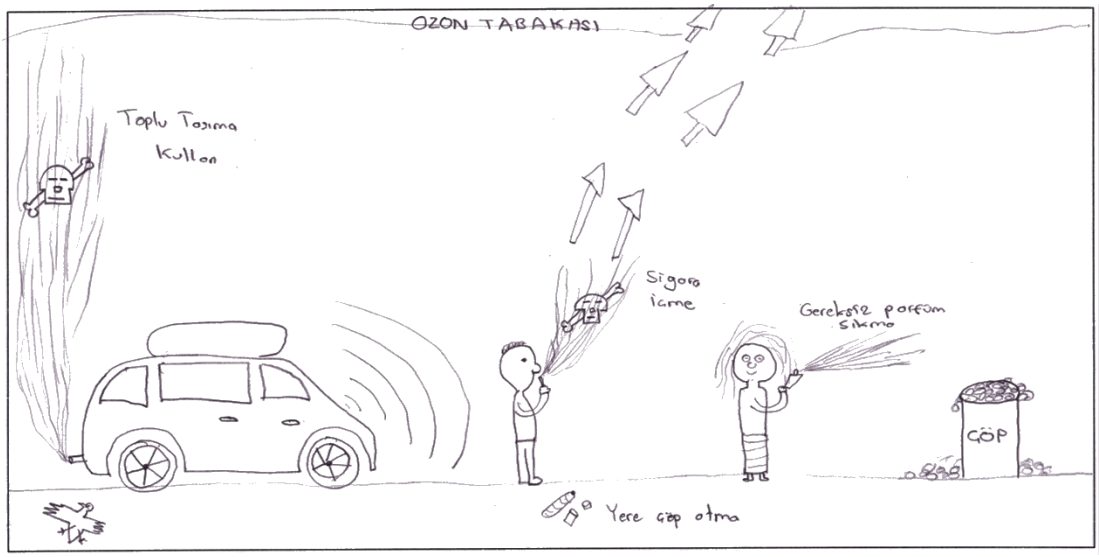
Figure 4.10 Student drawings: Mental Model 2/b

4.2.2.3 Model 2/c: Sources Causing Ozone Layer Depletion and/or Global Warming

Eleven of the students (37 %) out of 30, drew and explained just the sources for ozone depletion and/or greenhouse effect as, deodorants/perfumes, exhaust gases, and/or emissions from industrial and domestic sources without any explanation about the phenomenon (Figure 4.11).



a. Student's explanation: *"Deodorants and factories cause ozone depletion and this causes global warming, and animal species are decreasing." (Student 59)* (Basic code: C9; common code: C1, C2, C4, C6)



b. Student's explanation: "*We should use public transportation. We should not use perfumes unnecessarily because perfumes increase the amount of greenhouse gases. Also, smoking can cause ozone depletion." (Student 49)* (Basic code: C9; common codes: C2, C3, C12)

Figure 4.11 Student drawings: Mental Model 2/c

Moreover, common codes for Model 2 are comprised of the codes related to reasons and results (C1, C2, C3, C4), global warming-greenhouse effect relationship (C6), CO_2 (C8), and natural greenhouse effect (C11). Reasons and results of greenhouse effect were mentioned by 22 students, global warming-greenhouse effect relationship was mentioned by 8 students, and natural greenhouse effect was mentioned by 1 student (Table 4.4).

As a result it can be conferred that, students with Mental Model 2 have some knowledge in their minds related to greenhouse effect but, their misconceptions prevent them making reasonable connections. If, for example, they could distinguish the places of ozone layer and greenhouse gases layer in the atmosphere it would be more easier for them to explain greenhouse effect, since they seem to know the basic scientific idea and the reasons and the results.

Therefore, geenhouse effect Mental Model 2 of the 7^{th} grade elementary students can be summarized by the following figure.

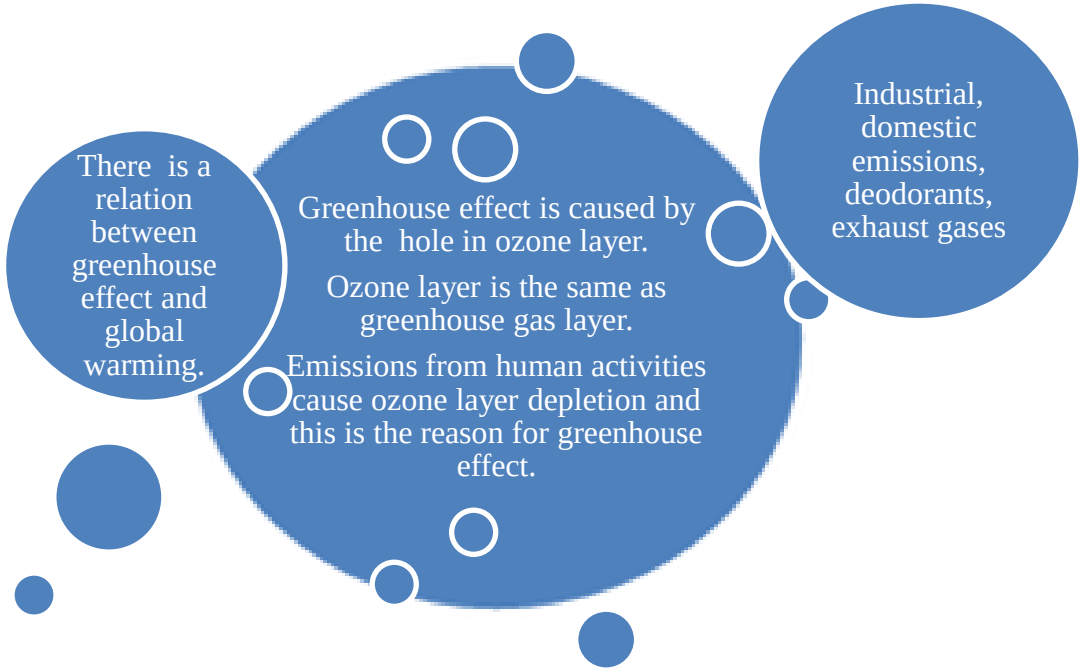


Figure 4.12 Mental Model 2: Misconception: Ozone layer depletion and greenhouse effect

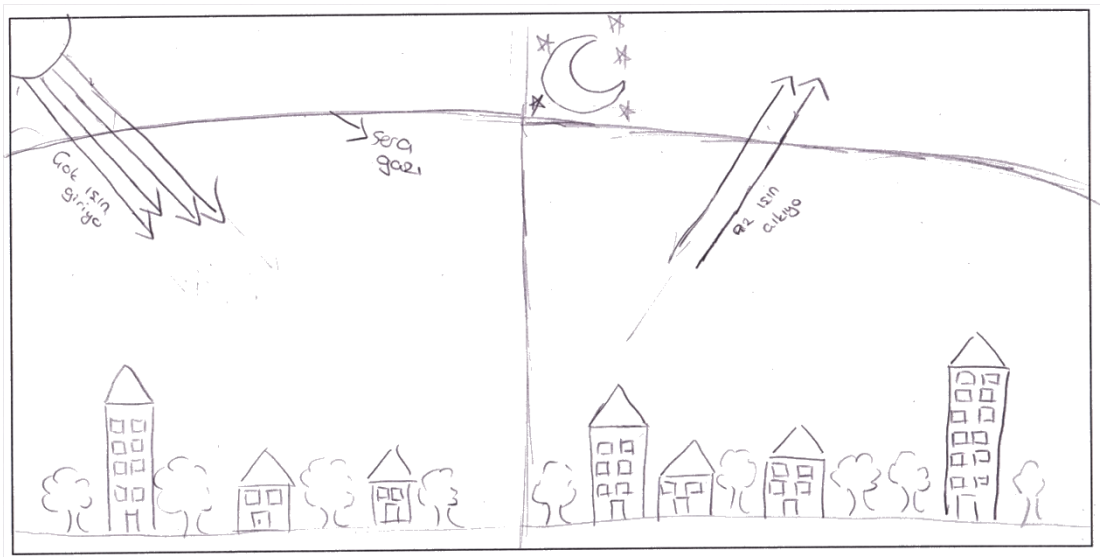
4.2.3 Mental Model 3: Misconception – Daily Temperature Difference

Ten (9 %) of the students' mental models are explained by Model 3. The basic idea of the students who have Mental Model 3 is that; sunlight that reaches the Earth in day time is reflected back to the atmosphere at night. The higher amount of sunlight reaching the Earth during day time, compared to that of reflected back to the space during night time, causes high temperatures during daytime and low temperatures during night time. Greenhouse gases are stated as the major actor in this system by the students. Thus, students with Mental Model 3 drew greenhouse effect as a night time phenomenon. Beside, 6 students (60 %) out of 10 also mentioned natural greenhouse effect to their drawings through common code C11 (Table 4.5 and Figure 4.13).

