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Research Article

Perceptions of pre-service science teachers towards technological disasters and examination of the sources of these perceptions

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ABSTRACT

The aim of this study is to examine the perceptions of pre-service science teachers regarding technological disasters, including oil tanker accidents, nuclear accidents, fires, fuel-related poisoning, and space accidents. Additionally, efforts have indeed been made to investigate the sources from which teacher candidates acquire the foundational knowledge shaping their perceptions. The study was conducted using a case study design. Data for the study were collected during the spring semester of the 2020–2021 academic year. The study was conducted with 80 pre-service science teachers enrolled in various years of the Science Education Department across four universities in Turkey. The data for the study were obtained through a drawing test. Thematic content analysis was used in the analysis of the data. Based on the findings of the study, it can be concluded that pre-service science teachers often confuse technological disasters with natural disasters and may hold non-scientific explanations regarding technological disasters. Additionally, they tend to describe technological disasters primarily in terms of their causes and consequences. In addition, it can be stated that pre-service science teachers' perceptions of technological disasters are significantly influenced by information obtained from mass media. It is recommended that pre-service science teachers should be given training about technological disasters, incorporating the effective use of mass media as part of these training sessions.

Keywords: disaster, technological disasters, perception, science education

INTRODUCTION

A disaster is defined as the impact of events that result in physical, economic, social, and environmental losses, disrupt or halt normal life and human activities, and overwhelm communities to the point where they are unable to cope using their local resources and capabilities (Disaster and Emergency Management Presidency [AFAD], 2014; United Nations International Strategy for Disaster Reduction [UNISDR], 2009). As can be understood from this definition, events and disasters are distinct concepts. For instance, an earthquake is a natural event; however, when it results in significant loss of life, economic damage, and disruption of normal life, it is classified as a disaster. Not every earthquake leads to a disaster. When the literature is examined, it is seen that disasters are classified in different ways. The Emergency Events Database (EM-DAT, 2024), an international disaster database established in 1988 through a joint initiative by The Center for Research on

This study is part of the master's thesis of the first author.

the Epidemiology of Disasters (CRED, 2016) and the World Health Organization, classifies disasters into two main categories: natural and technological (EM-DAT, 2024).

Technological disasters are catastrophic events resulting from human activities or triggered natural events that lead to significant physical, economic, social, and environmental losses. Examples include industrial accidents, mining incidents, nuclear power plant failures, transportation accidents, cyber threats, major fires, terrorism, and chemical, biological, radiological, and nuclear threats (AFAD, 2014; Gill & Ritchie, 2018). The Chernobyl nuclear accident in 1986, the Beirut chemical explosion in 2020, the Soma mining accident in 2014, the BP Deepwater Horizon oil spill in 2010, the National Aeronautics and Space Administration (NASA) Space Shuttle Challenger disaster in 1986, and the Bhopal gas tragedy in 1984 are among the major technological disasters of the past half-century (Park, 2020). The explosion on April 26, 1986, at the at the Chernobyl nuclear power plant, which is located in the northern region of Ukraine resulted in the release of substantial amounts of radioactive materials into the environment, leading to widespread air, water, and soil contamination across Europe and Turkey (International Atomic Energy Agency [IAEA], 2005; Kılıç, 2017). This event had significant short- and long-term negative consequences for both humans and the environment. The results of investigations conducted over the two decades following the Chernobyl disaster have clearly revealed that the accident led to an increase in birth defects, diseases, the destruction of plant life, rendering agricultural lands unusable, halting timber production in forests, and forced migration of the population in the affected area (AFAD, 2024; IAEA, 2005). These findings underscore the profound negative impacts of technological disasters.

Technological advancements act as tools to control and manage disasters, and they can also be sources of major catastrophes. The transition to modern industrial society has led to technological disasters becoming more frequent and problematic (Gill & Ritchie, 2018; Park, 2020). Technological disasters have constituted approximately one-third of all disasters reported in EM-DAT since 1900. Between 2000 and 2019, there were 2.251 technological disasters that affected more than 986.282 people and resulted in the death of 75.072 individuals in Asia (CRED, 2020). According to the EM-DAT database, a total of 313 disasters occurred in Turkey between 1923 and 2016. Of these 313 disasters, 51.1% (n = 160) were recorded as natural disasters, and 48.9% (n = 153) were recorded as technological disasters. Between 2000 and 2020, it has been determined that 102 technological disasters occurred in Turkey, resulting in the loss of 2.480 lives and affecting 1.961 individuals (Çelik et al., 2020). The "Poverty & death: Disaster mortality 1996-2015" report highlights that the consequences, number of affected individuals, and economic impacts of natural and technological disasters are similar. However, despite these similarities, technological disasters tend to receive less attention in the scientific community (CRED, 2016).

Effective disaster preparedness is essential to minimize the negative consequences of disasters. Disaster education plays a significant role in this preparation. Zhang and Wang (2022) emphasize that disaster education is a shared mission for humanity. The aim of disaster education is for individuals to be aware of the disasters that may occur in their area, to gain awareness and consciousness about them, and to take necessary precautions (Sever, 2019). In addition, disaster education is a crucial means of developing skills for disaster prevention and mitigation (Zhang & Wang, 2022).

Disasters and disaster education encompass various disciplines (Zhang & Wang, 2022), making them multidisciplinary and interdisciplinary subjects (Park, 2020; Sever, 2019). Disaster education has been studied primarily within disciplines such as disaster risk management, environmental science, civil engineering, and public health, and is a relatively new field within educational research (Kitagawa, 2021). In the field of educational research, there are various studies focusing on disaster education in literature. Some of these studies (such as Kitagawa, 2021; Park, 2020; Septikasari et al., 2024) presented fundamental concepts, effective training opinions, models and recommendations for disaster education. In the field of disaster education, several studies have examined the awareness, metaphors, misconceptions, and perspectives of teachers, pre-service teachers, and students at various educational levels. For instance, Kırıkkaya et al. (2011) investigated elementary school teachers' views on disaster education. Additionally, studies have explored metaphors used by teacher candidates regarding natural disasters, such as those by Değirmenci (2019) and Yazıcı and Ulu Kalın (2018). Kaya (2010) and Karakuş (2013) examined metaphors employed by secondary school students concerning earthquakes. Sapsağlam (2019) assessed the awareness levels of pre-school students about natural disasters. Sözcü and Aydınözü (2019) evaluated the natural disaster literacy levels of teacher candidates. Furthermore, misconceptions related to natural disasters were addressed in studies by Bozyiğit and Kaya (2017), Cin (2010), Solmaz and Kaymak (2012), and Turan and Kartal (2012). It is observed that while many studies in disaster education focus on natural disasters, technological disasters are neglected.

In disaster education, various innovative teaching strategies have been employed to enhance learning and engagement. These strategies include geographic information systems (Erdoğan, 2009), cartoons (Tokcan, 2013), game-book (Nouchi & Sugiura, 2014), pocket notebooks and cartoon films (Nouchi et al., 2015), animations (Dikmenli et al., 2018), simulation centers (Şahan, 2019), disaster storytelling (Nagamatsu et al., 2021), ICT based-programs (Uchida et al., 2021), developing games to enhance disaster prevention awareness (Arakawa et al., 2023), and technology-supported 3E learning model (Arıkan et al., 2024). While many studies in disaster education focus on natural disasters such as earthquakes, floods, and tsunamis, technological disasters have been less frequently addressed.

Teachers are a fundamental component of disaster education, as their awareness and understanding of disaster-related concepts are essential for achieving the desired educational outcomes. Perceptions, encompassing how individuals interpret their environment, beliefs, and behaviors, are key indicators of this understanding. Teacher perceptions significantly influence how they educate students about disasters. Karakuş (2019) examined pre-service teachers' perceptions of natural disasters. Özgen (2013) carried out a study to examine pre-service teachers' perceptions of erosion. However, these studies primarily focus on natural disasters, with technological disasters frequently being overlooked.

