USING A STEM EDUCATION APPROACH WITH A COMPUTATIONAL TOOL: THE IMPACT ON STUDENTS' COMPUTATIONAL THINKING SKILLS AND UNDERSTANDING OF CLIMATE CHANGE

by

Dilara Kara Zorluoğlu

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Dedicated to my family, Hülya and Recep Kara and Metehan Zorluoğlu.

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ABSTRACT

USING A STEM EDUCATION APPROACH WITH A COMPUTATIONAL TOOL: THE IMPACT ON STUDENTS' COMPUTATIONAL THINKING SKILLS AND UNDERSTANDING OF CLIMATE CHANGE

The current study applied the STEM-integrated teaching approach to middle school students using computational practices and tool. The purpose of this quasi-experimental study was to investigate whether teaching about climate change with a STEM approach using computational practices significantly changes eighth-grade students' CT skills and understanding of climate change. In addition, the effect of the CT approach as a thought system on the students' understanding of the concepts was investigated. Weintrop and colleagues' computational practices (2016) were integrated into the STEM-integrated teaching framework to focus on developing the CT skills of middle school students in science classes. The participants were 60 eighth-graders in a public middle school, selected using the purposive sampling method. The control group participated in a traditional lesson about climate change. The experimental group participated in an interactive lesson that integrated computational practices by incorporating the integrated STEM teaching approach and its steps, such as fact-finding and product development, and by using the LabStar™ as a computational tool. Two different instruments were applied as pre-and post-tests. Also, students' CT skills were analyzed qualitatively with worksheets and individual interviews. The findings of the study indicated that students in the experimental group had higher scores in the post-test on CTS and CCKT compared to the pre-test and students in the control groups. Engaging with computational practices in STEM lesson steps resulted in significant conceptual learning and algorithmic design.

ÖZET

STEM EĞİTİMİ YAKLAŞIMININ HESAPLAMALI DÜŞÜNME ARACIYLA KULLANIMI: ÖĞRENCİLERİN HESAPLAMALI DÜŞÜNME BECERİLERİ VE İKLİM DEĞİŞİKLİĞİ ANLAYIŞLARI ÜZERİNDEKİ ETKİSİ

Bu çalışma, FeTeMM entegre öğretim yaklaşımı, Hesaplamalı Düşünme (HD) uygulamaları ve aracı kullanılarak ortaokul öğrencilerine uygulanmıştır. Bu yarı deneysel çalışmanın amacı, hesaplamalı bir araç ve uygulamalar kullanarak iklim değişikliğini FeTeMM yaklaşımıyla öğretmenin sekizinci sınıf öğrencilerinin HD becerilerinde ve iklim değişikliğini anlamalarında anlamlı bir değişiklik sağlayıp sağlamadığını araştırmaktır. Ayrıca bir düşünme sistemi olarak HD yaklaşımının öğrencilerin kavramları anlamlandırma süreçlerine etkisi araştırılmıştır. Weintrop ve arkadaşlarının (2016) HD uygulamaları, fen sınıflarındaki ortaokul öğrencilerinin HD becerilerinin gelişimine odaklanmak için FeTeMM entegre öğretim çerçevesine entegre edilmiştir. Katılımcılar, amaçlı örnekleme yöntemine göre seçilen bir devlet ortaokulundaki 60 sekizinci sınıf öğrencisidir. Kontrol grubu iklim değişikliği ile ilgili geleneksel bir derse katılmıştır. Deney grubu ise entegre FeTeMM öğretim yaklaşımını ve onun bilgi edinme ve ürün geliştirme gibi adımlarını içeren ve ders boyunca hesaplama aracı olarak LabStar^{TM}'ı kullanarak HD uygulamalarını entegre eden interaktif bir derse katılmıştır. Ön ve son test olarak iki farklı araç uygulanmıştır. Ayrıca, öğrencilerin HD becerileri çalışma kağıtları ve bireysel görüşmelerle nitel olarak analiz edilmiştir. Çalışmanın bulguları, deney grubundaki öğrencilerin son testte ön teste ve kontrol grubundaki öğrencilere kıyasla CTS ve CCKT puanlarının daha yüksek olduğunu göstermiştir. FeTeMM ders adımlarında HD uygulamalarına yer verilmesi, önemli kavramsal öğrenme ve algoritmik tasarım ile sonuçlanmıştır.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF ACRONYMS/ABBREVIATIONS

