

Examination of Gifted Students' Perceptions Regarding Air Pollution, A Socio-Scientific Issue

İbrahim Benek^a, Aydın Tiryaki^{b*}

^a Ministry of National Education, <https://orcid.org/0000-0002-7124-4905>

^b Asst. Prof. Dr., İstanbul 29 Mayıs University, <https://orcid.org/0000-0001-5888-1689> *tiryaki0402@gmail.com

Research Article

Received: 04.11.2023

Revised: 23.04.2024

Accepted: 02.09.2024

Abstract

This study, which examined gifted students' perceptions of air pollution, was conducted using a phenomenological design, a qualitative research method. This study was conducted with 23 gifted students. Data were collected using the draw-write-tell method. Data were collected two hours a week for a total of eight hours. In the first and second weeks, data on the causes of air pollution were collected, and in the third and fourth weeks, data on the solution of air pollution were collected. An inductive content analysis method was used to analyze the data. According to gifted students, smoke from chimneys of factories and residences, gases emitted from car exhaust, forest fires, cutting down forests/trees, industrial and domestic wastes, use of non-renewable energy sources, uncontrolled fires, ship wastes, water pollution, airplane fuels, running generators, and smoking cause air pollution. In addition, they think that installing filters on car exhausts and residential/factory chimneys, afforestation, not cutting down forests, limiting the use of cosmetic products or not using these products, recycling, using renewable environmentally friendly energy sources, reducing or eliminating smoking, using public transportation, and using bicycles instead of motor vehicles can be reasonable solutions to reduce air pollution.

Keywords: Socio-scientific issues, air pollution, gifted students.

Sosyo-Bilimsel Konulardan Biri Olan Hava Kirliliğine Yönelik Özel Yetenekli Öğrencilerin Algılarının İncelenmesi

Öz

Özel yetenekli öğrencilerin hava kirliliğine yönelik algılarının incelendiği bu çalışma, nitel araştırma yöntemlerinden fenomenolojik desen kapsamında gerçekleştirilmiştir. Araştırma 23 özel yetenekli öğrenci ile gerçekleştirilmiştir. Veriler Çiz-Yaz-Anlat tekniği ile toplanmıştır. Veriler haftada iki saat olmak üzere toplam sekiz saat toplanmıştır. Birinci ve ikinci haftalarda hava kirliliğinin nedenlerine ilişkin veriler, üçüncü ve dördüncü haftalarda ise hava kirliliğinin çözümüne ilişkin veriler toplandı. Verilerin analizinde tümevarımsal içerik analizi yöntemi kullanılmıştır. Özel yetenekli öğrencilere göre fabrika ve konut bacalarından çıkan dumanlar, araba egzozlarından çıkan gazlar, orman yangınları, ormanların/ağaçların kesilmesi, endüstriyel ve evsel atıklar, yenilenemeyen enerji kaynaklarının kullanımı, kontrolsüz yangınlar, gemi atıkları, su kirliliği, uçak yakıtları, çalışan jeneratörler ve sigara içmek hava kirliliğine neden olur. Ayrıca araba egzozlarına ve konut/fabrika bacalarına filtre takılması, ağaçlandırma, ormanların kesilmemesi, kozmetik ürünlerin kullanımının sınırlandırılması veya kullanılmaması, geri dönüşüm, yenilenebilir çevre dostu enerji kaynaklarının kullanılması, sigaranın azaltılması veya ortadan kaldırılması, toplu taşıma araçlarını kullanmak, motorlu taşıtlar yerine bisiklet kullanmak hava kirliliğini azaltmak için makul çözümler olabilir.

Anahtar kelimeler: Sosyobilimsel sorunlar, hava kirliliği, üstün yetenekli öğrenciler.

To cite this article in APA Style:

Benek, İ. & Tiryaki, A. (2025). Examination of Gifted Students' Perceptions Regarding Air Pollution, A Socio-Scientific Issue. *Bartın University Journal of Faculty of Education*, 14(1), 279-296. <https://doi.org/10.14686/buefad.1386048>

INTRODUCTION

Air Pollution

Individuals need a variety of experiences regarding different settings and versions of nature to explore, reflect on, and understand how they perceive, comprehend, construct, compare, act, and relate to nature and the environment (Jickling, 2003). Environmental education plays an essential role in this regard. Environmental education aims to provide direct experiences with the environment, develop positive feelings and attitudes towards nature, foster empathy, and practically explore environmental conflicts and problems. Environmental education encourages students to understand how natural systems function. Environmental education involves children, teachers, and communities working collectively and democratically to address environmental issues and their solutions (Julie, 1998). Another focus of environmental education is social scientific issues. Socioscientific issues concern society; These are complex, open-ended and often controversial issues with no definitive answer. In addition, technological issues that have social dimensions and on which there are disagreements among scientists are referred to as socioscientific issues. Socio-scientific topics include phenomena experienced by humans in nature (such as climate change, alternative fuels) (Chen & Xiao, 2021). Since socioscientific issues derive their content from situations that may be encountered in daily life, understanding these issues and teaching them to students are among the important goals of science/environmental education. For example, ethical dilemmas and social concerns addressed in the context of socioscientific issues should not be considered separate from science/environmental education classes. Therefore, it is aimed to improve students' understanding of these issues. Understanding socioscientific issues plays an important role in students' conscious decision-making by helping them perceive the actions and processes underlying the decisions they make on dilemmas that they may encounter in daily life (Wahono, et al, 2021). Therefore, students, teachers, and researchers must understand the nature of their environmental experiences and the natural environment (home, school, playground, river, shopping mall, etc.) in which they occur (Payne, 2006). Environmental science is already available as a separate subject in many universities worldwide, and naturally, it should be included in primary and secondary education as well as sustainability education. Major environmental issues, such as the greenhouse effect, ozone depletion, acid rain, and air pollution, are of great educational importance (Mandrikas et al., 2017). How students understand global environmental concepts (e.g., global warming and air pollution) has been the focus of empirical research for more than a decade. There is a need to focus on how children conceptualize scientific concepts and phenomena in alternative, unique ways (especially in science education) regarding global warming and air pollution. Given the popularity and topicality of contemporary environmental issues, students' understanding and conceptualization of phenomena in this area should be an essential component of their educational programs (Dimitriou & Christidou, 2007). However, environmental issues are not away from everyday life; in particular, environmental degradation (air, water pollution, etc.) is increasingly affecting the quality of life of the planet. Moreover, in the case of air pollution, the adverse effects of this pollution are also directly experienced by humans. Therefore, knowing what students' perceptions of the occurrence and effects of air pollution are and how they are shaped is essential in shaping their daily life behaviors in the future (Thornberg et al., 1999). Moreover, regarding problems such as air pollution, it is unlikely that the impact on students' thinking is limited to the cognitive domain. Therefore, students may form perceptions of air pollution based on ideas from the school curriculum or from out-of-school environments. It is essential to reveal such perceptions. Even if the links between knowledge, perception, and behavior are far from direct, these three areas undoubtedly interact. This interaction is essential for students to perceive their environment, develop an understanding, and shape their behavior (Myers et al., 2004).

Millions of people are exposed to the adverse effects of air pollution annually. Air pollution poses severe risks to human health and other living conditions. To prevent air pollution, which is one of the leading causes of both acute and chronic health problems (Rakwongwan et al., 2021), doctors should cooperate with environmental organizations and lead actions to reduce air pollution and global warming to protect human health (D'Amato & Akdis, 2020).

Gifted Students and Environmental Education

Science education enables individuals to understand the environmental phenomena they encounter, which positively or negatively affects them through observations and experiments (Meador, 2003). For this reason, gifted students are often highly interested in science because of their intense curiosity about the objects they use daily, and what is happening in their natural environment stimulates their imagination (Smutny & Von-Fremd, 2004). Gifted students' sensitivity to environmental problems, such as air pollution, their interest in the natural environment, and their advanced problem-solving and reasoning skills make them efficient resources for solving

environmental issues. It has also been claimed that gifted students are more sensitive to the environment than their peers and can take more responsibility for solving environmental problems (Tarık-Önal, 2021). In addition, before organizing activities and training to support gifted students in developing positive behaviors and attitudes toward the environment, it is crucial to determine their thoughts and perceptions of the environment and environmental problems (Özarslan et al., 2017). Another important reason for determining the perceptions of gifted students about environmental events - socio-scientific issues such as air, water, soil pollution, etc.—is to develop the interests and curiosity of gifted individuals and directing them to work on environmental and global problems, and solutions to these problems in the future are considered very important for the development of countries and societies (Saraç & Özarslan, 2018).