Although technology and science are two different concepts, they interact with each other. Technological disasters are a result of the high level of interaction between science and society (Park, 2020). This situation highlights the strong connection between technological disasters and science education. Accordingly, the purpose of this study is to investigate pre-service science teachers' perceptions of technological disasters and identify the sources influencing these perceptions. To achieve this, the study addresses the following research questions:

RQ1: What are the perceptions of pre-service science teachers towards technological disasters? What are the sources of these perceptions?

RQ2: How do pre-service science teachers perceive specific technological disasters, such as oil tanker accidents, nuclear accidents, fires, fuel-related poisonings, and space accidents? What are the sources of these perceptions?

This study holds significant importance for several reasons. Firstly, it addresses a gap in the disaster education literature by focusing on technological disasters, which have often been overlooked. By examining pre-service science teachers' perceptions of technological disasters, the research provides insights into how these future educators might approach such topics in their teaching careers. Moreover, the study can identify the sources from which teacher candidates derive their perceptions about technological disasters. Recognizing these sources offers valuable clues about which information sources are most influential and how they can be utilized to enhance disaster education.

METHOD

This section presents detailed explanations of the research methodology, including the research design, study group, data collection tools, data collection procedures, and data analysis techniques.

Research Design

This study employed a qualitative research approach, aiming to understand participants' perceptions, experiences, and lives (Fraenkel & Wallen, 1990; Merriam, 1988). Specifically, a case study design was utilized, which involves a comprehensive analysis of a situation, program, event, action, process, or individual(s) within its real-life context (Creswell, 2017). By adopting this design, the study thoroughly examines individuals' mental representations of natural and technological disasters and investigates the sources from which these perceptions are formed.

Study Group

In this study, 80 pre-service teachers participated, with 20 from each year (1st through 4th) of the science teaching programs at four different universities in Turkey. Data collection occurred during the spring semester of the 2019–2020 academic year, a period when all universities in Turkey transitioned to online education due to the COVID-19 pandemic. Consequently, the study was announced to the target audience through social media channels. Individual communication was established with teacher candidates who volunteered to participate. In individual interviews, the study was explained in detail to the prospective participants.

Additionally, the participants were informed about the data collection process, which involved individual and/or small group meetings conducted via online platforms. The data collection process was planned and implemented according to the participants' preferences.

Data Collection Tool

In this study, data were collected through drawing tests, a widely used method for revealing perceptions. Drawings can capture understanding and perceptions in various contexts that are otherwise difficult to comprehend (Farver et al., 2000). It is considered that the act of drawing provides a complementary way for individuals to convey their thoughts (Moline, 1995). Unlike verbal methods, drawings facilitate the simultaneous evaluation of cognitive, social, emotional, and motivational dimensions (Armstrong, 2007), making them effective and powerful communication tools (Ağgül-Yalçın, 2012; Armstrong, 2007; Özsoy & Ahi, 2014). For these reasons, a drawing test was employed in this study.

The drawing test developed by the researchers consists of six sections. The data collection tool comprised six sections, each focusing on a specific type of technological disaster, respectively: technological disasters, oil tanker accidents, nuclear accidents, fires, fuel-related poisoning, and space accidents. Each section included three items. The first item asked participants to create a drawing representing the specific disaster type. The second item asked participants to provide explanations of their drawings. The third item asked participants to detail the sources from which they acquired their information. In the first section of the data collection tool, participants were asked to draw their perceptions of technological disasters, followed by providing explanations of their drawings and detailing the sources from which they acquired their information. For example, in the first section of the data collection tool, participants were asked to draw their perceptions of technological disasters, followed by providing explanations of their drawings and detailing the sources from which they acquired their information. During the development of the data collection tool, careful consideration was given to its content and format. The development process of the data collection tool involved considering the relevant literature and the K-8 science education curriculum. The items were drafted, and an initial version of the tool was created. This draft was then submitted for expert review. Following revisions based on expert feedback, a pilot study was conducted with 20 pre-service science teachers. During the pilot study, the first author observed the participants and documented key observations and events. Insights gained from the pilot study were used to refine the tool further. The revised version was subsequently presented to experts for additional feedback before being finalized.

Data Collection Process

The first author conducted data collection by administering the tool to participants through online platforms. Individual and small group meetings, comprising two to three participants, were organized using Google Meet and Zoom. During these sessions, the data collection tool was presented to the participants through screen sharing, and they were given ample time to complete their responses. Upon completion, participants photographed their responses and sent them to the researcher. These responses were archived using codes such as PST1, PST2, and PST3 to maintain confidentiality. Additionally, the online meetings were recorded to ensure a comprehensive record of the data collection process.

Data Analysis

The data analysis process began with an initial comprehensive reading of participants' responses to fully understand their expressions. After a brief interval, each section of the data collection tool was analyzed separately. In each section, the drawings and their corresponding descriptions were examined together, while the items concerning sources of information were analyzed independently. Thematic analysis (Anderson 2007; Riessman 2008) was employed to identify the key recurring themes within the qualitative data (Braun & Clarke 2006). In this process, themes emerged directly from the data itself, rather than being imposed by the researchers (Fereday & Muir-Cochrane 2006).

The responses provided by the participants were coded, and sub-themes were generated based on these codes. Themes were then created by grouping related sub-themes. The frequencies and percentages of these themes were calculated. The first author of this study conducted the data analysis. To ensure reliability, the researcher analyzed the data twice, at different times. Additionally, the consistency between the two coders was assessed. The second author independently analyzed four sections of the data collection tool. The consistency between the two researchers' analyses was evaluated using the formula "Reliability = (Agreement/(Agreement + disagreement)) × 100," as proposed by Miles and Huberman (1994). The calculated consistency was 80.37%. Any discrepancies between the coders were resolved through negotiation.

RESULTS

In this section, findings obtained regarding the research questions are presented in separate subheadings.

Results for the First Research Question

In this study, the perceptions of pre-service science teachers regarding technological disasters and the sources of these perceptions were explored. To uncover participants' perceptions, their drawings and the accompanying explanations were analyzed. The results are presented in **Table 1**.

Table 1. Findings from the analysis of the item "What comes to your mind when you hear the concept of technology-related disaster? Draw and explain your drawing"

Theme	Sub-theme	Code	Participants	f	%
According to the sources	Natural disasters	Landslide, avalanche, flood, earthquake, erosion, rockfall, famine, drought	PST2, PST71, PST77, PST3, PST4, PST9, PST10, PST11, PST12, PST15, PST17, PST18, PST22, PST24, PST41, PST42, PST50, PST51, PST52, PST53, PST55, PST56, PST67	24	30.00
	Technology-related disasters	Nuclear accidents, chemical accidents, transport accidents, occupational accidents, atomic bombs and weapons, cyber-attacks, fire / forest fire	PST1, PST5, PST6, PST7, PST9, PST13, PST14, PST16, PST19, PST21, PST23, PST25, PST26, PST27, PST29, PST30, PST33, PST34, PST35, PST36, PST38, PST39, PST40, PST43, PST44, PST45, PST46, PST47, PST48, PST49, PST50, PST51, PST54, PST57, PST59, PST60, PST61, PST62, PST63, PST65, PST66, PST68, PST73, PST79, PST80	45	56.25
Reasons	Unconsciousness	Improper use of medication and chemicals, deodorants, dumping trash into the sea, employing unqualified individuals in the field, creating excessive noise pollution, reckless skiing, reclaiming land from the sea, unconscious water consumption, excessive reliance on technology, deforestation	PST1, PST2, PST3, PST4, PST8, PST15, PST18, PST19, PST32, PST42, PST50	11	13.75
	Carelessness	The person who forgets to extinguish the fire, picnic, cigarette butt disposal	PST21, PST26, PST33, PST34, PST39, PST61, PST63	7	8.75
	Recklessness	Inadequate infrastructure, emissions of liquids and gases from factories, failure to implement traffic safety measures	PST1, PST8, PST13	3	3.75
	Technological mistakes	Technological malfunction	PST35, PST72	2	2.50
	Construction mistakes	Construction of non-durable structures, building homes in inappropriate locations, use of poor-quality materials	PST11, PST18, PST31, PST56, PST58, PST74, PST75, PST77	8	10.00

Table 1 (Continued).