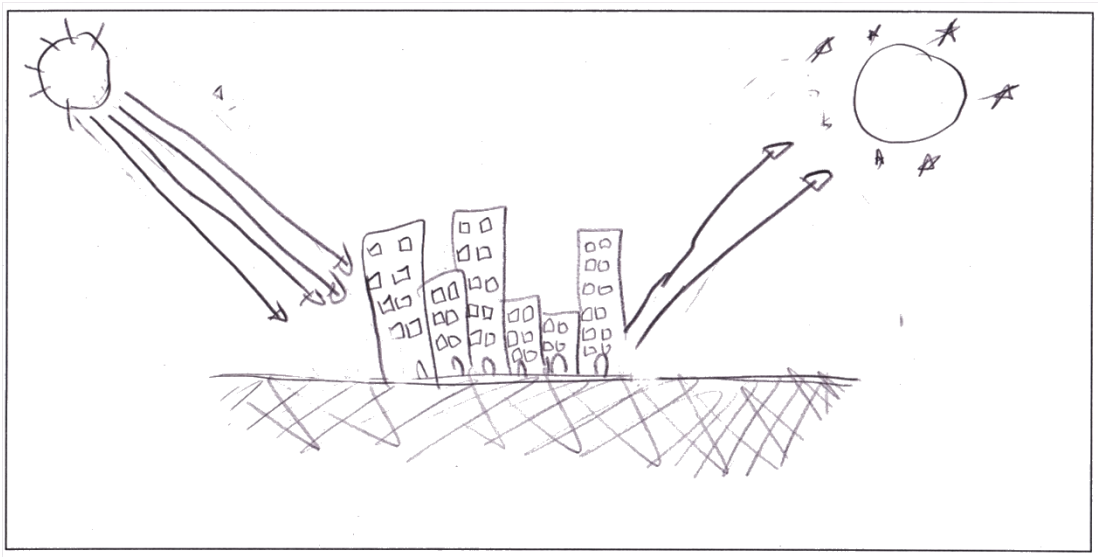
Table 4.5 Mental Model 3: The frequencies for the basic and common codes

Code Number	Code	Frequency	Percentage
C10	**Heating mechanism of greenhouse effect with misconception of daily temperature differences**	**10**	**100**
C1	Gaseous emissions of industrial and domestic sources	1	10
C2	Deodorant/perfume	1	10
C6	Greenhouse effect - global warming relation	1	10
C11	Natural greenhouse effect	6	60

Note. Percentages are based on the total group sample, n = 10.



a. Student explanation: *"Sunlight is reflected back at nights. But greenhouse gases absorb some of them to prevent Earth from freezing. Since the layer include greenhouse gases, the amount of incoming sunlight stays the same but the number of reflected rays decrease. Thus, the Earth's atmospheric temperature increases and this is called greenhouse effect." (Student 84)* (Basic code: C10; common code: C11)



b. Student explanation: *"If greenhouse gases did not exist, nights would be too cold. Therefore, greenhouse gases are vital. Greenhouse gases make days warm and nights cold. Sunlight is reflected back to the atmosphere from the Earth's surface, and is absorbed and reflected back to the Earth by greenhouse gases. By this way, greenhouse gases prevent Earth from freezing" (Student 90)* (Basic code: C10; common code: C11)

Figure 4.13 Student drawings: Mental Model 3

Therefore, greenhouse effect Mental Model 3 of the 7th grade elementary students can be summarized by the following figure.

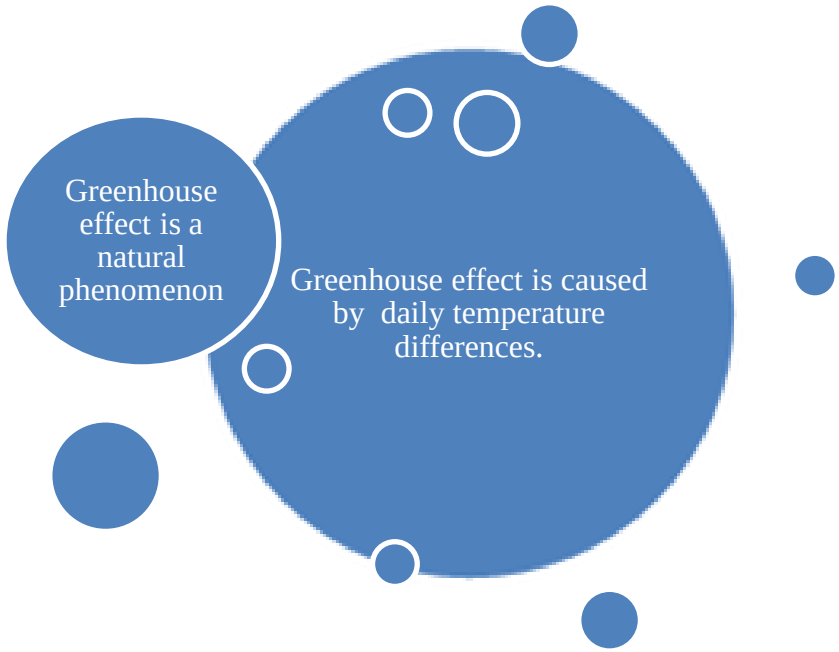


Figure 4.14 Mental Model 3: Misconception: Daily temperature differences and greenhouse effect

4.2.4 Model 4: Scientific Explanation of Greenhouse Effect

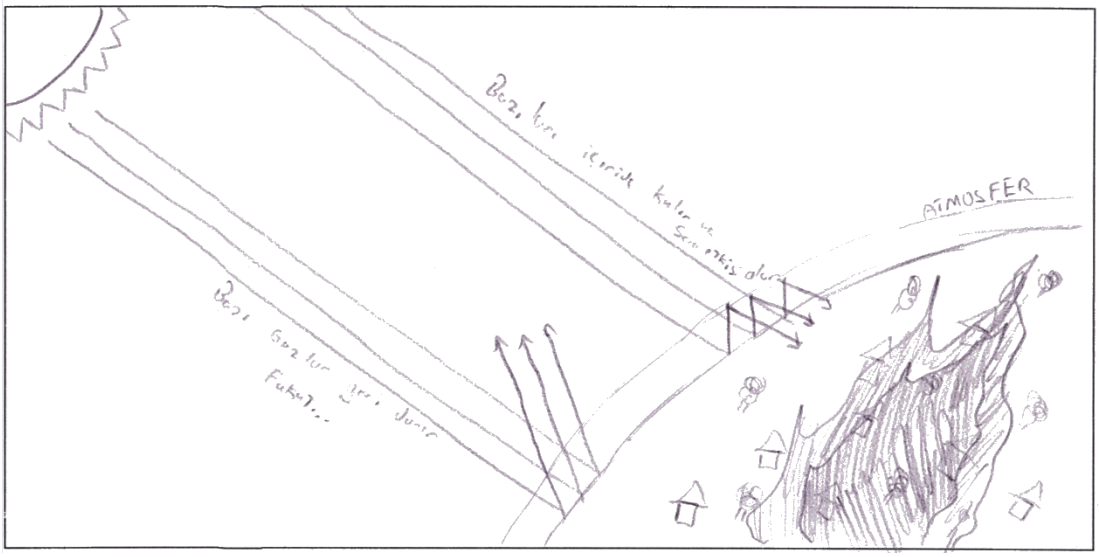
Twenty four students' (22 %) mental models on greenhouse effect can be explained by the Model 4. This group of students drew a scientific explanation for greenhouse effect. Therefore, students with Mental Model 4 can simply drew and explained that, greenhouse gases in the atmosphere absorb some of the sunlight that is radiated by the Earth's surface and emit this light back to the atmosphere, thus the atmospheric temperature increases. But still, just one of the students with Mental Model 4 drew or wrote about, greenhouse effect as a natural phenomenon and human activities causing the global warming.

Although, there are 24 students in this group who were able to explain greenhouse effect scientifically, 4 of them (17 %) mentioned about CO_2 as a greenhouse gas and no other greenhouse gases were mentioned (Table 4.6 and Figure 4.15).

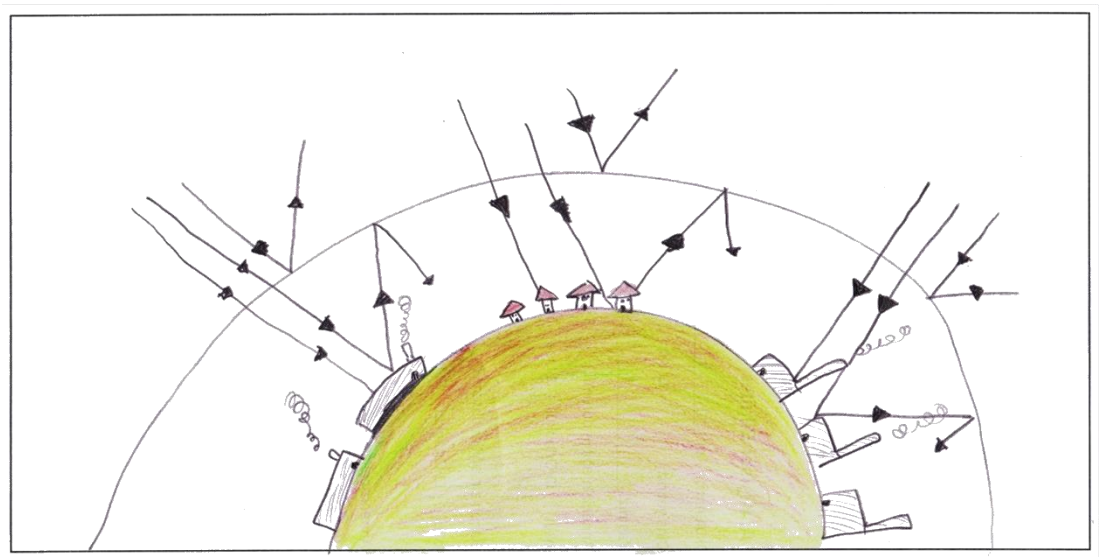
Table 4.6 Mental Model 4: The frequencies for the basic and common codes

Code Number	Code	Frequency	Percentage
C5	**Scientific explanation of greenhouse effect**	**24**	**100**
C1	Gaseous emissions of industrial and domestic sources	4	17
C2	Deodorant/perfume	3	13
C3	Exhaust gases	4	17
C4	Indicators of environmental impacts (penguins/polar bears on melting glaciers, rise in temperature, droughts)	4	17
C6	Greenhouse effect - global warming relation	4	17
C8	CO_2	4	17
C11	Natural greenhouse effect	1	4
C12	Other sources of greenhouse effect (waste, burning fossil fuels)	2	8

Note. Percentages are based on the total group sample, n = 24.