Gifted students are highly successful in solving global problems. These special children, who can change their world, produce solutions to many environmental problems and threats that occur spontaneously or are created by human beings. For example, gifted individuals have different perspectives on social and environmental issues. These characteristics enable them to think more creatively than their peers in analyzing changes in their environment and finding solutions to problems. Therefore, determining what kind of understanding gifted students develop towards solving environmental problems will provide fundamental data for shaping their future education (Hotoman, 2020).

Studies Conducted on Air Pollution and Socioscientific Issues

There are many studies on how students are motivated towards socio-scientific issues and how they use advanced thinking skills such as problem solving, creative thinking, discussion, decision making and critical thinking in the process of solving these issues (Herman, et al, 2021; Baytelman, et al, 2020). However, more focus has been placed on studies on air pollution under the heading of Socioscientific issues. When the related literature is reviewed, Özarslan (2022) conducted a study to determine the views of gifted students on environmental problems and their suggestions for solutions. It was found that students mainly emphasized current environmental issues, such as water and air pollution, and global warming. The students stated that environmental problems are mainly caused by society's lack of education and awareness of society and environmental pollutants. Students suggested recycling and waste treatment, educating individuals about the environment, reorganizing laws, and increasing inspections to solve environmental problems. Tanık-Önal (2021) aimed to describe the environmental education provided to gifted students and to determine their views on this issue. In his study, students reported that they should act more environmentally friendly and actively participate in environmental education in order to solve environmental problems. In Dimitriou & Christidou's (2007) study, which aimed to determine students' perceptions of air pollution, students held the production process (industry), transportation (both of which are significant contributors to air pollution caused by the combustion of fossil fuels), and solid waste responsible for air pollution. They added human activities, such as using insecticides and fertilizers in agriculture, spray use, and forest fires, as other sources of air pollution. These views of pollution were based on their concrete experiences linked to "bad smells." It also enables students to recognize, to some extent, the interdependence of different environmental factors and the link between air pollution and human health, flora, and fauna. Thornber et al. (1999) aimed to determine students' views of air pollution. It was found that students thought that transport and industry were the main causes of air pollution. Due to air pollution, plants and animals will die, and people will get sick due to air pollution. The study also concluded that pollution is most easily perceived in concrete terms by students of this age.

Air pollution is one of the main causes of both acute and chronic health problems (Rakwongwan et al., 2021). In addition, the World Health Organization (WHO) reported in 2012 that approximately 7 million people died as a result of exposure to air pollution (WHO, 2014). It is important to explore students' views about this phenomenon, which negatively affects the lives of humans and other living things, thus raising their awareness of this environmental problem.

Purpose of the Study

This study aimed to determine gifted students' perceptions towards air pollution, a socio-scientific issue, using the draw-write-tell technique. In this context, answers to the following questions were sought.

1. What are the perceptions of gifted students about the causes of air pollution?
2. What are the perceptions of gifted students towards the solution to air pollution?

METHOD

Research Design

This study was designed according to a phenomenological design, a qualitative research method. In phenomenological design, the lived experiences of several people about a phenomenon or concept are examined (Creswell, 2013). This design focuses on the phenomena we are aware of, but does not have an in-depth and detailed thought (Patton, 2014).

Research Group

The research group consisted of 23 gifted students studying at the Science and Art Center during the 2022-2023 academic year. The participants were recruited using convenience sampling, which is a non-random sampling method. The ages of the students ranged from 10-11 to years old.

Data Collection Tools and Data Collection

The study data were collected using the draw-write-tell technique. Various techniques need to be used to determine students' perceptions of concepts. One of these techniques is the draw-write-tell technique, which involves students drawing, writing and explaining the concept while explaining the concepts. The draw-write-tell technique is based on the principle that students first draw around certain concepts, then write their thoughts about this concept, and finally express their thoughts about the concepts (Dinç & Üztemur, 2017). Data were collected for a total of eight hours, two hours per week. In the first and second weeks, data on the causes of air pollution were collected, and in the third and fourth weeks, data on the solutions to air pollution were collected. Three stages of "Draw, Write, and Tell" were followed in the data collection process. In the first week, students were given A4 papers divided into four equal sections and asked to make four separate drawings about the causes of air pollution in this study. For this purpose, students were given the required materials such as pencils and paints. The students were told that they should not have aesthetic concerns while making drawings, because their drawing skills were not measured. Students were given 40 min to make their drawings. They were then asked to write their drawings. At this stage, the students wrote what they drew and what they wanted to explain in their drawings. Finally, focus group interviews were conducted with the students. In the interviews, students were asked to read the texts they wrote about air pollution and explain the critical parts they wanted to explain in the texts, the reasons for their thoughts, and the issues they wanted to emphasize. Through interviews, students' perceptions of the causes of air pollution were revealed in detail. The focus group interviews were conducted in two separate groups and lasted approximately 40 minutes. The same procedures in the first two weeks were also carried out in the third and fourth weeks, within the scope of the solution suggestions for air pollution.

Data Analysis

An inductive content analysis method was used to analyze the data. In this content analysis, the themes and categories were sourced from the dataset. Patterns, themes, and categories have been discovered in the data (Patton, 2014). In the content analysis, codes were developed based on the participants' views, and categories or themes were formed by combining the generated codes. For this purpose, the data obtained from students' drawings, writings, and interviews were transferred to a computer environment, and codes were created by reading them. Codes were created according to the participants' statements. Two independent researchers created the code list. Similar codes are created within a specific category and theme framework. Thus, we tried to determine the participants' perceptions of the causes of air pollution and their suggestions for solutions. Within the framework of ethical principles, the participants' real names were not used; instead, they were given codes such as Example-1, Example-2,..., and Example-23.

Validity and Reliability

Various strategies have been suggested to improve the quality of qualitative research (Creswell, 2013; Patton, 2014). In this study, the credibility, transferability, confirmability, and consistency strategies were used. To increase the credibility of the study, depth-oriented data were collected, expert opinions were obtained in the preparation of the questions to be included in the interview form, and participant confirmation was obtained regarding the data obtained. To increase the transferability of the study, rich and intensive definitions were made and explained in detail, the data obtained were described in detail, and direct quotations were used. To increase the confirmability of the research, all data were computerized and stored in a digital environment. The results obtained were confirmed with continuously collected data, and a logical explanation was provided to the reader in this context. Different coders were responsible for analyzing the data to ensure consistency in the research, and inter-coder consistency was calculated. Two researchers coded the data and the codes obtained were compared.

Coder reliability was calculated using the reliability formula suggested by Miles & Huberman (1994), and the agreement between the researchers was 92%.

FINDINGS

These findings were interpreted with two main headings. The first main heading includes findings on the causes of air pollution, and the second main heading consists of findings on the solution of air pollution.

Findings on the Causes of Air Pollution

To determine the students' perceptions towards the causes of air pollution, the drawings they made, the writings they wrote about their drawings, and the thoughts they shared during the interviews were used. The findings are presented in Figure 1.