Theme	Sub-theme	Code	Participants	f	%
Results	Environmental problems	Plant deaths, air and water pollution, inability of nature to regenerate itself, depletion of the ozone layer, environmental damage, disruption of ecological balance, drought, animal attacks, mucilage	PST1, PST5, PST8, PST24, PST28, PST36, PST64, PST66, PST70	9	11.25
	Psychological effects	Divorce	PST9	1	1.25
	Physical loss	Death, physical injury	PST13, PST25, PST28, PST29, PST30, PST38, PST 42, PST46, PST49, PST58, PST62, PST66, PST72	13	16.25
	Economic effect	Financial loss	PST11, PST12, PST58, PST62	4	5.00
	Sociological impact	Migrating people	PST79	1	1.25
Institutions & organizations involved in disasters	State institutions and organizations	Disaster and Emergency Management Presidency (AFAD)	PST37	1	1.25
Disaster management	Before disaster	Afforestation, paying attention to warning signs	PST20, PST78	2	2.50
	During disaster	Gas mask	PST49	1	1.25

Table 2. The findings from the analysis of the item "From which sources did you obtain the information that contributed to your responses about technology-related disasters?" Please explain it in the drawing test

Theme	Sub-theme	f	%
Mass media	Books	11	13.75
	Journals	3	3.75
	TV	7	8.75
	The Internet	19	23.75
	News	17	21.25
	Newspaper	1	1.25
	Videos	1	1.25
	Films	2	2.50
	Documentaries	8	10.00
Formal education	Teachers	3	3.75
	Departments	2	2.50
	Schools	19	23.75
	Lessons	11	13.75
Online platforms	Social media	17	21.25
Daily life	Social circle	4	5.00
	Personal experience	1	1.25
	Prediction	1	1.25
	Living	9	11.25
Being informed by institutions and organizations	AFAD	2	2.50
Scientific sources	Articles	2	2.50
	Research	3	3.75
Not obtained from any source	-	1	1.25

Upon examining **Table 1**, it is observed that 56.25% of participants address technology-related disasters in their drawings, while 30.00% focus on natural disasters. Additionally, 38.75% of participants concentrate on the causes of disasters in their responses. Among the causes identified, unconsciousness (13.75%) and carelessness (8.75%) are the most frequently mentioned. It was also found that 10% of the participants associate the negative consequences of construction errors, particularly during natural disasters like earthquakes and floods, with the occurrence of technological disasters. Additionally, 35% of the participants focused on the consequences of disasters in their responses. The sub-themes most frequently identified within this category were physical loss (16.25%) and environmental issues (11.25%). Examples of participants' drawings can be found in **Figure A1** in **Appendix A**.

To further investigate the sources of participants' perceptions regarding technological disasters, data from the final item of the first section of the drawing test were analyzed. The results of this analysis are presented in **Table 2**.

Table 3. Findings from the analysis of the item "What comes to your mind when you hear about oil tanker accidents? Draw and explain your drawing" in the drawing test

Theme	Sub-theme	Code	Participants	f	%
Reasons	Human errors	Unextinguished cigarettes, disregard the rules, carelessness, handling flammable substances improperly	PST10, PST 11, PST13, PST21, PST35, PST42, PST46, PST50, PST55, PST66, PST71	11	13.75
	Environmental factors	Weather conditions	PST61	1	1.25
	Occupational health and safety	Illegal deduction	PST69	1	1.25
	Problems occurring in transportation vehicles	Collision, toppling, formation of a hole, malfunction	PST4, PST23, PST24, PST33, PST34, PST40, PST44, PST54, PST60, PST65, PST73, PST75, PST78, PST79	14	17.50
	Errors occurring in the process	Discharge, transfer	PST5, PST11	2	2.50
	Fire/explosion occurring in an oil tanker	Fire, explosion	PST10, PST12, PST32, PST37, PST39, PST45, PST46, PST48, PST51, PST55, PST56, PST58, PST59, PST62, PST64, PST66, PST71, PST75, PST77, PST80	20	25.00
Results	Environmental problems	Harm to plants and animals, poisoning, environmental pollution, air and water pollution, oil residues, cracks, permanent damage	PST1, PST2, PST3, PST6, PST8, PST14, PST15, PST17, PST19, PST22, PST25, PST26, PST27, PST29, PST30, PST31, PST34, PST36, PST37, PST41, PST43, PST49, PST51, PST52, PST59, PST64, PST67, PST68, PST69, PST70, PST72, PST76, PST78, PST80	34	42.50
	Psychological effect	Stranded captain	PST37	1	1.25
Institutions & organizations involved in disasters	Municipality	Fire brigade	PST80	1	1.25
Taking measures	Warning signs and safety signs	Irritant, toxic substance, keep away from fire, flammable, combustible substances	PST3, PST10, PST18, PST46, PST55, PST77	6	7.50
Irrelevant response	Not being able to define	Not being able to generate an idea	PST7, PST16, PST20, PST47, PST63	5	6.25

Upon examining **Table 2**, it was found that the participants' responses were categorized into several sources: mass media, formal education, online platforms, daily life, and information provided by institutions and organizations, not obtained from any source, and scientific sources. The themes with the highest frequency were mass media (72.50%), formal education (43.75%), and online platforms (21.25%). Within the mass media theme, the sub-themes with the highest frequency were the Internet (23.75%) and news (21.25%). Additionally, it was observed that the rates of information provided by institutions and organizations and scientific sources were quite low.

Results for the Second Research Question

The second research question examined the perceptions of pre-service science teachers regarding various technological disasters, including oil tanker accidents, nuclear accidents, fires, fuel-related poisonings, and space accidents. The findings related to each type of technological disaster are presented below. **Table 3** presents the findings from the analysis of participants' drawings and explanations concerning oil tanker accidents.

Upon reviewing **Table 3**, it is evident that 61.25% of participants identified the causes of oil tanker accidents in their drawings and explanations. A quarter of the participants depicted fires and/or explosions as primary causes of oil tanker accidents, while 13.75% highlighted human errors, and 17.50% pointed to technical deficiencies or vehicle errors. The majority of participants focused on the consequences of such accidents, with 42% addressing environmental issues resulting from oil spills. Additionally, 6.25% provided irrelevant responses. Examples of these drawings are presented in **Figure A2** in **Appendix A**.