a. Student's explanation: *"Sunlight reaches to the Earth's surface and reflected back. However, some of the light can not go through the upper atmosphere because of CO_2 emissions of our cars. Therefore, the Earth becomes warmer; greenhouse effect and global warming occurs."* (Student 28) (Basic code: C5; common codes: C6, C8)



b. Student's explanation: *"Sun lights come to the Earth causes low temperatures since they are reflected back by atmosphere. However, increase amount of greenhouse gases in the atmosphere traps reflected lights to stay and make Earth warmer."* (Student 82) (Basic code: C5, common code: C1)

Figure 4.15 Student drawings: Mental Model 4

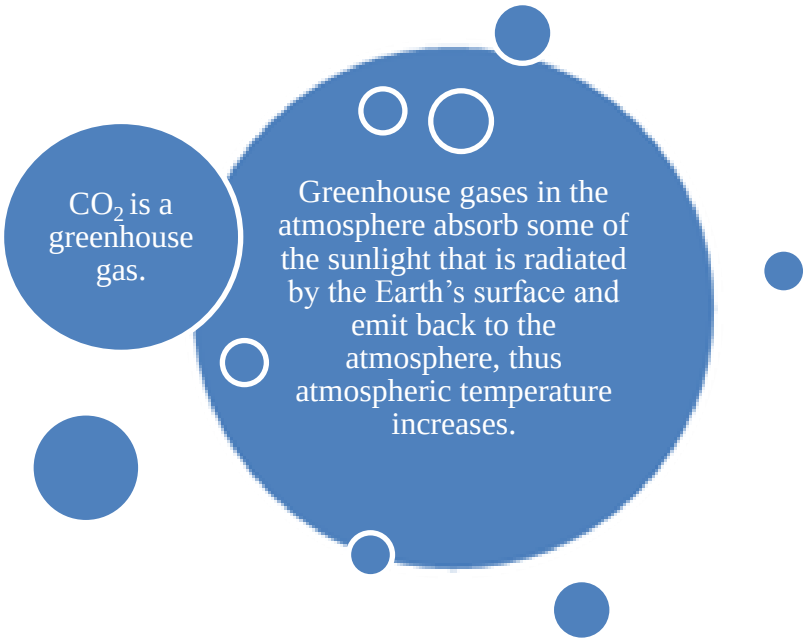


Figure 4.16 Mental Model 4: Scientific explanation of greenhouse effect

4.2.5 Mental Model 5: Misconception: Greenhouse Used for Agricultural Purposes

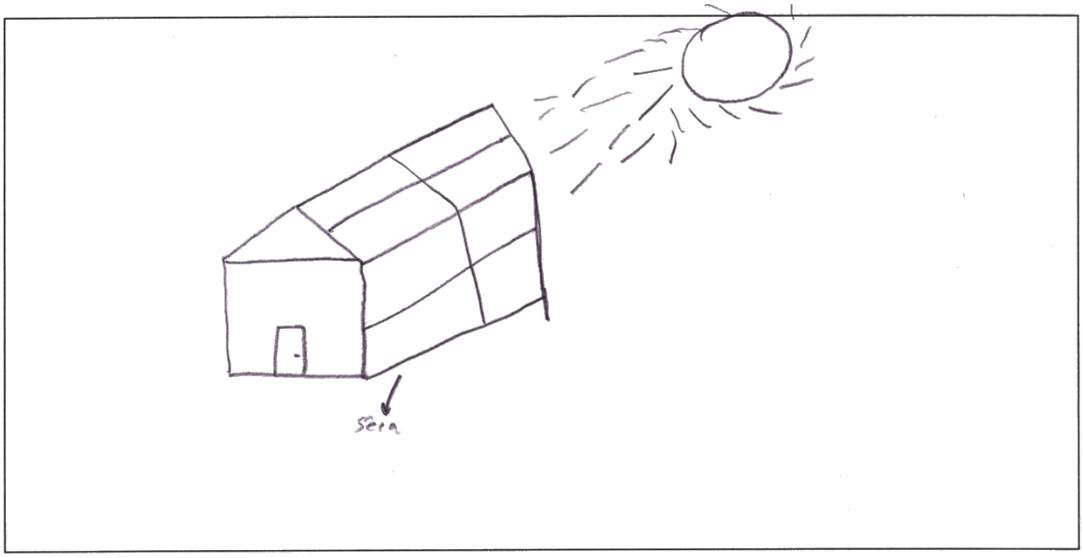
Although it is possible to explain 2 students' mental models with Model 5, it is found worthy to include the code as one of the mental models of this study. Because, what the model explains is a common misconception met in the related literature (Table 4.7; Figure 4.17).

The most interesting result related to this model, however, is that one student who drew a greenhouse did not draw anything else, like automobile exhausts or polar bears, etc. This result may be interpreted as either this student has never heard about greenhouse effect or although the students may have an idea, depending on several reasons, she/he may make a relation with a greenhouse. The other student who drew a greenhouse also drew a factory and a house. This result may be interpreted as this student has heard something about greenhouse effect but actually he/she did not know what greenhouse means and were not able to make connections.

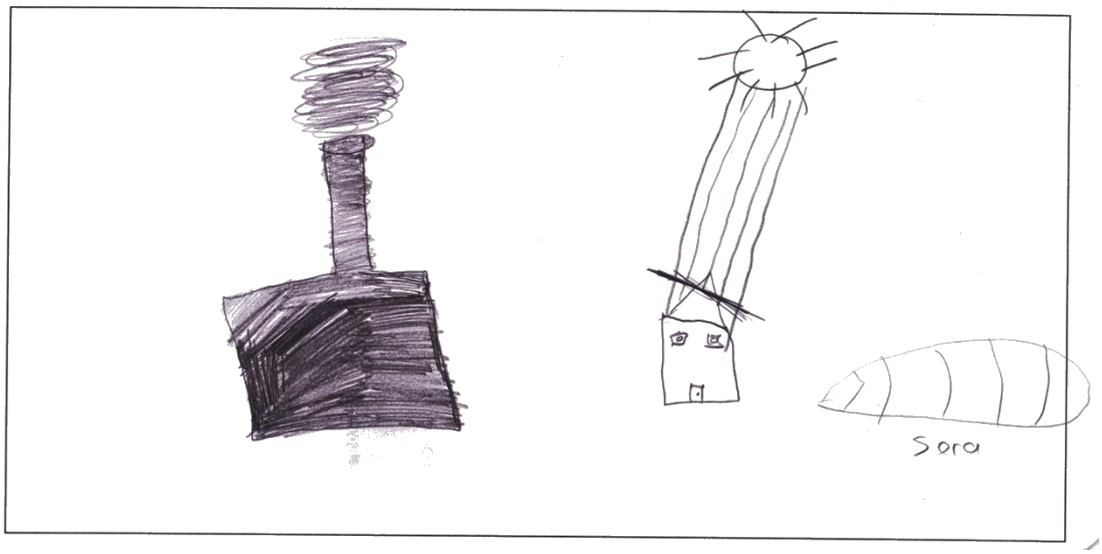
Table 4.7 Mental Model 5: The frequencies for the basic code

Code Number	Code	Frequency	Percentage
C14	Greenhouse used for agricultural purposes	2	100

Note. Percentages are based on the total group sample, n = 2.



a. Student's explanation: *"Fruits and vegetables grow in greenhouses that keep sunlight for any time in a year. " (Student 72)*(Basic code: C14)



b. Student's explanation: *"I drew a greenhouse because products grown in greenhouses include hormones and they pass our body by eating. Therefore, greenhouse is harmful. I also drew a factory because it emits harmful substances to the air. (Student 10)* (Basic code: C14)

Figure 4.17 Student drawings: Mental Model 5

Therefore, greenhouse effect Mental Model 5 of the 7th grade elementary students can be summarized by the following figure.

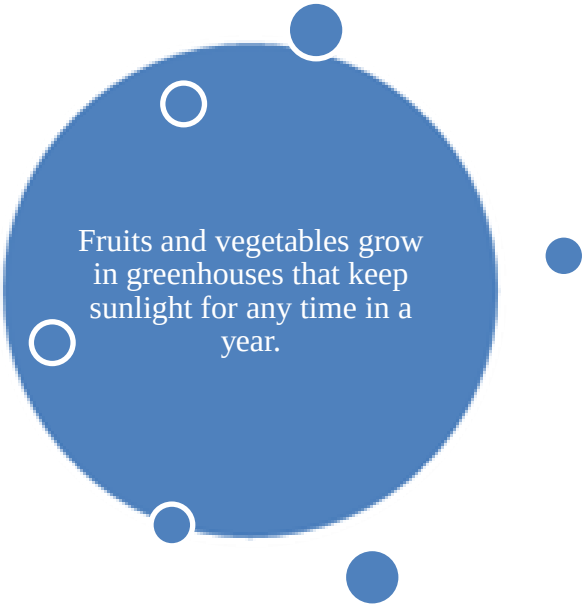
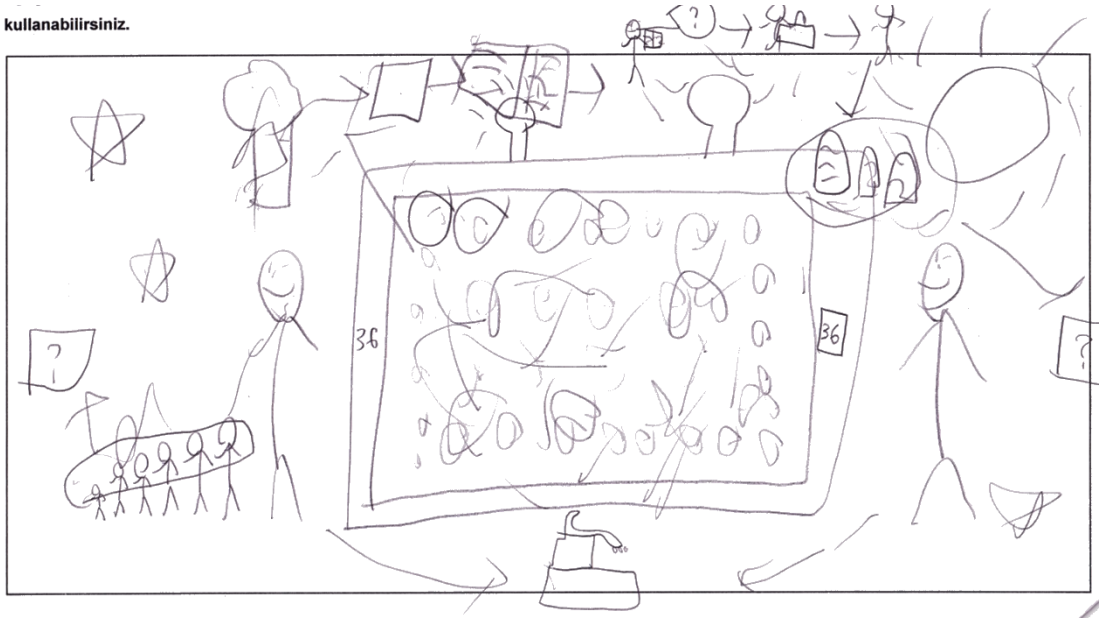