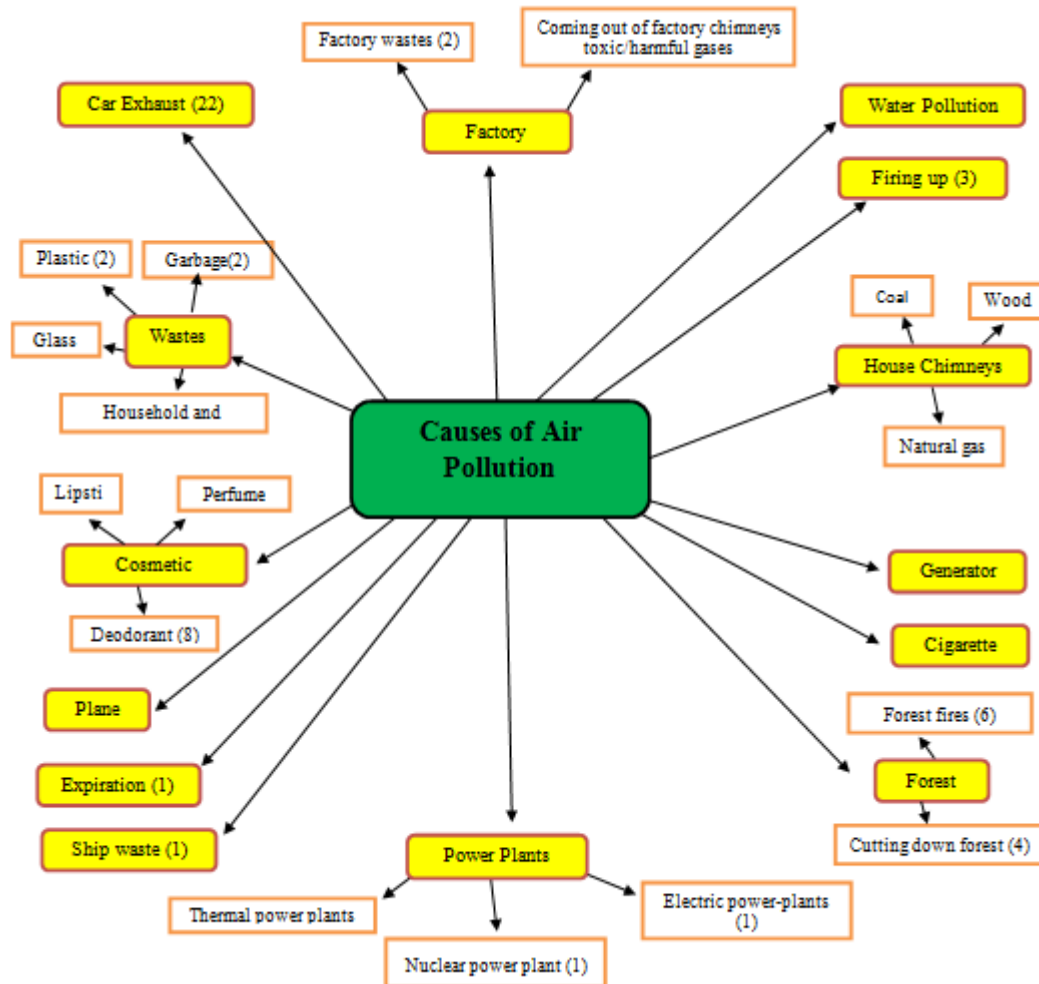


Figure 1. Students' Views on the Causes of Air Pollution

As shown in Figure 1, 14 themes were formed in line with the students' views on the causes of pollution. These themes were car exhaust, cosmetic products, factories, forests, house chimneys, waste, cigarettes, power plants, firing up, generators, planes, water pollution, expiration, and ship waste. The theme, cosmetic products, includes deodorants, perfumes, and lipsticks; the theme and factory includes toxic/harmful gases from factory chimneys and factory waste; the theme, forest, includes forest fires and cutting down forests; the theme, house chimney, includes coal, wood, and natural gas; the theme, waste, includes household and industrial waste, plastic, garbage, and glass; and the theme, power plants, including nuclear, thermal, and electric power plants.

Car Exhaust

Twenty-two participants stated that the gases emitted from car exhaust were an essential cause of air pollution by drawing and expressing their views. The drawings made by some participants are shown in Figure 2.

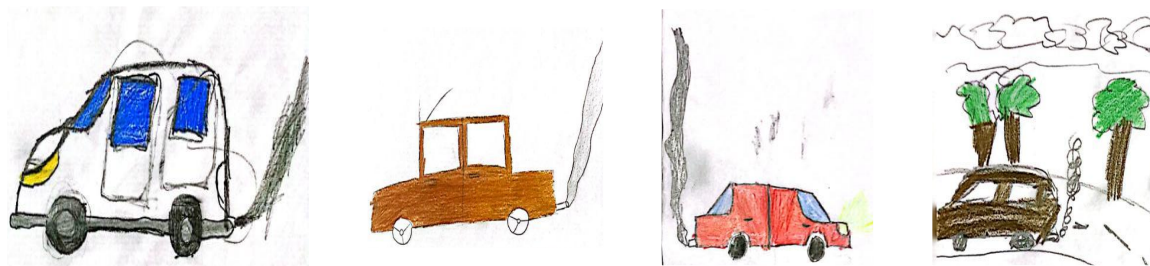


Figure 2. The Drawings of Students

When the writings and views of the participants were examined, the students stated that vehicles running on fossil fuels such as diesel, gasoline, and LPG emit harmful gases from their exhaust, which mix into the air and cause air pollution. Some students' views on this theme are as follows.

(E1) LPG, diesel fuel, and gasoline are used as fuel in cars. As a result of using these, dirty smokes come out of the car's exhaust. When this dirty smoke is released outside, the air is polluted.

(E10) As a result of the running of vehicles such as cars, buses, and minibuses, harmful gases are released from their exhausts into the air. These gases both pollute the air and cause damage to human health.

Cosmetic Products

Deodorant, perfume, and lipstick codes have been created for cosmetic products. Within the scope of this theme, eight students stated that deodorants, seven stated perfumes, and two stated that lipsticks cause air pollution, drawing and expressing their views. The drawings made by some participants are shown in Figure 3.

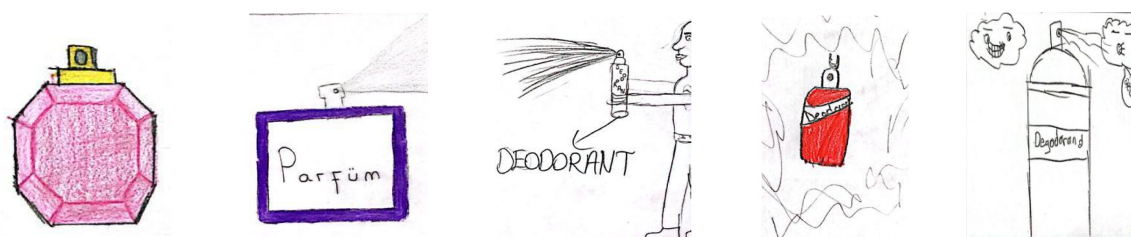


Figure 3. The Drawings of Students

When the writings and views of the participants were examined, students stated that there are chemical substances in cosmetic products, such as deodorants, perfumes, and lipsticks, that people use for care in their daily lives. According to the students, when these products are used, these harmful substances mix into the air and cause air pollution. Some students' opinions on this theme are as follows.

(E7) There are various chemical substances in cosmetic products, such as perfume, lipstick, nail polish, and deodorant, which people use. When people use these products, these chemicals inevitably mix into the air, thus polluting the air.

(E11) There are harmful chemicals in substances, such as deodorant, perfume, and nail polish, that people use. These harmful chemicals cause the ozone layer to thin. As the ozone layer becomes thinner, it becomes easier for harmful rays from the sun to reach the Earth. All these cause pollution of the air we breathe.

Factory

The codes of toxic/harmful gases emitted from factory chimneys and factory waste were created in the factory theme. Within the scope of this theme, 13 students stated that toxic/harmful gases were emitted from factory chimneys, and two stated that factory wastes cause air pollution and drew and expressed their views. The drawings made by some participants are shown in Figure 4.