Table 4. Findings from the analysis of the item "What comes to your mind when you hear about nuclear accidents? Draw and explain your drawing" in the drawing test

Theme	Sub-theme	Code	Participants	f	%
Causes	Human mistakes	Negligence experimentation, recklessness	PST32, PST34, PST35, PST40, PST70	5	6.25
	Technological mistakes	Reactor overheating, structural failure, power plant explosion	PST13, PST22, PST23, PST24, PST27, PST30, PST35, PST37, PST39, PST41, PST48, PST50, PST55, PST60, PST62, PST64, PST65, PST66, PST75, PST79	20	25.00
	Natural disasters	Tsunami, earthquake	PST14, PST76	2	2.50
Sample incidents	The most well-known nuclear accidents in the world history	Chernobyl, Nagasaki-Fukushima	PST4, PST6, PST10, PST12, PST17, PST19, PST28, PST36, PST38, PST53, PST56, PST58, PST61, PST69, PST74	15	18.75
Results	Environmental problems	Radiation spread, environmental damage, geographic contamination, drought, destruction of plants, extinction of species, degraded soil, fallen trees, burned cities, wilting plants	PST1, PST3, PST11, PST12, PST15, PST16, PST28, PST29, PST36, PST41, PST43, PST45, PST46, PST49, PST50, PST54, PST60, PST62, PST64, PST69, PST72, PST73, PST76, PST78	24	30.00
	Physical losses	Death, injury	PST26, PST28, PST32, PST37, PST38, PST43, PST54, PST57, PST63, PST69	10	12.50
	Economic impacts	Damage to the nuclear plant, destruction	PST3, PST20, PST52, PST67	4	5.00
	Psychological effects	Silence, scared people	PST5, PST39, PST78	3	3.75
	Health effects	Permanent damage, mutation, transmission to future generations	PST10, PST11, PST25, PST30, PST42, PST46, PST55, PST59, PST77	9	11.25
Disaster management	Before the disaster	Warning signs and safety signals (radiation symbol danger sign), establishing safe zones	PST22, PST26, PST36, PST52, PST68	5	6.25
	During the disaster	Wearing a gas mask	PST49	1	1.25
Non-scientific response	Incomplete/ incorrect information	Biological weapon	PST51	1	1.25
Irrelevant response	Not being able to generate an idea	-	PST2, PST7, PST8, PST9, PST18, PST21, PST31, PST33, PST44, PST47, PST1, PST80	12	15.00

The findings from the analysis of participants' drawings and explanations regarding nuclear accidents are presented in **Table 4**.

Based on **Table 4**, 72.50% of participants included themes related to the consequences of disasters in their drawings. Among these, 30.00% highlighted environmental issues, 12.50% illustrated physical losses, and 11.25% depicted negative health effects. Additionally, 25.00% of the participants identified technological errors as a cause of nuclear accidents.

The analysis revealed that 18.75% of the participants focused on historical incidents such as Chernobyl, Fukushima, and Nagasaki in their drawings. Additionally, 15% of the participants provided responses that were irrelevant to the topic. A small percentage (1.25%) included unscientific elements in their drawings related to nuclear accidents. Furthermore, 6.25% of the participants depicted precautionary measures that could be taken to prevent nuclear accidents. Examples of these drawings are provided in **Figure A3** in **Appendix A**. The findings from the analysis of participants' drawings related to fires, along with their accompanying explanations, are presented in **Table 5**.

Upon examining **Table 5**, it is evident that the most frequently occurring themes in participants' drawings are the types of fires and their consequences. Specifically, 85% of participants depicted the location of the fire, with 47.5% illustrating forest fires and 30% illustrating house fires. Additionally, 78.75% of participants focused on the aftermath of fires, highlighting environmental issues (40%) and physical losses (21.25%) as predominant sub-themes. Furthermore, 12.5% of participants addressed search and rescue operations in their drawings. Examples of these illustrations are provided in **Figure A4** in **Appendix A**.

Table 5. Findings from the analysis of the item "What comes to your mind when you hear about fires? Draw and explain your drawing" in the drawing test

Theme	Sub-theme	Code	Participants	f	%
Consequences	Human mistakes	People having a picnic, leaving glass in the forest, failing to extinguish cigarettes properly, making an unattended fire, leaving a fire unextinguished, forgetting to turn off the stove, greedy or insatiable behavior	PST5, PST10, PST12, PST14, PST32, PST42, PST53, PST60, PST61, PST64, PST72	11	13.75
	Environmental factors	Extreme heatwave	PST13	1	1.25
	Technological mistakes	Gas leak & sparks emanating from electric poles	PST21, PST49, PST50, PST66	4	5.00
Results	Environmental problems	Burnt trees, smoke and ash, damage to nature, long-lasting, irreversible harm, disruption of the ecological balance, environmental destruction, forest devastation	PST2, PST3, PST5, PST7, PST8, PST10, PST12, PST13, PST15, PST17, PST18, PST19, PST22, PST25, PST30, PST31, PST34, PST38, PST40, PST43, PST46, PST51, PST52, PST54, PST56, PST57, PST67, PST73, PST75, PST77, PST78, PST80	32	40.00
	Economic impacts	Financial losses	PST28, PST56, PST71	3	3.75
	Psychological effects	Homeless people, sorrow, unjust treatment	PST9, PST18, PST59, PST71	4	5.00
	Health effects	Poisoning	PST80	1	1.25
	Physical losses	Damages to animals, death	PST3, PST7, PST15, PST19, PST25, PST26, PST28, PST41, PST43, PST44, PST52, PST56, PST67, PST68, PST70, PST71, PST76	17	21.25
	Economic gain	Hotel construction	PST69	1	1.25
Types of fire	The place where the fire occurs	Forest	PST1, PST2, PST3, PST4, PST6, PST7, PST12, PST13, PST14, PST17, PST18, PST19, PST20, PST22, PST24, PST27, PST31, PST33, PST34, PST35, PST36, PST38, PST39, PST41, PST46, PST47, PST50, PST56, PST62, PST63, PST64, PST68, PST70, PST73, PST75, PST76, PST77, PST80	38	47.50
		House	PST1, PST2, PST9, PST11, PST16, PST21, PST26, PST29, PST33, PST34, PST35, PST37, PST38, PST48, PST49, PST50, PST54, PST58, PST59, PST63, PST66, PST68, PST75, PST79	24	30.00
		Vehicles	PST1, PST27, PST34, PST63, PST79	5	6.25
		Petrol station	PST39	1	1.25
Sample incidents	The most well-known fires in world history	Great fire of Rome, Australian bushfires	PST6, PST70	2	2.50
Search and rescue operations	Municipality / non-governmental organization	Fire department, volunteers	PST36, PST37, PST58, PST62, PST65	5	6.25
	Equipment	Water, fire extinguisher, hose, pump	PST36, PST37, PST39, PST51, PST74	5	6.25
Irrelevant response	Not being able to specify	Flame	PST23, PST36, PST44, PST45, PST51	5	6.25

The analysis of responses to the prompt, "What comes to your mind when you hear about fuel-related poisoning? Draw and explain your drawing," is presented in **Table 6**.

Upon analyzing **Table 6**, it was observed that 40% of participants created drawings and explanations related to fossil fuel-induced poisoning. The theme of the consequences of such poisoning appeared in 37.5% of the drawings, with 17.5% depicting fatalities, 15% illustrating emitted toxic gases, and 11.25% highlighting health effects. Additionally, 6.25% addressed the types of poisoning, while 10% erroneously identified carbon dioxide instead of carbon monoxide as the causative agent, leading to unscientific explanations. Furthermore, 8.75% provided irrelevant responses. Examples of these drawings are presented in **Figure A5** in **Appendix A**.