Figure 4.18 Mental Model 5: Misconception: Greenhouse used for agriculture

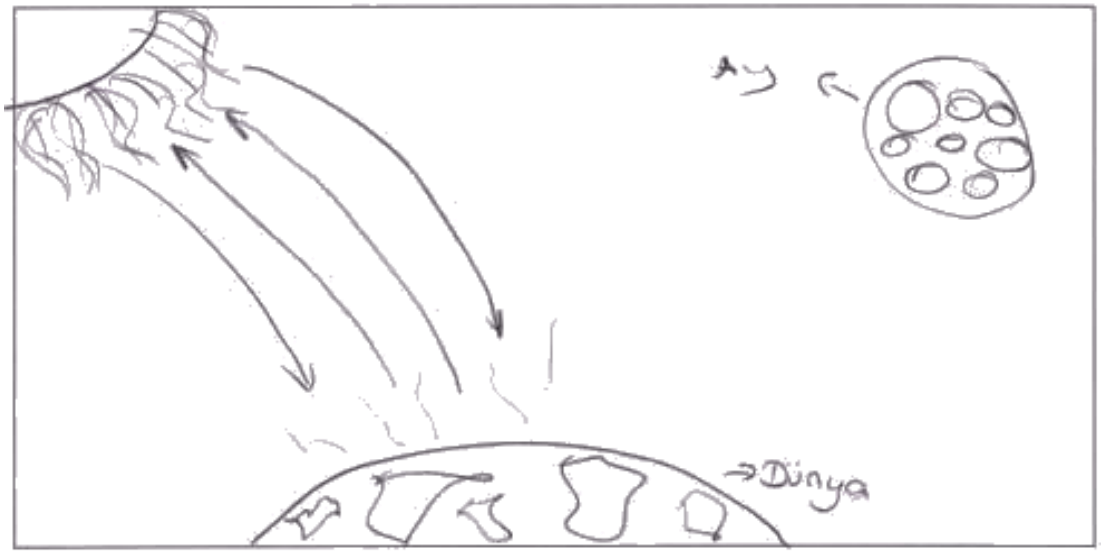
4.2.6 Miscellaneous

Four of the students' drawings did not represent any reasonable idea and therefore can not be included in any of the Mental Models. They are as follows:



a. Student's explanation: *"Life is meaningless, the important thing is evaluating the*

moments grate, advancing age and not to being idle. We should not miss opportunities." (Student 32) (Basic code: C15)



b. Student's explanation: *"Greenhouse effect is that evaporated water gets stuck in between Sun and Earth. This water evaporates from seas and lakes." (Student 30)* (Basic code: C15)

Figure 4.19 Student drawings: Miscellaneous

4.3 Source of Information

In the survey of this study, students were also asked how they get the information in the explanation part and 50 students (46 %) among 109 students indicated their information sources (Table 4.8).

According to responses, 58 % (n =29) of the students got the information that they drew in the first part of the survey, from their teachers and courses at the school. In other words, teachers are the major source of students' knowledge. They can direct the students to the right way or cause students' misconceptions or transfer their misconceptions to the students. % 24 (n = 12) of the students have learnt it through

Eco-School Programme and 14 % (n = 7) have learnt it through mass media such as internet, TV, newspapers, documentaries and magazines. The rest of the sources are parent and relatives, friends, themselves, books, seminars and games (Table 4.8).

Table 4.8 Source of information and frequency

Source of Information	**Frequency**
Teacher & Courses	29
Eco-team/Eco-School	12
Media (Internet, TV, newspapers, documentary, magazines)	7
Parents & relatives	4
Peers	4
Myself/my researches	3
Course book/Books	2
Seminar in school	2
Educational games	1

4.4 Summary of the Results

The most pronounced feature of the mental models derived through 109 7^{th} grade students' drawings is that students perceive greenhouse effect as a problem instead thinking it as a natural phenomenon. As was evaluated by the drawings, students drew and explained greenhouse effect and global warming as if they are the same. Although 2 of the mental models are related with students' misconceptions on ozone layer depletion and greenhouse effect, students can scientifically explain the phenomenon.

Besides, just a few students (11 among 109, 10 %) indicates CO_2 as a greenhouse gaseous and do not mention any other greenhouse gaseous.

The most common codes in the drawings are the causes of greenhouse effect and the causes drawn frequently are industrial and domestic emissions, deodorant/perfume, and exhaust gases.

Therefore, it may be inferred from the results that, 7^{th} grade students mental model of greenhouse effect is mainly shaped by the causes and results. The reason may be

related with the source of knowledge. This can be also inferred by students' misconceptions. Therefore, the source of knowledge, such as TV, internet, may have caused students not to get the scientific explanation but just the causes and results, thus making them to fulfill the rest by themselves.

As a summary of all, 7th grade students' mental models on greenhouse effect indicate that although they have something in their minds related to greenhouse effect, misconceptions and lack of scientific background on the issue prevent them making connections.

CHAPTER 5

DISCUSSION

Getting the answer of 'how' knowledge is constructed in students' minds is one of the most important parts of science education. For this purpose, various techniques were developed by researchers. The mental models are one of these techniques; and the current study was conducted in this theoretical framework.

To investigate 7th grade students' mental models of greenhouse effect, 109 students who were from Eco-Schools were asked to draw greenhouse effect. Data was collected during spring semester of 2011-2012 academic year. Inductive content analysis was utilized to determine the codes on the greenhouse effect as observed in the students' drawings. 15 codes were determined as a result, based on their typology and considering the related literature. Inter-rater reliability coefficient of the analysis was determined as .76. Consequently 5 mental models were set up representing 7th graders understanding of the greenhouse effect.

This chapter of this thesis is comprised of a discussion of findings the implications, as well as the recommendations for further research.

5.1 Discussion and Conclusions

5.1.1 The Overall Description of Greenhouse Effect Mental Models of 7th Year Turkish Students

Overall, the resulted mental models of the 7th grade Turkish Eco-School students indicated that students have insufficient knowledge and misconceptions about

greenhouse effect. The major indication for students having insufficient knowledge about greenhouse effect is that, only 11 students among 109 (10 %) indicated CO_2 as a greenhouse gas and no other greenhouse gases were mentioned by any student. Furthermore, only 9 (8 %) students featured greenhouse effect as a natural event and only 20 (17 %) students correlated greenhouse effect with global warming.

The most common codes found in the drawings were gaseous emissions of industrial and domestic sources (36 %, n=40), deodorant/perfume (32 %, n = 35), and exhaust gases (28 %, n = 31), which are very general reasons to state for any air pollution case. Students with strong background knowledge on greenhouse effect are, in general, expected to state more specific terms, such as, fossil fuel use, greenhouse gases emissions or deforestation. However, none of the students mentioned about these terms as the reasons for man-made greenhouse effect. On the other hand, air conditioners, garbage, and smoking were stated by just few of the students as reasons for greenhouse effect (6 %, n = 7).

The largest sample size of this study was belong to Mental Model 1 among 5 mental models. The most common symbols used by the students in their drawings were lonely penguins and polar bears.

5.1.2 Misconceptions on the Greenhouse Effect as Reflected by the Mental Models

Three of the 5 mental models of the students were related to misconceptions. Two of the most common misconceptions observed, within this context were related to ozone layer depletion – greenhouse effect, daily temperature difference, and greenhouse used for agricultural purposes (Mental Models 2 and 3).

Moreover, none of the students construct a relation between greenhouse effect, greenhouse gases, global warming and/or climate change.

As far as the relevant literature is concerned, it can easily be seen that, similar results have been obtained.

Boyes, Chambers and Stanisstreet (1995) for example, demonstrated by their study that, the misconception of global warming related to ozone layer depletion was common almost universally. The authors asserted that learning in this area can not be experimental and leads to misconceptions about the concepts. Similarly, Bozdogan (2011), reported that, this internationally widespread misconception prevails especially in primary school students. Bozdogan reviewed 62 Turkish publications that were related to global warming problem conducted in education and published between 1992 and 2009. Results indicated that in all level of education held similar global warming misconceptions, which mass media had negative impacts on.

It has been the general outcome of several researches in this area that, students think ozone layer depletion causes more sun light comes into the Earth's atmosphere and causes increase in atmospheric temperature (Christidou, 1994; Boyes, & Stannisstreet, 1993; Gautier, & Rebich, 2005; Rye *et al*,. 1997). The sample of this research did give the same response; 12 students (11 %) drew holes in the ozone layer causing greenhouse effect and 11 (10 %) students drew and wrote one of the causes of greenhouse effect as ozone depletion.

Boyes, Daniel, and Stanisstreet (2004), however, performed a questionnaire-based study to explore school students' ideas about the extent to which various actions might contribute towards reducing global warming. According to the results, many students appreciated that a decrease in industrial and vehicle emissions could play a major role in this reduction, and producing energy from renewable sources was another popular idea. The authors detected one major misconception as the idea that reducing nuclear power would diminish global warming. As a conclusions authors suggested that actions to help reduce global warming might be taught within a taxonomic framework of reduction, recycling, replacement and raising.