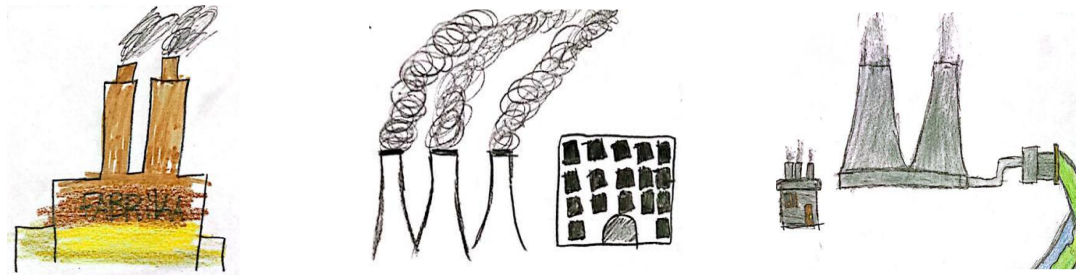


Figure 4. *The Drawings of Students*

According to the students' views, factory waste and the toxic/harmful gases coming out of the factory chimneys mix into the air and cause air pollution. Some students' opinions on this theme are as follows.

(E1) Factories use fuels such as natural gas, coal, and fuel oil. As a result, very harmful gases (carbon dioxide) are released into the air. Air pollution occurs when factories release that dirty smoke into the air.

(E13) There are many factories in industrial zones. Fossil fuels are used to run these factories. As a result of using these fossil fuels, the chimneys of the factories emit smoke. Where does this smoke go? Of course, it mixes with the air. This causes air pollution.

Forest

Forest fires and cutting-down forest/tree codes were created in the forest theme. Within the scope of this theme, while six students drew and expressed their views that forest fires caused air pollution, four students drew and expressed their views that cutting forests/trees caused air pollution. The drawings made by some participants are shown in Figure 5.



Figure 5. *The Drawings of Students*

When the writings and views of the participants were analyzed, the students stated that forest fires and forest/tree cutting caused air pollution. Some students' opinions on this theme are as follows.

(E5) People cut down forests for mining, tourism, and transportation. Desertification occurs as a result of cutting down forests. As forests are destroyed, the amount of oxygen decreases, and this causes an increase in air pollution.

(E8) If forests burn for any reason, there is much smoke. This smoke contains very harmful gases. These gases pollute nature. As the number of trees decreases, oxygen decreases, and carbon dioxide increases. This causes pollution of the air.

House Chimneys

The theme of "house chimneys" was formed in light of the students' responses from their drawings, writings, and views on the causes of air pollution. Eight participants stated that smoke coming out of house chimneys caused air pollution. The drawings made by some participants are shown in Figure 6.



Figure 6. *The Drawings of Students*

When the writings and views of the participants were analyzed, the students stated that the smoke coming out of the house chimneys was harmful and caused air pollution by mixing into the air. Some students' opinions on this theme are as follows.

(E2) The air is polluted due to bad and toxic smoke from the chimneys of houses. Especially coal smoke increases this even more. In fact, we can prevent air pollution by not releasing this toxic smoke from our homes into the air.

(E4) Today, many homes and workplaces are still heated with coal. As a result of coal burning, harmful gases are dispersed into the air and cause air pollution.

Wastes

Garbage, plastic, and glass codes were created for this waste theme. Within the scope of this theme, two students stated that garbage, two students stated that plastic waste, and one stated that glass waste causes air pollution, drawing and expressing their views. The drawings made by some of the participants are shown in Figure 7.

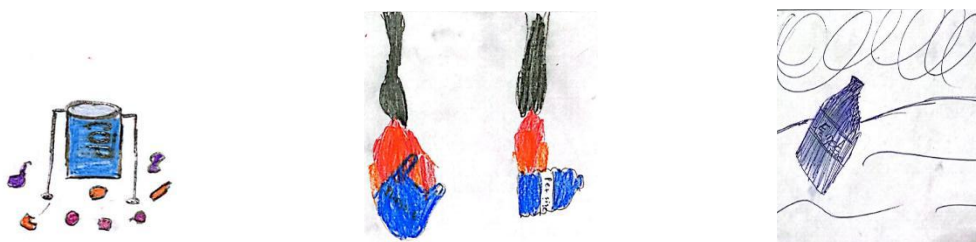


Figure 7. *The Drawings of Students*

When the writings and views of the participants were analyzed, it was found that the students stated that garbage, plastic, and glass waste caused air pollution. Some students' opinions on this theme are as follows.

(E3) When people throw glass waste, such as bottles, glasses, etc., into nature, they break. These broken glasses act as a lens. As a result of the sun's rays hitting these glass particles, all the rays gather at one point, and a fire starts. The fire grows, and forest fires occur.

(E9) People throw plastic bottles, beverage cans, cups, spoons, and forks into the environment. As such wastes pollute the environment, they also pollute the air.

Power Plants

In the theme of power plants, codes were created for nuclear, thermal, and electric power plants. Within the scope of this theme, one student for each code expressed their views that the aforementioned power plants increased air pollution. The drawings made by some participants are shown in Figure 8.

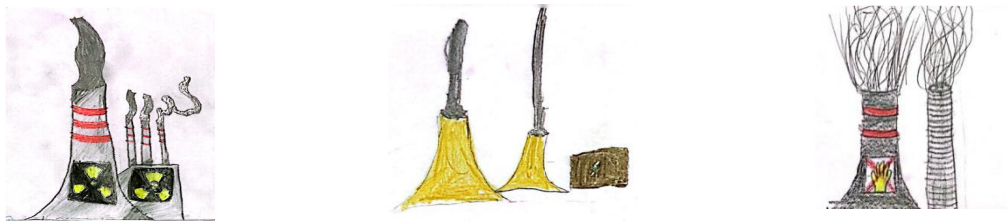


Figure 8. *The Drawings of Students*

When the writings and views of the participants were analyzed, it was observed that the students stated that nuclear, thermal, and electric power plants emitted harmful gases. These harmful gases mix with the air, causing air pollution. Some students' opinions on this theme are as follows:

(E8) Unfortunately, the materials used as fuel materials in nuclear power plants emit toxic gases. These toxic gases mix into the air, damaging the atmosphere and the ozone layer.

(E12) Coal is used in thermal power plants to generate electricity. As a result of the burning of coal used in power plants, carbon dioxide, carbon monoxide, methane, etc. gases are emitted; these gases pollute the air and cause the ozone layer to be depleted. These toxic gases also cause global warm in.

Cigarette, Fire, Generator, Airplane, Water Pollution, Exhalation, and Ship Waste

Participants also created themes such as cigarettes, fires, generators, planes, water pollution, exhalation, and ship waste. Within the scope of this theme, while seven students drew a drawing and expressed their opinion that cigarettes cause air pollution, three students drew and expressed their views that fire caused air pollution. For each remaining code, generators, airplanes, water pollution, exhalation, and ship waste, one student drew and expressed their views that these codes have an essential role in air pollution. The drawings made by some participants are shown in Figure 9.

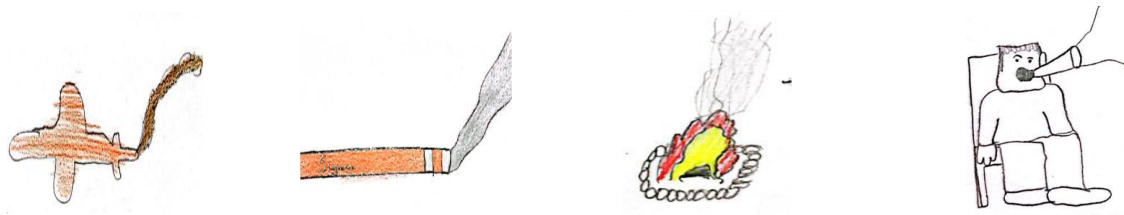


Figure 9. *The Drawings of Students*

When the writings and views of the participants were examined, the students stated that air pollution occurred because of the negative situations caused by cigarettes, fire, generators, airplanes, water pollution, exhalation, and ship waste. Some student opinions were as follows.

(E1) Gasoline is used when generators work. Therefore, toxic smoke comes out of their chimneys. This smoke pollutes the air.

(E7) When smoking, the toxic substances in the cigarette cause pollution.

(E17) When people have picnics, set up camps, and have barbecues, they light a fire. The smoke of these fires contains substances that harm the air. This is very damaging to the air.