Table 6. Findings from the analysis of the item "What comes to your mind when you hear about fuel-related poisoning? Draw and explain your drawing" in the drawing test

Theme	Sub-theme	Code	Participants	f	%
Causes	Fossil fuels	Petroleum and its derivatives, coal, natural gas	PST6, PST7, PST8, PST11, PST12,PST13, PST15, PST18, PST21, PST23, PST24, PST25, PST26, PST27, PST30, PST32, PST33, PST34, PST36, PST45, PST53, PST54, PST55, PST57, PST58, PST60, PST63, PST64, PST70, PST71, PST73, PST76	32	40.00
	Means of transport	Emissions from car exhaust, emissions from motorcycle exhaust, petrol spilled from a truck, overturned bus, oil spills from ships following collisions	PST15, PST16, PST20, PST37, PST52, PST59, PST68	7	8.75
	Search for energy	Gas emitted during nuclear accidents	PST52	1	1.25
	Industrial sector	Emissions from factory chimneys	PST10, PST41	2	2.50
	Negligence	Leaving the stove on	PST32, PST77	2	2.50
	Unconsciousness	Consuming fuel or improper use of coal	PST31, PST38, PST39, PST56, PST67	5	6.25
	Carelessness	Inhaling or smelling chemicals	PST1	1	1.25
Consequences	Environmental issues	Gas leakage	PST2, PST10, PST20, PST52, PST78, PST80	6	7.50
	Physical losses	Death	PST1, PST2, PST5, PST11, PST13, PST31, PST42, PST46, PST51, PST54, PST60, PST69, PST76, PST77	14	17.50
	Health effects	Inability to wake up, disruption of body functions, reduced physical activity, poisoning from consuming fish in polluted water, inhaling toxic chemicals, contracting infections from microbes	PST4, PST5, PST12, PST15, PST28, PST36, PST55, PST62, PST79	9	11.25
	Psychological effects	Exposure to harsh weather conditions	PST35	1	1.25
Types of poisoning	Poisonous gas	Smog	PST3, PST5, PST29, PST40, PST43, PST46, PST48, PST49, PST65, PST66, PST70, PST72	12	15.00
	Poisoning affecting digestion	Drinking chemicals	PST39	1	1.25
Unscientific explanation	Incomplete / incorrect information	Carbon dioxide poisoning	PST14, PST16, PST19, PST25, PST35, PST36, PST51, PST62	8	10.00
Disaster Management	During the disaster	Intervention by medical teams	PST62	1	1.25
Irrelevant response	Not being able to specify	Not being able to generate an idea	PST9, PST17, PST22, PST44, PST47, PST74, PST75	7	8.75

The findings from the analysis of participants' drawings and explanations regarding space accidents are detailed in **Table 7**.

Table 7. Findings from the analysis of the item "What comes to your mind when you hear about space accidents? Draw and explain your drawing" in the drawing test

Theme	Sub-theme	Code	Participants	f	%
Causes	Collision/crash	Collision between spacecrafts (rocket, satellite, shuttle, space station, or spaceship)	PST1, PST4, PST31, PST35, PST41, PST46, PST55, PST60, PST62, PST78	10	12.50
		Collision between celestial bodies (meteor, meteorite, asteroid)	PST17, PST42, PST59	3	3.75
		Collision of celestial bodies with spacecraft	PST24, SPT25, PST28, PST31, PST44, PST51, PST54, PST55, PST68, PST76, PST79	11	13.75
	Falling	Meteorite fall & spacecraft (satellite, shuttle, rocket, etc.) crash	PST15, PST32, PST36, PST39, PST49, PST59, PST77	7	8.75
	Environmental factors	Asteroid shower, frictional forces, explosion of dying stars, sun's potential approach to earth	PST3, PST10, PST38, PST55	4	5.00

Table 7 (Continued).

Theme	Sub-theme	Code	Participants	f	%
	Explosion/fire	Fire onboard spacecraft, explosion of space-bound vehicles	PST5, PST22, PST23, PST28, PST29, PST33, PST36, PST48, PST58, PST61, PST63, PST64, PST70	13	16.25
	Technological mistakes	Astronaut suit malfunction, materials used in spacecraft construction, fuel tank leakage, detachment of spacecraft parts, oxygen deficiency	PST34, PST61, PST62, PST71	4	5.00
	Human mistakes	Incorrect calculations, incorrect setup, failure to take off, loss of control, fuel depletion	PST11, PST13, PST18, PST37, PST72, PST80	6	7.50
Consequences	Environmental issues	Environmental impact damage, falling into the sea, gas emissions	PST6, PST15, PST27	3	3.75
	Damage to spacecraft	Scattered debris, disintegration, disruption of movement	PST13, PST22, PST25, PST37, PST43, PST46, PST51, PST52, PST63, PST73	10	12.50
	Physical losses	Astronaut fatalities and injuries	PST43, PST51, PST63, PST71	4	5.00
	Mission failure	Failure to reach the intended destination, orbital deviation	PST19, PST80	2	2.50
Location	The location where the accident occurred	Earth, outer atmosphere of earth, exosphere, space, moon	PST1, PST12, PST18, PST58	4	5.00
	The time when the accident occurred	Launch sequence, landing sequence, in-flight mode	PST6, PST14, PST22, PST36, PST50, PST53, PST72, PST73	8	10.00
Sample incidents	Space accidents in history world	Challenger Space Shuttle accident in 1986, Columbia Space Shuttle accident	PST6, PST56, PST74	3	3.75
Space technologies	Space crafts	Space shuttle, space station	PST9, PST20, PST26, PST30, PST32, PST40, PST45, PST50, PST56, PST65, PST74	11	13.75
Space studies	The place where space studies are conducted	NASA	PST39	1	1.25
	Individuals involved in space-related studies	Elon Musk	PST5, PST39	2	2.50
Irrelevant responses	Not being able to specify	Not being able to generate an idea	PST2, PST7, PST8, PST16, PST21, PST47, PST52, PST75	8	10.00

Upon analyzing **Table 7**, it is observed that 72.5% of participants included the causes of space accidents in their drawings. Among them, 30% depicted collisions or crashes, while 16.25% illustrated explosions or fires. Additionally, 23.75% of participants included the consequences of space accidents in their drawings, with 12.5% focusing on the resulting damage.

Furthermore, 13.75% depicted space technologies such as space shuttles and space stations. Notably, 2.5% drew Elon Musk, and 1.25% drew NASA. It was also found that 10% of the responses were irrelevant.

The second question of the study examined the sources from which participants obtained information that contributed to their perceptions about technological disasters, including tanker accidents, nuclear accidents, fires, fuel-related poisoning, and space accidents. Examples of the drawings are presented in **Figure A6** in **Appendix A**. The findings regarding the information sources influencing participants' perceptions of these technological disasters are presented in **Table 8**.

Upon examining **Table 8**, participants' responses were categorized into several sources: mass media, formal education, online platforms, daily life, information provided by institutions and organizations, scientific sources, and irrelevant responses. For each type of technological disaster considered in the study, mass media emerged as the most frequently cited source (oil tanker accidents 80.00%, nuclear accidents 86.25%, fires 93.75%, fuel-related poisoning 87.50%, space accidents 98.75%).

Within the mass media category, the most frequently cited sub-sources were news (oil tanker accidents 36.25%, nuclear accidents 22.50%, fires 37.50%, fuel-related poisoning 37.50%, space accidents 23.75%) and the Internet (oil tanker accidents 22.50%, nuclear accidents 27.50%, fires 27.50%, fuel-related poisoning 25.00%, space accidents 30.00%).