Deutsch, Gautier, and Rebich (2006) analyzed the evolution of misconceptions related to global warming in a classroom setting as a function of evolving instruction. As a result the authors concluded that misconceptions are hard to eliminate. Because, as they reported, results from pre- to mid-test, students misconceptions decreased or decreased more than the decrease in the number of topics suggesting a global improvement in understanding by the students in the class. Only in a few cases, however, students displayed an increase in the number of topics addressed with a decrease in number of misconceptions, which was the situation normally expected as the result of instruction.

5.1.3 Possible Reasons for Misconceptions: Sources of Knowledge

Shephardson et al. (2009) made a relation between misconceptions and source of knowledge. The authors reported that the main sources of students' knowledge about greenhouse effect were school science class/textbook (29%), TV programs and videos (20%), other individuals (not teachers) (6%), other media source (6%), and greenhouse experience (5%). Similarly, Rickinson (2001) asserted that, TV serves as a major source of students' environmental information as well as school science textbooks.

Moreover, Rye et al. (1997) also suggested that, there are three reasons for the greenhouse effect related misconceptions: (1) Students' prior knowledge, (2) media and (3) school curriculum. According to the authors, firstly, students perceive the Sun that warms up the Earth and holes in the ozone layer causes more Sun light that reaches to the Earth and thus more heat in the planet's atmosphere. According to the authors, the second reason for misconceptions is the media. Global warming and ozone layer depletion are presented together in the media and such presentations mainly include chlorofluorocarbons (CFCs) and involve radiation coming from the Sun. Consequently, audiences infer that primary cause of global warming is the holes in the ozone layer.

To illustrate, it was found in this study that, 7 (14 %) students among 50 indicated mass media such as internet, TV, newspapers, documentaries and magazines as the source for their information on greenhouse effect. Media also may be the reason for famous figures in drawings related to global warming such as desperate polar bears. And, 29 students (58 %) among 50 indicated their teachers and courses as the source of their knowledge.

Therefore, when the results of this study are evaluated in line with those of the related research, one can infer that, misconceptions related to greenhouse effect hold by the students' of this study may be due to their source of information.

When it is proposed that, students' misconceptions on the greenhouse effect is due to their source of information and considering more than half of the students' source of information is teachers and courses, it is necessary to concentrate on the science and technology curriculum in Turkey.

Mental Model 3 of this study (Table 4.2. Misconception – Daily Temperature Difference) may be an explanation for the misconception caused by textbooks. Model 3 of this study showed that students have a perception that, greenhouse effect is the mechanism which makes days warm and nights cold. The most reasonable explanation for this misconception may be due to the knowledge given in the Science and Technology Course Textbook published by the Ministry of National Education (Appendix B):

> Why is our planet cold at nights?
>
> Due to radiation coming from the Sun during the day, the Earth heats up. But it can not get heat from the Sun by radiation at nights. Nevertheless, the Earth emits heat by radiation at nights. Therefore, rocks, soil, brooks, lakes, living environments are colder at nights than they are in days.

> Although nights are colder than days in the Earth, the difference in temperature between day and night is 10-15 ^{o}C at most. In the Moon, the Earth's satellite, the temperature can reach 120 ^{o}C in the day and -155 ^{o}C at night. The reason of this huge amount of daily temperature difference in Moon is the lack of atmosphere. What about other planets?
>
> Some amount of Sun's radiation is lost in the atmosphere while coming to the Earth. Atmospheric composition (gases constituting the atmosphere) prevents reflected invisible lights from spreading through the space. Due to the Earth's atmospheric composition, some amount of Sunlight hits to the Earth surface, and some amount of reflected sunlight is absorbed in the atmosphere. This phenomenon is called greenhouse effect and this is how atmosphere makes Earth's temperature suitable for life. (MEB, 2010)

The above explanation in the Turkish 6th grade Science and Technology Textbook therefore can be asserted as the reason for the misconception found in Mental Model 3.

However, although they have a misconception related to day-night temperature differences, students holding Mental Model 3 drew heating mechanism of greenhouse effect but labeled the layer that wraps the Earth as ozone layer. Therefore, their situation may be evaluated as having a slight confusion that is likely to be easily removed.

Similarly, Hansen (2010) performed a research on the Norwegian students' confusion on the greenhouse effect with the effects of the ozone layer. He discussed some possible causes for these trends, and gave some recommendations for teaching the topics in accordance with the Norwegian national curriculum implemented in 2006. In this research Hansen emphasized the media and public focus on greenhouse effect and the effects of the ozone layer as the sources of information causing informal learning among pupils. The results of Hansen's article reflect the development in Norwegian students' misconceptions between greenhouse effect and

ozone layer. According to the results, in 1989 only 1 out of 4 15-year-old pupils in Norway did know that the greenhouse effect is necessary for life on the Earth. In 2005, however, 3 out of 4 knew. According to the writer, both formal learning in school and informal learning from media and public discourse might have contributed to increased knowledge. In addition, as the writer asserted, from the late 1990s the media and public interest in ozone problems have decreased due to retardation in the development of ozone layer depletion. At the same time, there has been an increased focus on increasing greenhouse effect and global warming. This double situation might have influenced the teaching and learning in the compulsory school in a way that might be the answer to why factual knowledge about the causes and effects of the greenhouse effect has decreased and the confusion of the greenhouse effect for the effects of the ozone layer has increased from 1989 to 2005. The confusion could perhaps partly be a result of pupils' tendency to over-generalize environmental problems caused by the use of the concept "pollution" in different contexts.

5.1.4 True Explanation of Greenhouse Effect

Students of this study holding Model 4 (22 %, n = 24) have fairly well developed mental models. According to the students' drawings of this model, Sun's radiation travels through the atmosphere, reaches the Earth, after some amount is absorbed by the Earth's surface, it is reflected back through the atmosphere and some amount of the reflected radiation is absorbed, thus keeping the atmospheric temperature at a reasonable level for life. Although students in this model developed an adequate mental model, there are still several inconveniences detected. The most important inconvenience, however, is that most of the students who hold this model did not include CO_2 in their drawings (only 4 students drew/wrote CO_2) and no one mentioned any greenhouse gases.

This group corresponds Model 5 in Sherdson et al.'s study which is that sun's rays are 'bounced' or reflected back and forth between the Earth's surface and greenhouse gases, heating the Earth (2011). They were categorized 13 % of their participant (n =

225) into this model. Similarly, not all students of this model could identify any greenhouse gases. However, two students mentioned clouds' effect to the greenhouse effect (Shepardson et al., 2011), which did not explained by anyone in this current study.

5.1.5 Literal Perception of Greenhouse Effect: Drawing a 'Greenhouse'

Shepardson et al. (2011) found in their study on 7th grade English students' mental models of the greenhouse effect that, 29 % of the students (n = 225) perceived greenhouse effect literally and drew a '*greenhouse*'. According to authors, students' concrete thinking and daily language guided their meaning-making process and caused their greenhouse effect perceptions as 'greenhouse' which they know very well from their lives. Similarly, 2 of the students of this study, who hold Mental Model 5, drew a "greenhouse", exemplifying how daily language effects their meaning construction. It may be inferred from this results therefore that, greenhouse effect is likely to be perceived as a well-known concrete object 'greenhouse' used for agricultural purposes.

As a conclusion of all, 7th grade Turkish Eco-School students' drawings resulted with 5 mental models on the greenhouse effect. The main reflection of the mental models regarding students' perceptions of greenhouse effect was in line with the related literature. That is to say that the students perceive greenhouse effect just as any air pollution issue that is caused by stack emissions; they do not perceive greenhouse effect as a natural phenomenon; they have 3 types of misconceptions related to ozone layer, daily temperature differences and the "greenhouse". The reasons for students having insufficient knowledge and misconceptions related to greenhouse effect have been explained with 2 basic factors as; curriculum content and textbooks and media. Last of all, the conclusions drawn from this study are all in line with those of the related literature.

5.2 Implications of the Study

The results of this study have suggested some implications that should be dealt with seriously by educators, educational administrators and planners, and environmental education programmers.

First of all, teachers should take consideration of common students' misconceptions about global warming and greenhouse effect. Especially, the difference between greenhouse effect and ozone depletion should be clear in students' minds. Unfortunately, some researches indicated that even in-service teachers as well as pre-service teachers held this misconception (Dove, 1996; Khalid, 2003; Papadimitriou, 2004). Therefore, environmental education programs should be carried out not only for students but also for teachers.

An international environmental education program, Eco-Schools, fell behind its essential objectives according to the results of this study. Therefore, environmental education programmers should design outcome-oriented, effective, appropriate programs that are capable of instilling abstract and complex environmental topics. At this time, the power of mass media should not be ignored and media organs such as television and newspapers should not mislead public about these topics that are closely related to our lives.

Moreover, curriculum planners are responsible for students' misconceptions as much as teachers, environmental education programmers and media. National Turkish science and technology curriculum fails to provide efficient ESD to students. In order to improve quality and effectiveness of the courses, ESD should be integrated into curriculum more excessively and deeply. Students' motivation through environmental topics can be raised by associating them with their lives. Therefore, while representing such topics to students, it can be stressed that how environmental problems and humans affect each other. In this manner, students have responsibility

toward environment and change their attitudes and behaviors in a more environmentally-friendly way. All environmental topics are interrelated; therefore curriculum should link to each other but do not let them to be jumble in students' minds.

As reported by Hansen (2010), several of the reported articles about students' conceptions of the greenhouse effect and the effects of the ozone layer give recommendations for teaching those topics.