Findings on Solutions to Air Pollution

In this part of the findings, to determine the students' perceptions of the solutions to air pollution, the drawings they made, the writings they wrote about their drawings, and the thoughts they expressed during the interviews were used. The results are shown in Figure 10.

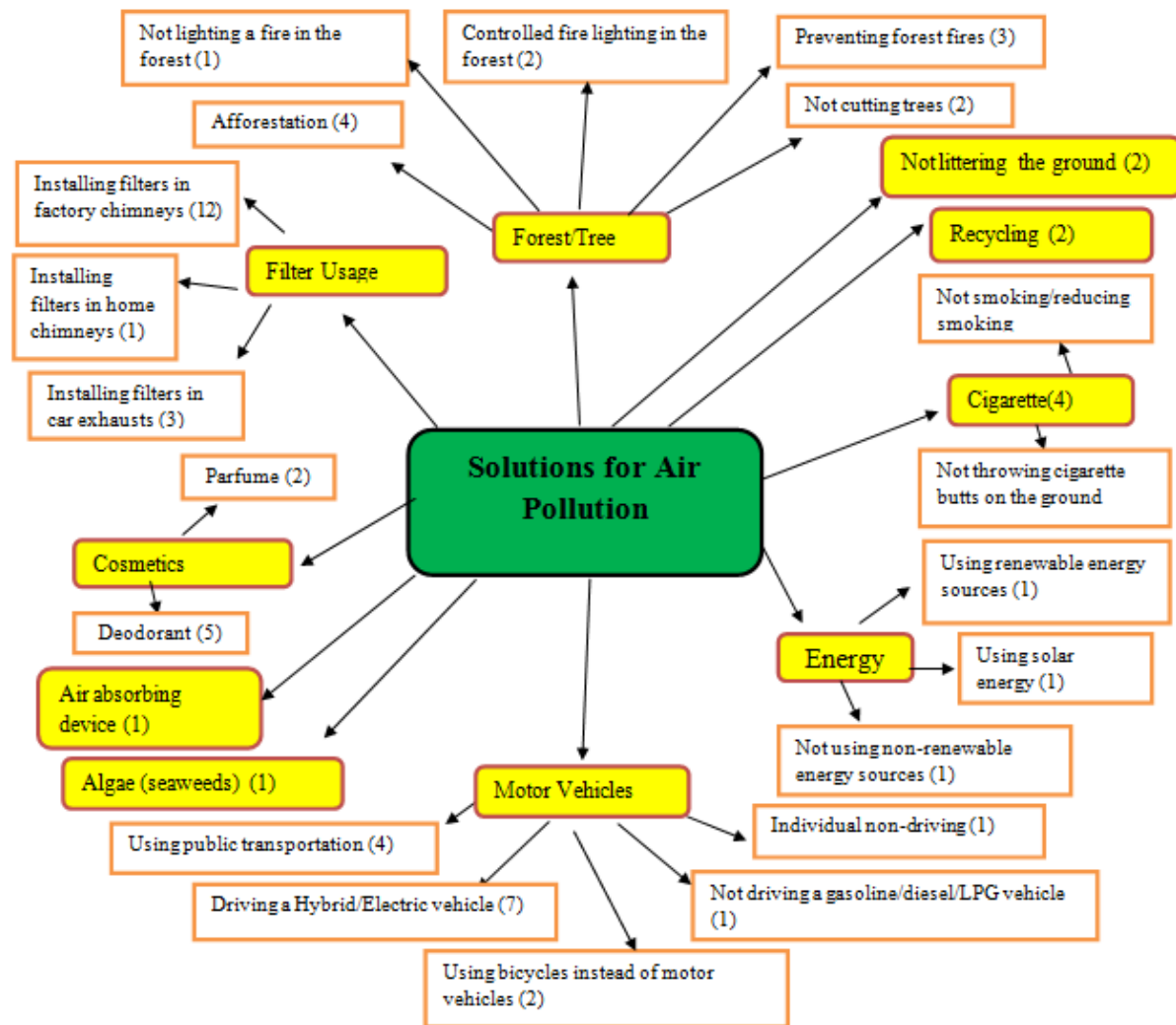


Figure 10. Students' Views on Solutions to Air Pollution

As seen in Figure 10, 11 themes were formed in line with the students' views on solutions to air pollution. These themes were motor vehicles, forests/trees, filter use, cigarettes, cosmetic products, energy, recycling, not throwing garbage, algae, and air-absorbing devices. While the motor vehicle theme includes codes for using public transportation, using electric/hybrid vehicles, not using gasoline/diesel/LPG vehicles, not using individual vehicles, and using bicycles instead of motor vehicles, the forest/tree theme includes codes for afforestation, not cutting down trees, not burning fires in forests, controlling fires in forests, and preventing forest fires. In the filter usage theme, there are codes for installing filters on factory chimneys, installing filters on car exhausts, and installing filters on home chimneys; in the cigarette theme, there are codes for not smoking/reducing smoking and not throwing cigarette butts on the ground; in the cosmetic products theme, there are codes for deodorants and perfumes; and in the energy theme, there are codes for using renewable energy sources, non-renewable energy sources, and solar power.

Motor Vehicles

In the theme of motor vehicles, four participants expressed their opinion that using public transportation would be an excellent solution to prevent air pollution. Codes for the use of electric/hybrid vehicles, not using gasoline/diesel/LPG vehicles, not using individual vehicles, and using bicycles instead of motor vehicles were also drawn and expressed by seven, one, one, and two participants, respectively. The drawings made by some participants are shown in Figure 11.

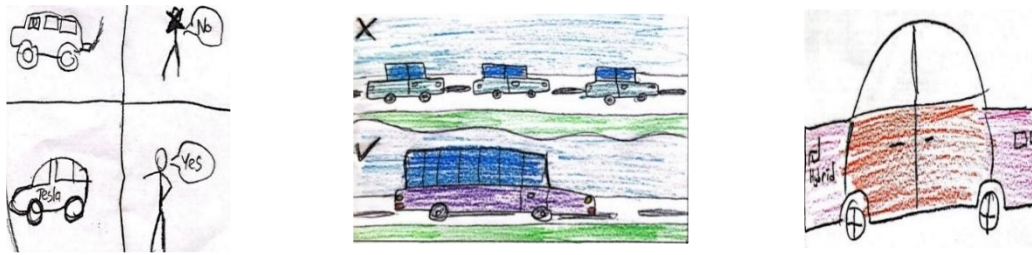


Figure 11. The Drawings of Students

When the writings and views of the participants were examined, it was found that the students stated that the use of individual cars might cause an increase in the rate of harmful gases in the air, so the use of public vehicles will play an essential role in reducing air pollution rather than using individual vehicles. In addition, students stated that harmful gases from the exhaust of gasoline/diesel/LPG-powered vehicles increase air pollution; therefore, using electric/hybrid vehicles will play an essential role in reducing air pollution. Some students' opinions on this theme are as follows:

(E2) Toxic gases from the exhausts of cars pollute the air. Therefore, if each person starts his/her automobile, there will be an increase in the amount of harmful gases entering the air. Instead, people should use public transportation.

(E6) Vehicles running on gasoline, diesel, and LPG release highly harmful gases into the air. These fuels increase air pollution. Using electric vehicles instead of these vehicles decreases air pollution because electric vehicles do not release harmful gases into the air like these vehicles.

(E23) People should use bicycles for transportation instead of motor vehicles. If they go somewhere, they should go by bicycle.

Forest/Tree

In the forest/tree theme, four participants made a drawing about and expressed their views on afforestation: three students on preventing forest fires, two students on not cutting trees and making controlled fires in the forest, and one student on not making fires in the forest as an essential method in solving air pollution. The drawings made by some participants are shown in Figure 12.