Table 8. The findings from the analysis of the items "From which sources did you obtain the information that contributed to your responses about tanker accidents, nuclear accidents, fires, fuel-related poisoning, and space accidents? Please explain" in the drawing test

Theme	Sub-theme	Oil tanker accidents		Nuclear accidents		Fires		Fuel-related poisoning		Space accidents	
		f	%	f	%	f	%	f	%	f	%
Mass media	Books	5	6.25	4	5.00	10	12.50	7	8.75	5	6.25
	Journals	2	2.50	2	2.50	3	3.75	1	1.25	8	10.00
	TV	5	6.25	4	5.00	4	5.00	9	11.25	4	5.00
	News	29	36.25	18	22.50	30	37.50	30	37.50	19	23.75
	The Internet	18	22.50	22	27.50	22	27.50	20	25.00	24	30.00
	Newspaper	-	-	3	3.75	4	5.00	1	1.25	-	-
	Documentaries	3	3.75	8	10.00	2	2.50	2	2.50	9	11.25
	Films	1	1.25	3	3.75	-	-	-	-	9	11.25
	Videos	-	-	1	1.25	-	-	-	-	1	1.25
	TV Dramas	1	1.25	4	5.00	-	-	-	-	-	-
	Public service announcement	-	-	-	-	1	1.25	-	-	-	-
Formal education	Teacher	3	3.75	2	2.50	2	2.50	1	1.25	1	1.25
	Department	2	2.50	2	2.50	2	2.50	3	3.75	2	2.50
	School	6	7.50	11	13.75	19	23.75	15	18.75	5	6.25
	Lesson	6	7.50	14	17.50	13	16.25	7	8.75	7	8.75
	Practice	-	-	-	-	1	1.25	-	-		
Online platform	Social media	13	16.25	12	15.00	8	10.00	9	11.25	14	17.50
Daily life	Living	9	11.25	5	6.25	14	17.50	10	12.50	1	1.25
	Social circle	3	3.75	7	8.75	8	10.00	11	13.75	3	3.75
	Personal experience	-	-	1	1.25	6	7.50	4	5.00	-	-
	Prediction	5	6.25	1	1.25	-	-	2	2.50	4	5.00
Giving information	AFAD	-	-	-	-	-	-	-	-	-	-
Scientific sources	Article	1	1.25	2	2.50	-	-	-	-	1	1.25
	Research	1	1.25	5	6.25	1	1.25	3	3.75	4	5.00
Irrelevant response	Not being able to generate an idea	11	13.75	6	7.50	3	3.75	9	11.25	10	12.50

DISCUSSION

In this study, one of the purposes was to explore pre-service science teachers' perceptions of technological disasters. The findings indicate that pre-service science teachers often perceive natural disasters, such as earthquakes, landslides, and avalanches as technological disasters. Upon reviewing the literature, it is noted that while natural disasters are well-defined, there is uncertainty in categorizing other types of disasters. There is also skepticism about including technology-related disasters within the broader definition of disasters. Studies have shown that individuals often perceive natural disasters as more significant and prominent than technological disasters (Koç et al., 2020; Öztürk, 2014). It is also stated that the concept of disaster is frequently misunderstood, with many in society conflicting it with natural events. This misunderstanding leads to the widespread use of the term "natural disaster." As a result of this incomplete or insufficient understanding of the disaster concept, events that should be considered disasters may be incorrectly evaluated (Öztürk, 2014). One of the main reasons for this situation may be the curricula implemented in schools. Disasters are generally covered under the topics such as natural disasters and destructive natural events in social sciences and science courses in formal education, as expressed by Değirmenci et al. (2019). In addition to this, there is limited inclusion of technological disasters in educational curricula (Park, 2020). Another reason may stem from the traditional association of the term "disaster" with natural events and the human suffering due to the destruction they cause both in the literature of social sciences and other field (Harding, 2007). Based on the findings of the study, it can be concluded that pre-service science teachers view the selection of disaster-resistant settlements and the construction of disaster-resistant buildings as essential technological measures for mitigating natural disaster risks and damages during the preparation phase of an integrated disaster management system. This situation suggests that teacher candidates may lack a comprehensive understanding of the potential benefits of integrated disaster management systems in mitigating natural disaster risks through proactive measures implemented before disasters occur. This situation may stem from the difficulty in distinguishing between different types of disasters. In other words, whether a disaster is natural or technological is not always clearly defined. The natural and human aspects of disasters are intertwined (Cockelbergh, 2016). Some technological disasters can be triggered by natural events. For example, an earthquake or volcanic eruption can lead to a nuclear accident. Conversely, certain human activities can induce natural disasters. Industrial activities, for instance, can cause earthquakes. Based on the study's findings, it can be concluded that pre-service science teachers often attribute technological disasters to human negligence or unconscious behaviors. However, technological disasters typically arise from technological or industrial conditions, hazardous procedures, infrastructure failures, or specific human activities (Gill & Ritchie, 2018; United Nations Office for Disaster Risk Reduction [UNDRR], 2020). When considering the various factors contributing to technological disasters, it becomes evident that humans are often at the root of these events. As a result, technological disasters are commonly referred to as man-made disasters (Lindsey et al., 2021). Given this context, pre-service science teachers may tend to emphasize the role of unconscious human behaviors as a primary cause of technological disasters. Based on the study's findings, it can be concluded that pre-service science teachers primarily focus on the physical consequences, such as death and injury, as well as environmental issues resulting from technological disasters. The literature emphasizes that the loss of life in disasters leaves a profound impact on people's minds (Bozyiğit & Kaya, 2017; Değirmenci, 2019; Karakuş, 2019; Tokcan & Yiter, 2017). Among the most significant consequences of disasters is the loss of human lives, which is often the primary focus in the definition of disasters across various sources. Consistent with this, both national and international disaster databases prioritize reporting the number of individuals affected by disasters and those who have lost their lives. Another reason could be the way disaster education is implemented in schools. Despite the central role of science and technology in understanding disasters, their scientific and technological aspects are often taught in isolation from their human and social dimensions. For a comprehensive understanding of disasters, it is essential to grasp both their scientific mechanisms and the societal contexts of vulnerability. Therefore, curricula, especially in science courses and in other courses associated with disasters, should emphasize the scientific aspects of disasters. In other words, science education plays a crucial role in disaster education. (Park, 2020). For these reasons, it is not surprising that pre-service science teachers emphasize the potential loss of life resulting from technological disasters. One reason for this focus on environmental issues may be their awareness of the significant and long-lasting damage caused by major technological disasters recorded in the world, such as nuclear accidents, chemical explosions, and oil tanker spills. These events have caused widespread harm to air, water, and soil.

Another purpose of this study is to examine the perceptions of pre-service science teachers regarding technological disasters, including oil tanker accidents, nuclear accidents, fires, fuel-related poisoning, and space accidents. The study's findings indicate that pre-service science teachers attribute oil tanker accidents primarily to fires and explosions. This perspective stems from their understanding of chemical properties of oil. Given that oil is a highly flammable and explosive substance, there is a risk of combustion and explosion in the tanks where it is stored. This understanding is likely to lead pre-service science teachers to focus on the negative consequences of oil tanker accidents, particularly environmental pollution. Oil tanker accidents are among the most significant contributors to marine pollution (Ung, 2019). Petroleum and its derivatives serve as significant energy sources worldwide, with substantial volumes of imports and exports contributing to a significant commercial trade volume. Therefore, the transportation of oil is also crucial. In the literature, it is noted that a significant portion of global crude oil trade is conducted via maritime routes (Wang et al., 2022) Approximately 20% of the world's crude oil trade is conducted via the Mediterranean Sea (Yalçın-Erik, 2017). Turkey, as a Mediterranean country, has one of the longest coastlines along this sea. Turkey is a country with a significant volume of oil tanker traffic, not only because it is a Mediterranean country but also due to being surrounded by seas on three sides and connecting seas and continents through the Bosporus and Dardanelles Straits. Turkey serves as a crucial transit point for maritime oil transportation. This intensity may also bring both advantages and disadvantages. All these factors could have influenced the formation of the perceptions identified in this study regarding pre-service science teachers.