Assuming that the trends and analysis in this study are true, one recommendation for promoting "education for sustainable development" with regard to increased greenhouse effect and prolonged ozone problems might be Boyes et al.'s (1995) old advices:

> "The teaching strategy that could address the conceptual problems surrounding the ozone layer will be that characterized by a less holistic approach in which the causes and consequences of different environmental problems (like increasing greenhouse effect) are dissected and teased apart."

Therefore, it might be useful to link the conceptual problems to hands-on experience when possible. For example, the basic physical processes like transmission, reflection, absorption, and emission of different wavelengths of electromagnetic radiation could easily be illustrated through student experiments or teacher demonstrations (Hansen, 2003).

Media and internet are often setting the agenda for the public debate on environmental problems. A second recommendation is to use these sources actively in the teaching of the scientific as well as the societal, political, ethical, and other aspects of the problems.

Role play is powerful, for instance a “Climate Conference” or “Panel-debate on TV” where pupils work out their own facts sheet for one character based on information from media (Hansen, 2003).

Media and internet (and text books) could be sources when making a quiz. Each student works out many questions and answers. Groups of 3 or 4 students fight against each other in a cup system ending up with a final (Hansen, 2003).

And it will be necessary to couple the learning of the scientific aspects of environmental problems like ozone depletion and global warming with the pupils’ personal attitudes, visions, feelings, engagement, and political and practical action.

This could be done in “Discussion Groups” or pairs (like reported in Andersson, 2000, on “How should the emission of carbon dioxide per person and year be limited in developing countries and industrialized countries?”).

An alternative is a “Consensus Conference” where social aspects of science are included in evaluation and validation of knowledge claims (Kolstø, 2000).

Climate education for empowerment involves fostering in young people an integrate understanding of the many aspects (scientific, ethical, political, etc.) of the climate (and ozone) issue, hopeful visions for the future and a conviction that it lies in their power to shape the future. That is a challenge which we as science educators can take up (Schreiner et al., 2005).

5.3 Recommendations for Further Research

According to the results of this study and the related literature, following recommendations for further research can be made:

Replication of the same study with a larger sample comprising elementary students will be beneficial for the sake of generalizing results. Further researches about

investigation of whether there is a meaningful difference between Eco-schools and non-Eco-Schools or not will make great contribution to the literature. Comparison of these different groups in terms of their mental model patterns may be shed light on effects of Eco-Schools Programme.

The number of mental model researches needs to be increase to clarify mental model strategy. Therefore, supplementary research about mental model with different environmental problems and topics is suggested. Furthermore, extended researches may be clarify the reasons of various mental models categories such as gender, socioeconomic status etc.

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APPENDIX A

DRAW-AND-WRITE SURVEY FOR GREENHOUSE EFFECT MENTAL MODELS

Sera Etkisi Zihinsel Model Belirleme Ölçeği

Sevgili Öğrenciler,

Bu çalışmanın amacı sera etkisi ile ilgili zihinsel modellerinizi belirlemektir. Anketin tamamlanması yaklaşık 20–25 dakikanızı alacaktır. **Ankete katılım isteğe bağlıdır ve isminizi yazmanız gerekmemektedir.** Ankette yer alan kişisel bilgileriniz kesinlikle gizli tutulacak, sonuçlar sadece araştırma amacı ile kullanılacaktır. Aşağıdaki soruları dikkatle okuyarak her bir soru için tek bir seçenek işaretleyiniz (X).

Sizlerin görüşleri bizler için çok önemlidir. Katkılarınız ve yardımlarınız için teşekkür ederim.

İrem ARIK
ODTÜ Eğitim Fakültesi İlköğretim Bölümü
Fen Bilgisi Öğretmenliği

A. Kişisel Bilgiler

1. Okulunuzun Adı: _____

2. Cinsiyetiniz: ❑ Kız ❑ Erkek

3. Yaşınız: _____

4. Annenizin eğitim durumu:

❑ İlkokul ❑ Ortaokul ❑ Lise ❑ Üniversite ❑ Yüksek Lisans ❑ Doktora

5. Babanızın eğitim durumu:

❑ İlkokul ❑ Ortaokul ❑ Lise ❑ Üniversite ❑ Yüksek Lisans ❑ Doktora

6. Anneniz çalışıyor mu? : ❑ evet ❑ hayır

Yanıtınız "evet" ise çalıştığı kurum:

❑ devlet dairesi ❑ özel sektör ❑ kendi işyeri ❑ emekli

7. Babanız çalışıyor mu? : ❑ evet ❑ hayır

Yanıtınız "evet" ise çalıştığı kurum:

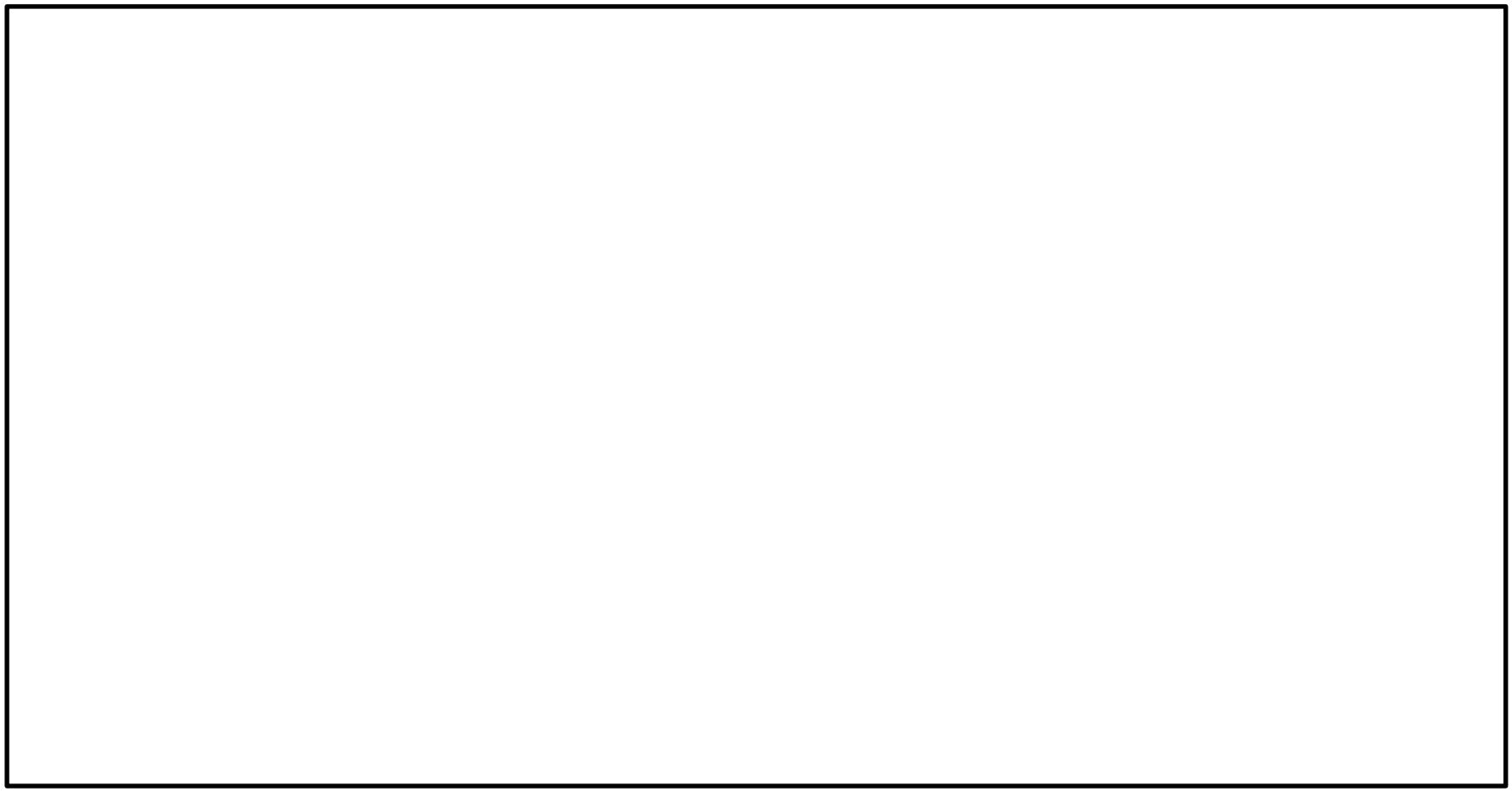
❑ devlet dairesi ❑ özel sektör ❑ kendi işyeri ❑ emekli

8. Şimdiye kadar yaşadığınız bölge aşağıdakilerden hangisi ile tanımlanabilir?

- ❑ Kırsal alan, Çiftlik
- ❑ Kasaba (nüfusu 25.000 ile 100.000 kişi arasında)
- ❑ Büyük şehir (nüfusu 100.000 kişiden fazla)

B. Sera Etkisi Zihinsel Modelleme Ölçeği

B. 1 Aşağıdaki boş bırakılan alana sera etkisinin sizin için ne ifade ettiğini çizerek anlatınız. Gerekli gördüğünüz yerlerde açıklayıcı kelimeler kullanabilirsiniz.



B. 2.

Aşağıdaki boş bırakılan alana yukarıdaki çiziminizi anlatınız ve bu bilgileri nereden öğrendiğinizi yazınız.

……

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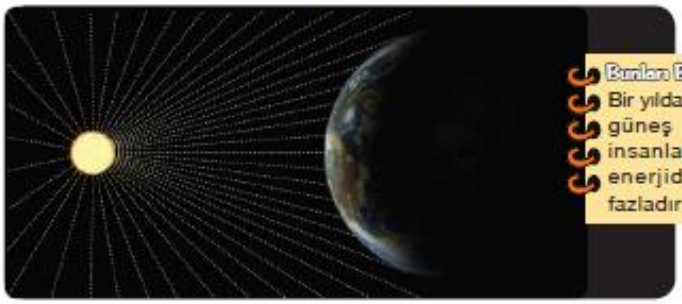
APPENDIX B

GREENHOUSE TOPIC IN NATIONAL SCIENCE AND TECHNOLOGY COURSE BOOK

Peki, Güneş'ten Dünya'ya ısı nasıl ulaşır?