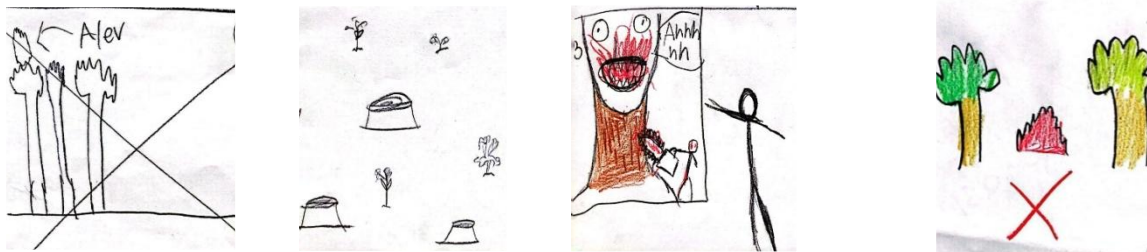


Figure 12. The Drawings of Students

When the writings and views of the participants were analyzed, it was found that the students stated that afforestation, not cutting trees/forests, preventing forest fires, not burning fires in the forest, and controlling fires in the forest would play an essential role in solving air pollution. Some students' opinions on this theme are as follows:

(E6) Air pollution will decrease if afforestation is done in places with no trees because the tree takes carbon dioxide gas and gives oxygen gas to the air. People should be made aware of afforestation.

(E17) When we go to forested lands, we must be cautious when lighting a fire. Because the fire we burn in the forest can splatter on the trees, and this fire can go out of control and turn into a big forest fire. If there is a forest fire or the trees are burned, oxygen production will decrease, resulting in air pollution.

Filter Usage

With regard to the use of filters, 12 participants drew a drawing. They expressed their views on installing filters in factory chimneys; three participants on car exhausts and one participant on house chimneys would be an excellent solution to prevent air pollution. The drawings made by some participants are shown in Figure 13.

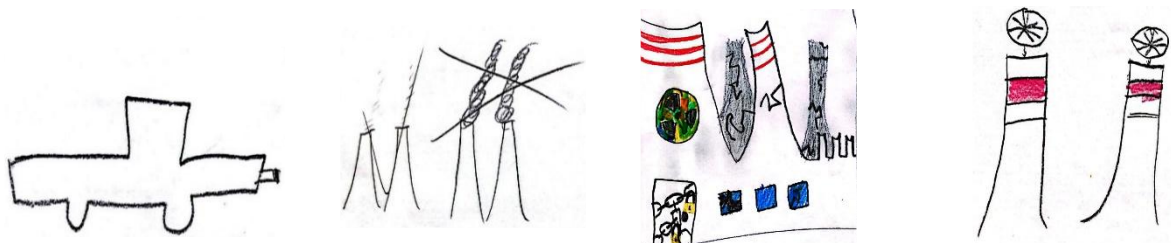


Figure 13. *The Drawings of Students*

When the writings and views of the participants were examined, the students stated that the installation of filters in the chimneys of factories, houses, and vehicles was an essential factor in the solution of air pollution to prevent toxic gases from polluting the air. Some students' views on this theme are as follows.

(E3) Fossil fuels are used in factories. Harmful gases are released as a result of their burning. Installing filters in the chimneys of factories will significantly reduce the rate of harmful gases entering the air because installing filters reduces air pollution by 90%.

(E13) The chimneys of coal-heated houses emit much harmful smoke into the air, and air pollution occurs. If filters are installed in the chimneys of the houses to reduce the harm of this smoke, further pollution of the air will be prevented.

Cigarette

Regarding the theme of cigarettes, four students made drawings about and expressed their views that not smoking or reducing the use of cigarettes, and not throwing cigarette butts on the ground would be excellent solutions to prevent air pollution. The drawings made by some participants are shown in Figure 14.

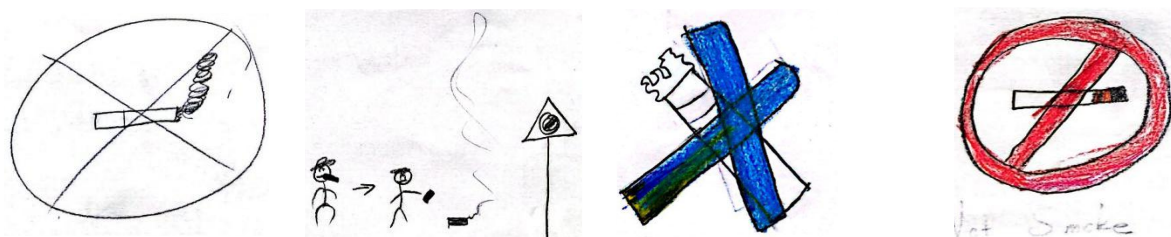


Figure 14. *The Drawings of Students*

When the writings and views of the participants were analyzed, the students stated that not smoking, reducing smoking, not throwing cigarette butts on the ground, and raising awareness among people about smoking were effective in reducing air pollution. Some students' opinions on this theme are as follows.

(E2) Air pollution will decrease if people reduce cigarette consumption and do not smoke because the chemicals in cigarette smoke pollute the air considerably. If cigarettes are reduced or smoking is stopped, the air will not be polluted, and human health will be positively affected.

(E17) Harmful chemicals in cigarettes cause severe damage to nature and air. Unconscious people throw cigarette butts on the ground. This situation pollutes the environment and causes the harmful substances in those cigarettes to mix into the air.

Cosmetic Products

In the cosmetics theme, six students expressed their views on not using or reducing the use of deodorants, and one student expressed that not using or reducing the use of perfume is an essential factor in solving air pollution. The drawings made by some of the participants are shown in Figure 15.



Figure 15. The Drawings of Students

Students stated that cosmetic products, such as deodorants and perfumes, contain various chemicals, that harmful chemicals are mixed into the air because of the use of these products, and that not using or reducing the use of these products effectively reduces air pollution. Some students' opinions on this theme are as follows.

(E6) The chemicals in cosmetic products such as perfume and deodorant that people use pollute the air by mixing into the air. This can be very harmful to humans and other living things. For this reason, we should not use such cosmetic products.

(E18) Deodorants pollute the air considerably because deodorants contain harmful gases and chemicals. These harmful gases and chemicals pollute the air.

Energy

Each code under the energy theme—not using renewable energy sources, non-renewable energy sources, and solar power—was drawn and expressed as an essential factor in solving air pollution. The drawings made by some participants are shown in Figure 16.



Figure 16. The Drawings of Students

Students stated that using non-renewable energy sources increases air pollution; therefore, renewable energy sources should be used instead of non-renewable energy sources. Some students' opinions on this theme are as follows.

(E12) Due to using fossil fuels, such as coal, oil, etc., very harmful and toxic gases are released into the air. If renewable energy sources, such as water, sun, and wind, are used instead, air pollution will be reduced.

(E18) Fossil fuels are non-renewable energy sources. Very harmful gases are released into the air when these energy sources are used. When we use these fossil fuels, greenhouse gases are produced, which are very harmful to the air.

Recycling, Not littering, Air Absorbing Devices, and Algae

When the students' drawings, writings, and views were analyzed, the themes of "recycling," "not littering," "air absorbing device," and "algae" were formed. Two students stated the theme of recycling, two stated the theme of not throwing garbage on the ground, one stated the theme of absorbing devices, and one stated that the theme of algae would have essential effects on the solution of air pollution. The drawings made by some participants are shown in Figure 17.

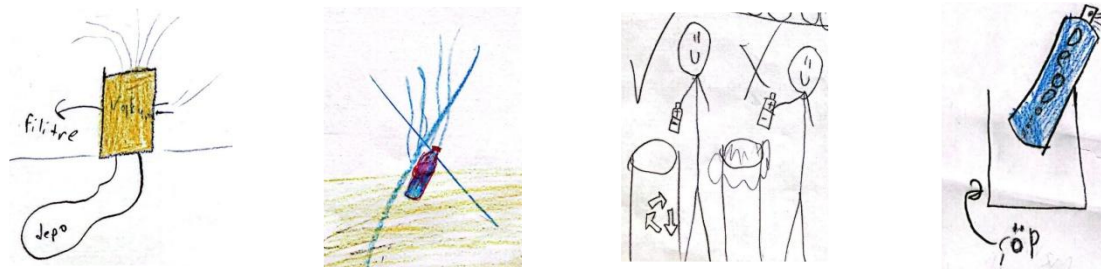


Figure 17. *The Drawings of Students*

When the writings and views of the participants were analyzed, the students stated that not throwing garbage on the ground, throwing batteries into recycling bins instead of garbage, and using a device that absorbs polluted air would effectively prevent air pollution. Some students' opinions on these themes are as follows.