The study's findings reveal that pre-service science teachers predominantly emphasize the environmental impacts of nuclear accidents. In most cases, radiation released during such accidents directly or indirectly contaminates water, soil, and air. This contamination extends beyond the immediate vicinity of the incident, potentially affecting neighboring countries and, in some cases, entire continents. Moreover, the negative effects of nuclear accidents can persist for extended periods (Doğruluk et al., 2018; Günalp, 2017). This focus on environmental issues may stem from an awareness of the widespread and long-lasting consequences of nuclear accidents.

The findings of the study suggest that fires leave a significant impression on pre-service science teachers, particularly in terms of their causes, locations, and consequences. It can be inferred that pre-service science teachers predominantly perceive human behaviors as the causes of fires. Today, human activities are responsible for the majority of fires, with some regions attributing up to 99% of fires to human causes (Robinne, 2021). The General Directorate of Forestry (2021) reported that only 11% of forest fires in Turkey between 2011 and 2020 were natural. For all these reasons, it is not surprising that pre-service science teachers associate fires with human behavior. The findings of the study suggest that when pre-service science teachers think of fires, they predominantly associate them with forest fires. Ayanoğlu et al. (2017) highlighted that the destructive impact of fire primarily occurs in forested areas. Consequently, it can be inferred that forest fires are a prominent concern in the minds of pre-service teachers. Additionally, pre-service science teachers tend to focus more on environmental issues resulting from the negative impacts of fires. Moreover, pre-service science teachers tend to emphasize the environmental issues arising from the negative impacts of fires, particularly forest fires. This focus is likely due to the significant harm these fires cause to humans and other living beings, both directly and indirectly. Forest fires disrupt habitats, food sources, and essential systems such as the oxygen cycle. The flames and gases produced contribute to air pollution, while the visible consequences of these fires, such as the transformation of areas into ashes, can persist over long periods. Given that forests are complex ecosystems, wildfires can result in substantial ecosystem loss, leading to environmental disasters (Robinne, 2021).

Based on the study's findings, it can be concluded that pre-service science teachers primarily associate fuel-related poisoning with incidents involving fossil fuels. This perception is likely influenced by the prevalence of poisoning cases related to coal and natural gas, especially during the winter months when these fuels are used for heating purposes. Such incidents are frequently reported in the media, raising public awareness. For instance, Can et al. (2019) reported that between 2008 and 2018, there were 2.667 deaths in Turkey attributed to carbon monoxide poisoning. In addition, in the 2013 and 2018 Middle School Science Curriculum, the topics of stove and natural gas poisoning and the measures to be taken against them are included (Ministry of National Education, 2013, 2018). It was argued that some pre-service science teachers have referred to carbon dioxide poisoning, which may indicate a confusion between carbon dioxide and carbon monoxide.

The study's findings indicate that pre-service science teachers significantly emphasize the potential causes of space accidents, particularly explosions or fires in spacecrafts, collisions between spacecraft, and impacts with celestial bodies. This perception is likely influenced by notable historical space incidents, such as the Challenger Space Shuttle disaster, and recent events reported in the news like the meteor impact on the James Webb Space Telescope's mirror. It is noteworthy that pre-service science teachers sometimes misidentify space technologies, institutions, and researchers involved in space research as causes of space accidents, along with 10% providing irrelevant responses. These findings may reflect a lack of sufficient knowledge among pre-service science teachers about space-related incidents. One of the main reasons of these results is that in Turkey, the science curriculum and textbooks typically focus on space technologies, institutions, organizations, and scientists involved in space research, while space accidents are often overlooked.

Another purpose of this study is to investigate the sources shaping pre-service science teachers' perceptions of technological disasters, including oil tanker accidents, nuclear accidents, fires, fuel-related poisonings, and space accidents. The findings of the study suggest that these perceptions of pre-service teachers predominantly originate from information acquired through mass media channels. Studies have shown that media exposure significantly influences individuals' disaster coping and emergency preparedness behaviors (Hong et al., 2019). The main reason for this is that mass media channels provide quick and easy access to audiovisual content and diverse information about past and potential disasters, both locally and globally. Another reason is that mass media plays a significant role in the disaster management system before, during, and after disasters by informing the public, disseminating early warnings, and providing timely and accurate information during and after disasters.

CONCLUSIONS AND RECOMMENDATIONS

The study's findings indicate that pre-service science teachers often perceive natural disasters as technological ones and may hold incomplete or incorrect knowledge about technological disasters. To address these misconceptions, it is essential to provide targeted training sessions for pre-service science teachers. Such programs should focus on elucidating fundamental scientific concepts related to integrated disaster management systems, differentiating between natural and technological disasters, and understanding their respective causes and consequences. Such training would help pre-service science teachers accurately distinguish between different types of disasters. The study's findings reveal that pre-service science teachers primarily focus on the causes and consequences of technological disasters, with less emphasis on the pre-disaster period and the roles of institutions and organizations in disaster management systems. Therefore, it is recommended to place greater emphasis on topics that receive less attention in disaster education. Additionally, the study suggests that information obtained from mass media plays a significant role in shaping pre-service science teachers' perceptions of technological disasters. Therefore, it is recommended to use mass media effectively for disaster education. Moreover, disaster education within formal education should be structured to enhance its impact on individuals, aligning with the training provided by institutions and organizations involved in disaster management systems.

Limitations of the Study

One of the main limitations of this study is that data were collected through online platforms. During the data collection process, the COVID-19 pandemic broke out, and universities in Turkey, as elsewhere, transitioned to online education. Consequently, the study's announcement to potential participants, selection of participants, and data collection were all conducted through online platforms. The data collection tool was individually administered to each participant via online platforms, leading to longer data collection times for each participant. During the study, the drawing test was planned as a data collection tool. However, due to the time-consuming nature of this method, it was not possible to employ additional data collection tools, such as semi-structured interviews, to triangulate the data. As a result, participants' perceptions were primarily assessed through a drawing test. In future studies, employing a combination of data collection methods could provide a more comprehensive understanding of pre-service science teachers' perceptions of technological disasters. This research examined pre-service science teachers' perceptions of technological disasters, including oil tanker accidents, nuclear accidents, fires, fuel-related poisonings, and space accidents. Exploring the perceptions of pre-service and in-service science teachers regarding technological disasters–such as mining accidents linked to the minerals curriculum and global climate change associated with environmental issues–can provide valuable insights into the education students receive on these topics.

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APPENDIX A

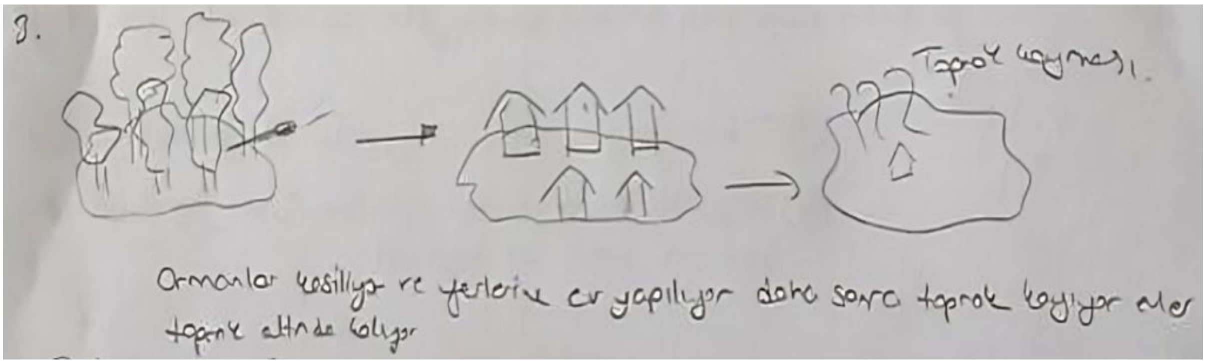

Figure A1. An example drawing of soil erosion for the sub-theme of natural disasters according to its sources