Dünyamızın güneş ışınları sayesinde ısındığını biliyoruz. Güneş'ten yayılan ışınlar uzay boşluğunda hareket ederek ışıma yoluyla dünyamıza gelir. Boşlukta maddeleri oluşturan tanecikler bulunmadığı için güneş ışınları dünyaya çok kısa sürede ulaşır.



Bunları Biliyor muydunuz?

Bir yılda Dünya'ya ulaşan güneş enerjisi bütün insanlara gerekli olan enerjiden çok daha fazladır.

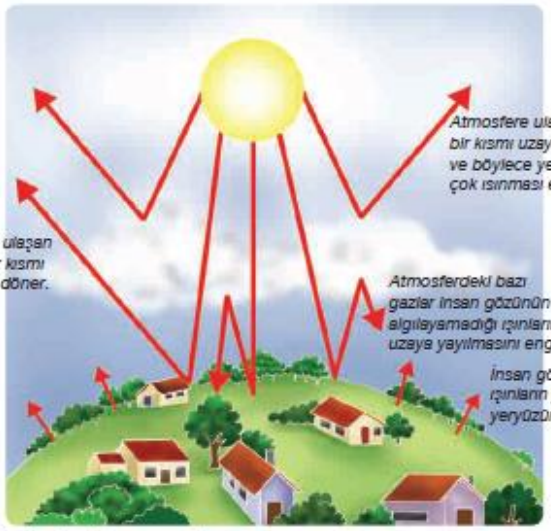
Kışın güneşli günlerde dışarıda sıcaklık sıfırın altında iken evimizin güneş alan kısmı soba yanmasını gerektirmeyecek kadar ısınır. Bu olay ışıma yoluyla ısı yayılmasına iyi bir örnektir. Bundan dolayı kışların soğuk geçtiği bölgelerde, ev ve işyerlerimizin güneş almasını tercih ederiz. Resmi incelediğimizde evin güneş alan kısmındaki karın daha önce eridiğini ve güneşe bakan odaların daha sıcak olduğunu farkederiz.

Geceleri dünyamız neden soğur?

Dünyamız gündüzleri güneşten ışıma yoluyla gelen ışınlar sayesinde ısınır, fakat geceleri güneşten ışıma yoluyla ısı alamaz. Buna rağmen Dünya, geceleri ışıma yoluyla ısı yayar. Bunun içindir ki kayalar, toprak, dereler, göller, yaşadığımız ortamlar geceleri gündüzlere göre daha soğuktur.

Dünya'da geceler gündüzlere göre daha soğuk olmasına rağmen gece ve gündüz arasındaki sıcaklık farkı en fazla 10-15 °C olur. Dünya'nın uydusu olan Ay'da sıcaklık gündüzleri 120 °C, geceleri ise -155 °C'a ulaşır. Gece ile gündüz arasındaki sıcaklık farkının bu kadar fazla olmasının sebebi Ay'da atmosferin olmamasından kaynaklanmaktadır. Peki, diğer gezegenlerde durum nasıldır?

Atmosfer, Güneş ışınlarının tamamını yeryüzüne ulaştırmaz. Bundan dolayı Dünya'nın çok sıcak olması engellenir. Ayrıca atmosferi oluşturan gazlar, yeryüzünün yaydığı göremediğimiz ışınların uzaya yayılmasını engelleyen bir perde oluşturur. Atmosfer, Güneş ışınlarının bir kısmının yeryüzüne ulaşmasına izin verirken yeryüzüne ulaşan ışınların bir kısmının da dışarı çıkmasını engeller. Bu olaya **sera etkisi** denir. Böylece Dünya, atmosfer sayesinde canlıların yaşamasına elverişli sıcaklığa ulaşmış olur.



Atmosferi oluşturan gazlar Dünya için elverişli sıcaklığı sağlar. Ancak bazı gazların miktarının çeşitli sebeplerle artması Dünya'nın normalden daha fazla ısınmasına yol açar. Endüstrinin gelişmesi, motorlu araçların sayısının artması vb. sonucu fosil yakıtların kullanımı, buna bağlı olarak da çevreye yayılan gaz miktarı artmaktadır. Bu durum buzulların erimesine ve bunun sonucunda da iklimlerin değişmesine sebep olur.

8 Çevremiz Hava 116. s

Araştıralım, Hazırlanalım

Neden havanın açık olduğu geceler bulutlu gecelerden daha soğuktur? Düşündüklerimizi yazılı olarak ifade edelim ve arkadaşlarımızla paylaşalım.

APPENDIX C

TURKISH SUMMARY

7. SINIF EKO-OKUL ÖĞRENCİLERİNİN SERA ETKİSİ ZİHİNSEL MODELLERİNİN BELİRLENMESİ

1 Giriş

1800'lerin sonlarında, Sanayi Devriminin bir sonucu olarak, dünya aşırı kömür kullanımı ile karşı karşıya kalmıştır ve bir İsveç bilim adamı, Arrhenius, atmosferdeki karbondioksit miktarının iki katına çıkması durumunda, Dünya üzerindeki ortalama sıcaklığın 5-6 ^{o}C artacağını öngörmüştür (aktaran Houghton, 2005). Dünya tarihinde "küresel ısınma" terimini ilk kez 1975'te Wallace S. Broecker kullanmış ve insan kaynaklı sera gazı salınımlarının küresel ısınmaya sebep olabileceğini söylemiştir. 1979'daki ilk Dünya İklim Konferansında insanlar fosil yakıt kullanımı, ormansızlaşma, arazi kullanımındaki değişiklikler, artan azotlu gübre kullanımı gibi aktiviteleri nedeniyle uyarılmış ve bunların bölgesel ve hatta küresel iklim değişikliklerine yol açabileceği belirtilmiştir (DGVN, 1979).

Hükümetlerarası İklim Değişikliği Paneli'nin ilk yıllık raporu doğal olmayan sera etkisinin küresel ısınmaya ve küresel ısınmanın da iklim değişikliğine sebep olduğu duyurulmuştur (IPCC, 1990).

Sürdürülebilir kalkınma, 1987 Dünya Çevre ve Kalkınma Komisyonu'nda "Bugünün ihtiyaçlarını, gelecek nesillerin ihtiyaçlarını karşılama kabiliyetinden ödün vermeden karşılayan kalkınma" olarak tanımlanmıştır ve bu komisyonun yayınladığı "Brundtland Raporu" ile popüler olmaya başlamıştır. Sürdürülebilir kalkınmanın küresel bir ihtiyaç olmasıyla birlikte sürdürülebilir kalkınmanın önemli parçalarından biri de eğitim olmuştur (WCED, 1987).

Birleşmiş Milletler Çevre ve Kalkınma Konferansı'nın deklare ettiği Gündem 21 ve Birleşmiş Milletler Eğitim, Bilim ve Kültür Örgütü (UNESCO) sürdürülebilir kalkınma için eğitimin önemini vurgulamakta olup genç neslin küresel ısınmayı anlaması, tutum ve davranışlarını değiştirmesi ve iklim değişikliğinin gerektirdiği adaptasyonlara uyum sağlaması için onlara yardım etmeyi amaçlamaktadırlar (UNCED, n.d., UNESCO, n.d.-b).

2 Yöntem

Bu çalışmanın amacı 7. Sınıf Eko-Okul öğrencilerinin sera etkisi zihinsel modellerinin belirlenmesidir. Bu çalışma nitel bir çalışma olup anket araştırması deseni ile yapılmıştır. Bu çalışmanın katılımcıları İstanbul'daki üç Eko-Okulda bulunan 7. sınıf öğrencileridir. Bu çalışmaya 62'si erkek, 47'si bayan olmak üzere toplamda 109 öğrenci katılmıştır. Veriler yazma/çizme yöntemi ile toplanmıştır. Bu yöntemin uygulanmasında, öğrencilerden sera etkisinin onlar için ne ifade ettiğini çizmeleri ve çizimlerini açıklamaları istenmiştir. Ayrıca bu bilgileri nereden öğrendikleri de sorulmuştur.

Öğrencilerin çizim ve açıklamalarının tümevarım analizi sonucunda 15 kod belirlenmiştir. Bu kodlar ve çizimlerdeki görülme frekansları aşağıdaki gibidir.

C1	Endüstriyel ve evsel gaz salınımları	40
C2	Deodorant/parfüm	35
C3	Egzoz	31
C4	Çevresel etki belirteçleri (eriyen buzullar üzerindeki penguenler/kutup ayıları, sıcaklık artışı, kuraklıklar, nesli tükenmekte olan canlılar, yaralı veya ölü canlılar, ormansızlaşma, mevsimlerde değişiklikler, seller, kuşların göç etmesi)	31
C5	Sera etkisinin bilimsel açıklaması	24
C6	Sera etkisi – küresel ısınma ilişkisi	20
C7	Ozon tabakasındaki deliklerin Dünya'nın atmosferinin sıcaklığını artırması	12

C8	CO2	11
C9	Ozon tabakasının delinmesinin nedenleri (deodorant, parfüm, egzoz gazları, endüstriyel ve evsel gaz salınımları)	11
C10	Günlük sıcaklık farkları ile sera etkisinin açıklanması	10
C11	Doğal sera etkisi	9
C12	Diğer sera etkisi kaynakları (klima, atıklar, sigara içme)	7
C13	Sera etkisinin açıklaması olarak ozon tabakası	7
C14	Tarımsal amaçlar için kullanılan sera	2
C15	Diğer (tanımlanamamış, Dünya ile Güneş arasında gidip gelen monoksit gazlar, doğal su kaynaklarından buharlaşan suların Dünya ile Güneş arasında kalması)	4

Yapılan kodlama işleminin tutarlığını sağlamak için başka bir fen öğretmeni tüm verilerden rastgele seçilen 21 çizime ayrı olarak bakmış ve kodlama işlemini gerçekleştirmiştir. Daha sonra araştırmacının ve diğer fen bilgisi öğretmeninin kodlamaları karşılaştırılmış ve sınıf içi korelasyonu hesaplanmıştır (.76). Böylece kodların iki araştırmacı tarafından benzer şekilde belirlendiği tespit edilmiştir.