(E2) Algae are photosynthesizing organisms. With photosynthesis, these creatures take carbon dioxide from the environment and provide oxygen to the environment. They can reduce air pollution because they provide oxygen to the environment. Also, an air vacuum device can be made. This device absorbs and cleans the polluted air. Then, it releases the cleaned air to the outside. Thus, air pollution is reduced.

(E8) Air pollution occurs when plastic, glass, chemical, and medical wastes are thrown into the environment. If such materials are recycled, the harmful gases they release into the air are prevented. Also, when the paper is recycled, the cutting of trees is reduced. Since the cutting of trees decreases, air pollution decreases.

DISCUSSION & CONCLUSION

According to gifted students, many factors cause air pollution, the most frequently mentioned of which are transportation and factory-related causes. The participants stated that gases and chemicals in fossil fuels directly enter the air and cause air pollution. Students stated that harmful gases are emitted from the exhaust of cars running on fuels such as gasoline, diesel, and LPG, and these gases cause air pollution. At this point, the students drew attention to air pollution caused by transportation. Varaden et al. (2021) found that most participants understood the effects of traffic-related air pollution. Similarly, they believed that harmful gases emitted from the chimneys of factories using fossil fuels cause air pollution.

The results revealed that the students believed that these harmful gases mixed with the air from cars and factories negatively affected the lives and health of people and other living things. Experts at the International Agency for Research on Cancer recently assessed the carcinogenicity of diesel and gasoline engine exhausts and some nitroarenes (Benbrahim-Tallaa et al., 2012). Air pollution poses a significant risk to the environment and living conditions (Sadatshojaie & Rahimpour, 2020). Air pollution has long-lasting effects, increasing the global incidence of the disease to approximately 147.42 million citizens. Air pollution has become a global problem (Elsaid & Ahmed, 2021). For example, in 2012, 193,000 people in developed countries in Europe died of airborne particles (Ortiz et al., 2017). Air pollution and human exposure to poor-quality air are currently the most critical environmental threats to public health worldwide (WHO, 2016). These findings support the views.

In addition to determining that using transportation and industrial sources increases air pollution, students suggested solutions for air pollution caused by these two sources. The participants put forward various suggestions related to motor vehicles and factories, and they think that air pollution will not occur, will be prevented, or will be reduced thanks to the solution suggestions they put forward. According to the students, using hybrid vehicles powered by batteries instead of gasoline, diesel, and LPG-powered vehicles, preferring public transportation instead of individual driving, and using bicycles instead of motor vehicles can be effective solutions to prevent air pollution. For example, S23 stated that using bicycles instead of motorized vehicles would reduce air pollution. Similarly, in a study conducted by Varaden et al. (2021) with students aged 5-11, one student stated that he started riding a bicycle to school regularly. With the increase in the use of motor vehicles, the amount of exhaust gas emitted increases. In addition, air pollutants emitted from chimneys in factories, residences, and workplaces pose significant risks to the lives of humans and other living organisms. Students put forward ideas to eliminate or reduce the adverse conditions created by this situation. The students in the study group thought that installing filters on car exhausts, chimneys of factories, and residences had an essential effect on the solution of air pollution. In his study, Uyanık (2017) reported that participants expressed opinions on air pollution caused by car exhaust

and residential chimneys. In addition, Kirilmazkaya (2022) reported that the participants stated that factory smoke causes air pollution. These findings are similar to those obtained in our study.

According to the students, cosmetic products such as deodorants, perfumes, and nail polishes contain harmful chemicals and gases. They stated that air pollution occurs when harmful substances in these products are mixed into the air. Researchers believe that chemicals in personal care products, such as deodorants, makeup, and hairspray, may increase air pollution levels (Behal & Behal, 2020). Similarly, Kilicoglu and Yilmaz (2021) stated in their study that students see deodorants as a cause of global warming. The students in our study think that not using or reducing deodorants, perfumes, makeup products, etc., is an excellent solution to prevent air pollution.

Air pollution is one of the biggest killers of our time (Landrigan, 2017). Forest fires are among the most significant contributors to pollution. Biomass burning is one of the most important sources of air pollution worldwide (Yarragunda et al., 2020). In parallel with these explanations, the students in the research study group stated that air pollution occurs when harmful and dirty smoke mixes with air during forest fires. In addition, they believe that cutting forests or trees for tourism, industry, transportation, etc., has a severe role in creating air pollution. Students developed solutions for air pollution caused by forest fires. Students thought that afforestation, not cutting trees in forested lands, burning fires in forests and picnic areas, or controlled fires are essential to reducing air pollution. In a study conducted by Kirilmazkaya (2022) with secondary school students, it was concluded that the students responded as "agree" with a mean of 3.96 to the item "I do not burn a fire in forested lands or at picnics" on their attitude towards the environment scale. In our research, it was found that students stated that making a fire in forestlands or picnic areas poses a significant risk for a fire, and for this reason, either no fire should be burned in these areas or controlled fires should be burned.

One of the critical pollutants that pollute the air is waste. Wastes that pollute the environment and the air can be very diverse. Industrial and domestic activities cause air pollution (Sadatshojaie & Rahimpour, 2020). Garbage, medical and chemical waste, plastics, glass and paper, electronic, sewage, and factory waste that people throw into the environment can cause significant environmental problems. According to the students in the study group, garbage, plastics, and glass waste thrown into the environment cause air pollution. It has even been observed that some glass shards cause forest fires in forested land. In the study by Kiliçoglu and Yilmaz (2021), participants stated that they considered waste an essential cause of global warming. Within the scope of this issue, students argued that people should not throw garbage uncontrollably and should raise awareness. Similarly, in the study by Uyanık (2017), the participants emphasized that awareness should first be raised to prevent environmental pollution.

According to gifted students, power plants are an important cause of air pollution. Coal-fired thermal power plants play an important role in air pollution. After using fossil fuels, harmful gases are emitted into the air, polluting clean air. In particular, using fossil fuels in industries, power plants, construction, quarries, and transportation causes air pollution (Sadatshojaie & Rahimpour, 2020). In this regard, students think using renewable energy sources instead of non-renewable ones will be beneficial in preventing air pollution. It is thought that using environmentally friendly energy sources will be effective in solving the major environmental problems of our age.

The students stated that cigarettes contain harmful chemicals that mix with the air when they smoke. Therefore, they stated that reducing or eliminating cigarette use plays a role in reducing air pollution. They also believed that the fuel used by airplanes, ships-wastes, water pollution, and generators increased air pollution. In addition, they emphasized that uncontrolled fires in outdoor activities, such as camping and picnics, are risky. Gifted students thought that recycling and not throwing garbage on the ground would positively affect their solutions to air pollution.

It was found that gifted students primarily mentioned transport, industry, forest fires, and cosmetic products as causes of air pollution. In addition, they believe that installing filters on chimneys, protecting forests, limiting or not using cosmetic products, recycling, using environmentally friendly energy sources, and using public transport can be efficient solutions to reduce air pollution. From this point of view, gifted students correctly defined the causes of air pollution and suggested solutions to eliminate or reduce air pollution

Statements of Publication Ethics

Ethics Committee approval for the study was obtained from the Ethics Committee of the affiliated Istanbul 29 Mayıs University with the dates 02.01.2023 and 2023/01-3.

Researchers' Contribution Rate						
Authors	Literature review	Method	Data Collection	Data Analysis	Results	Conclusion
Author 1's name	☒	☒	☒	☒	☒	☒
Author2's name	☒	☒	☒	☒	☒	☒

Conflict of Interest

This study has no conflict of interest.