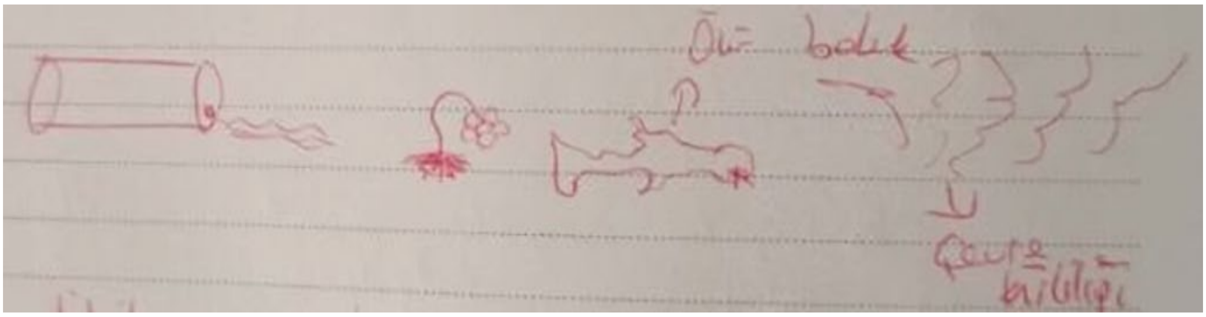

Figure A2. An example of drawing for the sub-theme environmental issues under the theme consequences of oil tanker accidents

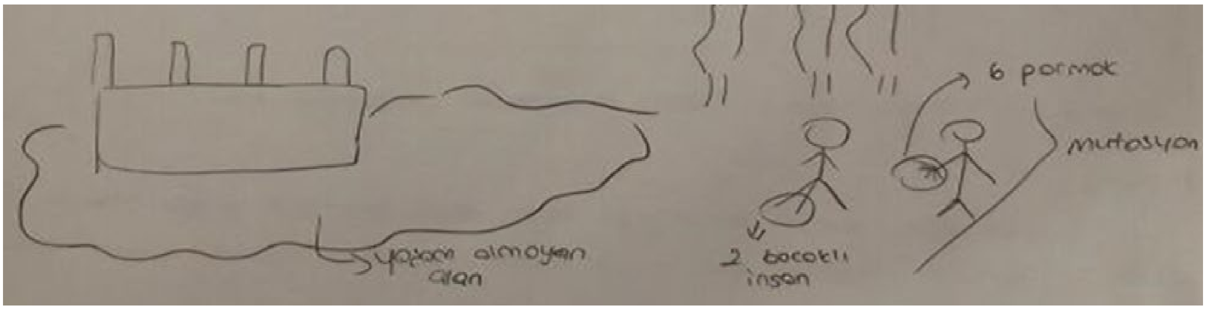

Figure A3. An example of drawing for the sub-theme of health effects under the theme of consequences of nuclear accidents

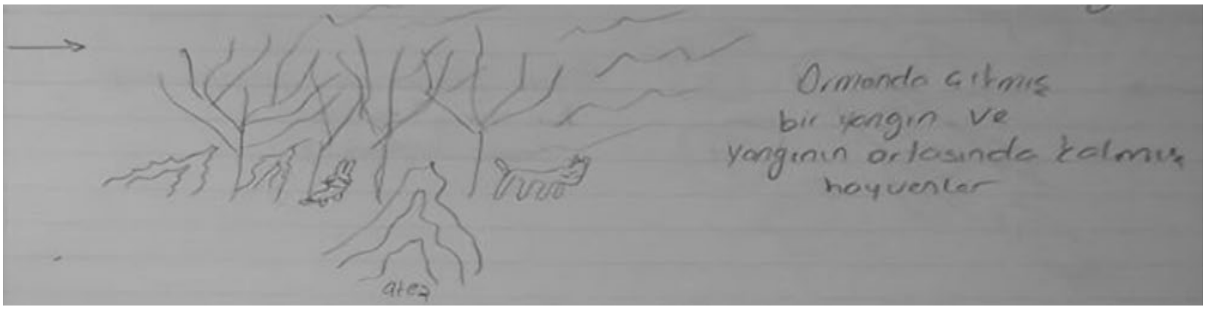

Figure A4. An example of drawing for the sub-theme of physical losses under the theme of consequences of fires

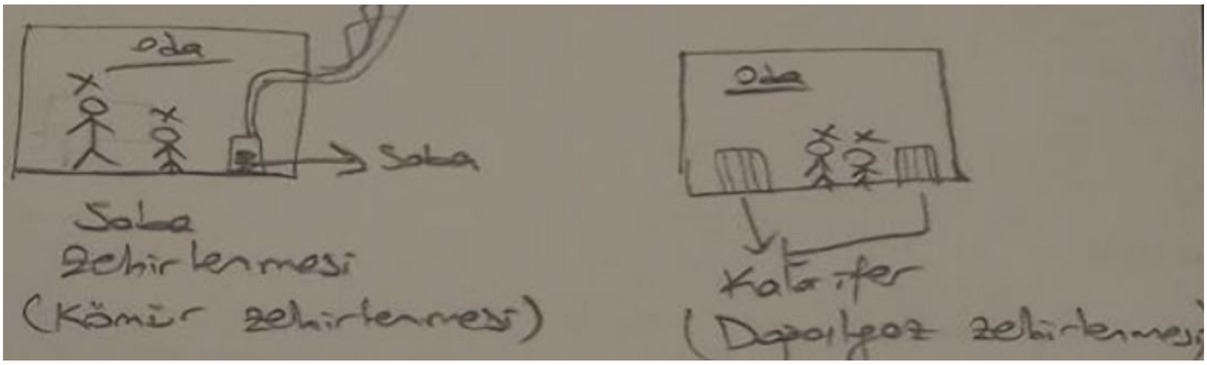

Figure A5. An example of drawing for the sub-theme of causes of fuel-related poisoning under the theme of fossil fuels

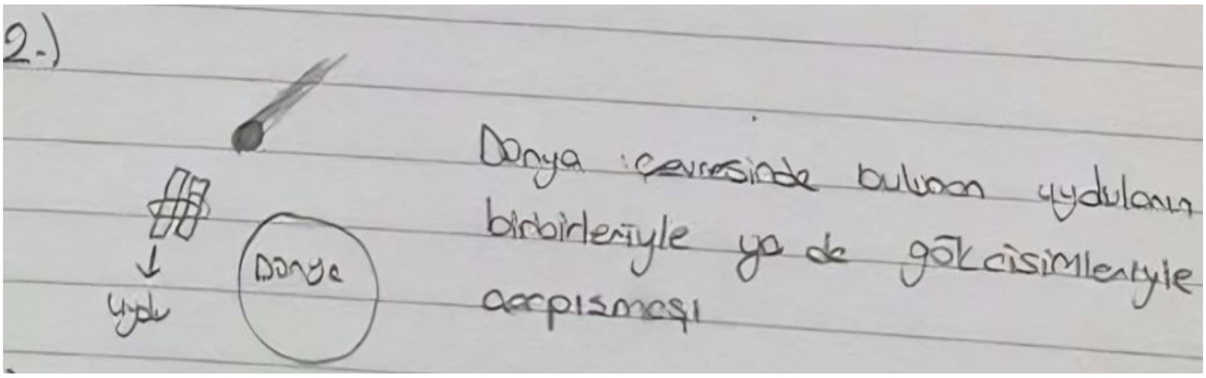

Figure A6. An example of drawing for the sub-theme of causes of space accidents under the theme of collision/crash with the space crafts and celestial bodies

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