Zihinsel modeller oluşturulurken temel kod ve ortak kod olarak 2 çeşit kod türü belirlenmiştir. Her kod bir modelin temel kodu olmakla birlikte diğer modeller için ortak kod olabilmektedir. Örneğin, C1 (endüstriyel ve evsel gaz salınımları) Model 1 için temel kod olsa da, diğer modellerde ortak kod olarak bulunmaktadır. Çünkü sera etkisinin nedenlerini ve sonuçlarını içeren Model 1'de C1 (endüstriyel ve evsel gaz salınımları) öğrencinin temel olarak vurgulamak istediği noktadır. Ancak ozon tabakası ve sera etkisi bağlantısının kurulduğu Model 2'de bulunan C1 (endüstriyel ve evsel gaz salınımları) çizimin temelini oluşturmak yerine yan faktör olarak bulunmaktadır. Bu çizimle öğrencinin esas belirtiği ozon tabakasıdır.

3 Sonuç

Yapılan analiz sonucunda beş farklı zihinsel model ortaya çıkmıştır: (1) Sera Etkisinin Nedenleri ve Sonuçları, (2) Kavram Yanılgısı – Ozon Tabakası ve Sera Etkisi, (3) Kavram Yanılgısı – Günlük Sıcaklık Farkı, (4) Sera Etkisinin Bilimsel Açıklaması, (5) Kavram Yanılgısı – Tarımsal Amaçlar için Kullanılan Sera.

Otuz dokuz öğrencinin zihinsel modeli Model 1 (Sera Etkisinin Nedenleri ve Sonuçları) olarak tanımlanmıştır. Bunlardan 31 tanesi sera etkisinin nedenlerini, geri kalan 8 tanesi de sonuçlarını çizmiştir. Bu modelin temel kodları C1, C2, C3, C4, C12 iken ortak kodları C6, C8, C11'dir. Bu modelde öğrenciler temel olarak sera etkisine insan kaynaklı gaz salınımlarının neden olduğunu ve bunların insan ve diğer canlıların yaşamı üzerindeki zararlarını belirten çizimler yapmışlardır. Öğrencilerin bir kısmı sera etkisi ile küresel ısınma arasında bağ kurabilmiş ve bir kısmı da karbondioksitin sera etkisine neden olduğunu belirtmiştir. Bu modelde çizilen kodlar ve frekansları aşağıdaki gibidir:

C1	**Endüstriyel ve evsel gaz salınımları**	**22**
C3	**Deodorant/parfüm**	**17**
C2	**Egzoz**	**12**
C4	**Çevresel etki belirteçleri (eriyen buzullar üzerindeki penguenler/kutup ayıları, sıcaklık artışı, kuraklıklar, nesli tükenmekte olan canlılar, yaralı veya ölü canlılar, ormansızlaşma, mevsimlerde değişiklikler, seller, kuşların göç etmesi)**	**11**
C12	**Diğer sera etkisi kaynakları (klima, atıklar, sigara içme)**	**4**
C6	Sera etkisi – küresel ısınma ilişkisi	7
C8	CO2	5
C11	Natural greenhouse effect	1

Otuz öğrencinin zihinsel modeli Model 2 (Kavram Yanılgısı – Ozon Tabakası ve Sera Etkisi) olarak tanımlanmıştır. Bu modelin temel kodları C7, C9, C13 iken ortak

kodları C1, C2, C3, C4, C6, C8, C11'dir. Bu model 3 alt gruptan oluşmaktadır: Ozon tabakasındaki deliklerin Dünya'nın atmosferinin sıcaklığını artırması, Ozon tabakasının delinmesinin nedenleri (deodorant, parfüm, egzoz gazları, endüstriyel ve evsel gaz salınımları), ve Sera etkisinin açıklaması olarak ozon tabakası. Bu modelde çizilen kodlar ve frekansları aşağıdaki gibidir:

C7	**Ozon tabakasındaki deliklerin Dünya'nın atmosferinin sıcaklığını artırması**	**12**
C 9	**Ozon tabakasının delinmesinin nedenleri (deodorant, parfüm, egzoz gazları, endüstriyel ve evsel gaz salınımları)**	**11**
C13	**Sera etkisinin açıklaması olarak ozon tabakası**	**7**
C2	Deodorant/parfüm	19
C1	Endüstriyel ve evsel gaz salınımları	12
C3	Egzoz	10
C4	Çevresel etki belirteçleri (eriyen buzullar üzerindeki penguenler/kutup ayıları, sıcaklık artışı, kuraklıklar, nesli tükenmekte olan canlılar, yaralı veya ölü canlılar, ormansızlaşma, mevsimlerde değişiklikler, seller, kuşların göç etmesi)	8
C6	Sera etkisi – küresel ısınma ilişkisi	8
C8	CO_2	2
C11	Doğal Sera Etkisi	1

On öğrencinin zihinsel modeli Model 3 (Kavram Yanılgısı – Günlük Sıcaklık Farkı) olarak tanımlanmıştır. Bu modelin temel kodları C10 iken ortak kodları C1, C2, C6, C11'dir. Bu modelde çizilen kodlar ve frekansları aşağıdaki gibidir:

C10	**Günlük sıcaklık farkları ile sera etkisinin açıklanması**	**10**
C1	Endüstriyel ve evsel gaz salınımları	1
C2	Deodorant/perfume	1
C6	Sera etkisi – küresel ısınma ilişkisi	1
C11	Doğal sera etkisi	6

Yirmi dört öğrencinin zihinsel modeli Model 4 (Sera Etkisinin Bilimsel Açıklaması) olarak tanımlanmıştır. Bu modelin temel kodları C5 iken ortak kodları C1, C2, C3, C4, C6, C8, C11, C12'dir. Bu modeldeki öğrenciler genel olarak atmosferdeki sera gazlarının Güneş'ten gelen ve Dünya'dan geri yansıyan bu ışınlarının bir kısmını tutarak Dünya atmosferinin sıcaklığının artmasına neden olduğunu anlatan çizimler ve açıklamalar yapmışlardır. Bu öğrenciler temelde sera etkisinin ne olduğunu bilmelerine rağmen sadece 4 öğrenci çiziminde ve açıklamalarında karbondioksitten bahsetmiş olup diğer sera gazlarını belirten olmamıştır. Bu modelde çizilen kodlar ve frekansları aşağıdaki gibidir:

C5	**Sera etkisinin bilimsel açıklaması**	**24**
C1	Endüstriyel ve evsel gaz salınımları	4
C2	Deodorant/parfüm	3
C3	Egzoz	4
C4	Çevresel etki belirteçleri (eriyen buzullar üzerindeki penguenler/kutup ayıları, sıcaklık artışı, kuraklıklar, nesli tükenmekte olan canlılar, yaralı veya ölü canlılar, ormansızlaşma, mevsimlerde değişiklikler, seller, kuşların göç etmesi)	4
C6	Sera etkisi – küresel ısınma ilişkisi	4
C8	CO_2	4
C11	Doğal sera etkisi	1
C12	Diğer sera etkisi kaynakları (klima, atıklar, sigara içme)	2

İki öğrencinin zihinsel modeli Model 5 (Kavram Yanılgısı – Tarımsal Amaçlar için Kullanılan Sera) olarak tanımlanmıştır. Bu modelin temel kodu C14'dür ve ortak kodu bulunmamaktadır. Bu modelde sadece 2 öğrenci bulunmasına rağmen bu modelin oluşturulmasının nedeni literatürde çok yaygın olarak bulunan bir kavram yanılgısı olmasıdır. Öğrencilerin günlük dilinin onların anlam-yapma sürecini etkilediği ve soyut olan kavramları kendi hayatlarından çok iyi bildikleri somut kavramlarla eşleştirdiği görülmüştür (Shepardson, 2011).

Öğrencilerin zihinsel modelleri göstermiştir ki öğrencilerin sera etkisi ile ilgili bilgileri yetersiz olup bazılarının kavram yanılgısı bulunmaktadır. Örneğin sadece 11 öğrenci karbondioksiti sera gazı olarak belirtmiştir ve diğer sera gazları hiçbir öğrenci tarafından belirtilmemiştir. Sadece 9 öğrenci sera etkisinin doğal bir olay olduğunu söylemiş ve 20 tanesi sera etkisi ile küresel ısınma arasında bağ kurabilmiştir.

En çok rastlanan kodlar C1, C2 ve C3 olmuştur ki bunlar herhangi bir hava kirliği için belirtilebilecek nedenler arasındadır. Nedenler arasında fosil yakıtlar, ormansızlaşma veya sera gazı salınımları hakkında bahseden bulunmamaktadır.

Elli öğrenci bu bilgilerinin kaynağını belirtmiştir ve bu cevaplar aşağıdaki gibidir:

Öğretmenler & dersler	29
Eko-tim/Eko-Okul	12
Medya (İnternet, TV, gazete, belgesel, magazine)	7
Aile & akrabalar	4
Akranlar	4
Kendi araştırmaları	3
Ders kitapları/kitaplar	2
Okuldaki seminerler	2
Eğitici oyunlar	1

Yapılan araştırmalar öğrencilerin ve hatta öğretmenlerin sera etkisi ile ilgili çoğunlukla medya kaynaklı kavram yanılgıları olduğunu göstermiştir (Ünlü, 2011). Bu çalışma da öğrencilerin sera etkisi ile ilgili kavram yanılgılarının müfredat içeriği, ders kitapları ve medya etkenli olduğunu öne sürmektedir.