REFERENCES

- Baytelman, A., Iordanou, K., & Constantinou, C. P. (2020). Epistemic beliefs and prior knowledge are predictors of constructing different types of arguments on socio-scientific issues. *Journal of Research in Science Teaching*, 57(8), 1199–1227. <https://doi.org/10.1002/tea.21627>
- Behal, A. & Behal, D. (2020). Smell good, breathe bad: How scented products add to air pollution. <https://www.downtoearth.org.in/blog/environment/smell-good-breathe-bad-how-scented-products-add-to-air-pollution-74501>
- Benbrahim-Tallaa L, Baan RA, Grosse et al. (2012). International Agency for Research on Cancer monograph working group. Carcinogenicity of diesel-engine and gasoline-engine exhausts and some nitroarenes. *Lancet Oncol*, 13, 663–664. [https://doi.org/10.1016/S1470-2045\(12\)70280-2](https://doi.org/10.1016/S1470-2045(12)70280-2)
- Chen, L., & Xiao, S. (2021). Science teachers' perceptions, challenges and coping strategies in teaching socioscientific issues: A systematic review. *Educational Research Review*, 32, 100377. <https://doi.org/10.1016/j.edurev.2020.100377>
- Creswell, J. W. (2013). *Qualitative inquiry and research design: Choosing among five approaches*. Sage Publications.
- D'Amato, G., & Akdis, C. (2020). *Global warming, climate change, air pollution, and allergies*. Authorea Preprints.
- Dimitriou, A., & Christidou, V. (2007). Pupils' understanding of air pollution. *Journal of Biological Education*, 42(1), 24-29. <https://doi.org/10.1080/00219266.2007.9656103>
- Dinç, E. & Üztemur, S. (2017). Investigating student teachers' conceptions of social studies through the multidimensional structure of the epistemological beliefs. *Educational Sciences: Theory & Practice*, 17(6), 2093-2142. <https://doi.org/10.12738/estp.2017.6.0429>
- Elsaid, A. M., & Ahmed, M. S. (2021). Indoor air quality strategies for air-conditioning and ventilation systems with the spread of the global coronavirus (COVID-19) Epidemic: Improvements and recommendations. *Environmental Research*, p. 199, 111314. <https://doi.org/10.1016/j.envres.2021.111314>
- Gonzalez-Martin, J., Kraakman, N. J. R., Perez, C., Lebrero, R., & Munoz, R. (2021). A state-of-the-art review on indoor air pollution and strategies for indoor air pollution control. *Chemosphere*, 262, 128376. <https://doi.org/10.1016/j.chemosphere.2020.128376>
- Herman, B. C., Newton, M. H., & Zeidler, D. L. (2021). Impact of place-based socioscientific issues instruction on students' contextualization of socioscientific orientations. *Science Education*, 105(4), 585-627. <https://doi.org/10.1002/sce.21618>
- Jickling, B. (2003). Environmental education and environmental advocacy: Revisited. *The Journal of Environmental Education*, 34(2), 20-27. <https://doi.org/10.1080/00958960309603496>
- Julie, D. (1998). Young children, environmental education, and the future. *Early Childhood Education Journal*, 26, 117–123.
- Kilicoglu G., & Yilmaz, M. A. (2021). Opinions of secondary school students on global warming. *Journal of Global Health & Natural Sciences*, 4(2), 102-112.

- Kirilmazkaya, G. (2022). Secondary school students' views on environment and environmental problems. *Adnan Menderes University Faculty of Education Journal of Educational Sciences*, 13(1), 1-11.
- Landrigan, P. J. (2017). Air pollution and health. *The Lancet Public Health*. <https://www.thelancet.com/action/showPdf?pii=S2468-2667%2816%2930023-8>
- Mandrikas, A., Stavrou, D., & Skordoulis, C. (2017). Teaching air pollution in an authentic context. *Journal of Science Education and Technology*, 26, 238-251. <http://dx.doi.org/10.1007/s10956-016-9675-8>
- Meador, K., S. (2003). *Thinking creatively about science suggestions for primary teachers*, Gifted Child Today.
- Miles, M. B., & Huberman, A. M. (1994), *Qualitative data analysis: An expanded sourcebook*. Sage.
- Myers, G., Boyes, E., & Stanisstreet, M. (2004). School students' ideas about air pollution: Knowledge and attitudes. *Research in Science & Technological Education*, 22(2), 133-152. <https://doi.org/10.1080/0263514042000290868>
- Özarslan, M. (2022). Environmental problems according to the gifted and talented students and their solution proposals: A qualitative research. *International Journal of New Trends in Arts, Sports & Science Education*, 11(4), 201-216.
- Özarslan, M., Çetin, G., & Yıldırım, O. (2017). Parental views of gifted and talented students about biology projects in science and art centre. *Abant İzzet Baysal University Journal of the Faculty of Education*, 17(3), 1411-1436.
- Patton, M. Q. (2014). *Qualitative research and evaluation methods*. Sage Publications
- Payne, P., G. (2006). Environmental education and curriculum theory. *The Journal of Environmental Education*, 37(2), 25–35. <https://doi.org/10.3200/JOEE.37.2.25-35>
- Rakwongwan, U., Archankul, A., Rujivan, S., & Bastian, P. (2021). The numerical visualization of air pollution propagation from a single generator to an observed area. *Chiang Mai Journal of Science*, 48(5), 1430-1443.
- Sadatshojaie, A., & Rahimpour, M. R. (2020). CO₂ emission and air pollution (volatile organic compounds, etc.) are related to problems causing climate change. *Current trends and future developments on (bio-) membranes*, 1-30. <https://doi.org/10.1016/B978-0-12-816778-6.00001-1>
- Sarac, H., & Özarslan, M. (2018). Environmental attitude levels of gifted and talented students and analysis of metacognitive in terms of some variables. *Journal of Computer and Education Research*, 6(11), 65-87. . <https://doi.org/10.18009/jcer.364377>
- Smutny, J. F. & Von-Fremd, S. E. (2004). *Differentiating for the young child: Teaching strategies across the content areas (K-3)*. Corwin Press.
- Tanik-Onal, N. (2021). Environmental education for gifted students. *International Journal of Geography and Geography Education*, 43, 122-135. <https://doi.org/10.1007/s10639-021-10474-7>
- Thorner, J., Stanisstreet, M., & Boyes, E. (1999). School students' ideas about air pollution: Hindrance or help for learning? *Journal of Science Education and Technology*, 8, 67-73. <https://doi.org/10.1023/A:1009481521719>
- Toren, M., & Mollahasanoglu, H. (2022). Investigating electric motors in electric and hybrid vehicles and estimating changes in CO₂ emissions: A sample of Türkiye. *El-Cezerî Journal of Science and Engineering*, 9(3), 1082-1097. <https://doi.org/10.31202/ecjse.1107454>
- Uyanik, G. (2017). Opinions towards environmental pollution of primary school students. *YYU Journal of Education Faculty*, 14(1), 1574–1600. <http://doi.org/10.23891/efdyu.2017.56>
- Varaden, D., King, H., Rushton, E., & Barratt, B. (2021). Engaging primary students with the issue of air pollution through citizen science: lessons to be learned. *Journal of Emergent Science*, 21, 30-36.
- Wahono, B., Chang, C. Y., & Khuyen, N. T. T. (2021). Teaching socio-scientific issues through integrated STEM education: an effective practical averment from Indonesian science lessons. *International Journal of Science Education*, 43(16), 2663-2683. <https://doi.org/10.1080/09500693.2021.1983226>

- World Health Organization (2016). Ambient air pollution: A global assessment of exposure and burden of disease. <https://www.who.int/publications/i/item/9789241511353>
- World Health Organization (WHO) (2014). 7 million premature deaths annually linked to air pollution. <https://www.who.int/news/item/25-03-2014-7-million-premature-deaths-annually-linked-to-air-pollution#:~:text=25%20March%202014%20%7C%20Geneva%20%2D%20In,result%20of%20air%20p%20ollution%20exposure>.
- Yarragunta, Y., Srivastava, S., Mitra, D., & Chandola, H. C. (2020). Influence of forest fire episodes on the distribution of gaseous air pollutants over Uttarakh and, India. *GI Science & Remote Sensing*, 57(2), 190–206. <https://doi:10.1080/15481603.2020.171210>