APoKS	Authentic Problems of Knowledge Society
CCKT	Climate Change Knowledge Test
CSTA	Computer Science Teachers Association
CT	Computational Thinking
CTS	Computational Thinking Skills
IPCC	Intergovernmental Panel on Climate Change
ISTE	International Society for Technology in Education
ITP	Integrated Teaching Framework
LP1	Lesson Plan 1
LP2	Lesson Plan 2
MoNE	Ministry of National Education
NGSS	Next Generation Science Standards
NRC	National Research Council
P1	Participant 1
P2	Participant 2
P3	Participant 3
P4	Participant 4
P5	Participant 5
P6	Participant 6
STEM	Science, Technology, Engineering, and Mathematics

1. INTRODUCTION

With the development of information and communication technologies, different thought systems have emerged to change our thinking to reform a sustainable society (Easterbrook, 2014). 21st-century problems require competencies, knowledge, and perspective of multiple disciplines. According to Ring and colleagues (2017), individuals in different occupational groups must acquire the necessary competencies to produce fast solutions to daily life problems. Developments in computers, science, and technology have led to changes in thought systems, problem-solving techniques, and skills in education. Along with critical thinking and problem-solving skills, Wing (2006) points out a greater emphasis on computational thinking (CT) skills. According to Grover and Pea (2013), CT should be incorporated into the educational system as a significant learning goal to provide students with the skills they will need in the future.

CT is a problem-solving process that includes certain features such as logical sequencing, analyzing data, generating solutions using certain steps or algorithms, and open-ended and complex problems (Barr and Stephenson, 2011). The multifaceted character of CT has resulted in the creation of approaches and practices for fostering it in a variety of educational settings (Li et al., 2020). Apart from computer science, it becomes a significant skill for mathematics, science, and social sciences with interdisciplinary studies. Wing (2006) claimed that CT, which comprises problem-solving, pattern recognition, and algorithm design, can assist students in improving analytical skills through CT practices.

While the skills necessary in almost every field are constantly changing, studies draw attention to CT by using technologies and tools. CT and the core practices of science, technology, engineering, and mathematics (STEM) education are similar by supporting students' learning of science and math concepts (Basu et al., 2016) and focusing on problem-solving (Wing, 2006). Although the core set of concepts and practices of CT were central to all STEM disciplines, research reveals that CT has not been adequately integrated into K–12 scientific curricula or addressed in science classrooms (Sengupta et al., 2013; Aksit and Wiebe, 2020). Even though there are CT-integrated studies with science subjects in the literature, there are very few studies evaluating processes that aim to directly teach a science subject by using CT practices during the learning process (Arık and Topçu, 2022).

Recent studies in the literature have provided examples of how lesson plans should be CT integrated (Peters-Burton et al., 2020; Peters-Burton et al., 2022). In this study, the examples of CT-integrated lesson plans were designed using Peters-Burton and colleagues' guidelines (2022) by incorporating the data practice component of the framework developed by Weintrop et al. (2016). As Peters Burton and colleagues (2023) stated, CT skills are significant in using traditional science pedagogy to enhance students' data practice skills (i.e., analyzing data, visualizing data) with the help of activities including scientific investigations. Moreover, daily life problems like global climate change require interdisciplinary lenses to have a better understanding of how data has been analyzed, interpreted, and communicated (Moser and Dilling, 2012). Park and Park (2018) demonstrated how computational practices could be implemented to science classrooms at different grade levels using climate change and water shortage topics to increase the scientific literacy of students. To include the data practices component of the CT Framework developed by Weintrop et al. (2016), the climate change topic is a familiar topic for students to learn the concepts and relationships by using computational practices.

The current study explored the implementation of CT into eighth-grade science lessons with an integrated STEM teaching approach. A two-week classroom intervention was designed and implemented in a public middle school to engage students in learning climate change concepts and using computational practices through STEM activities. Students created posters using computational practices during data practice integrated lesson plans on climate, weather events, climate change, and carbon emission concepts. While the STEM lesson plans were implemented in the experimental group, the traditional lecture was implemented in the control group. The engagement with data-based activities into STEM lesson plans and the evaluation of the computational practices of students used during the implementation were qualitatively assessed. It was examined whether there was a statistically significant difference in CT skills and conceptual change in climate change concepts between the experimental and control groups with the effect of the interventions.

This study contributed to the literature on (1) supporting the understanding of climate change concepts and relations with CT practices, (2) incorporating CT and STEM education to reach interdisciplinary objectives, (3) utilizing a computational tool to promote data practices that aim to support eighth-grade students' understanding and CT skills. This study shows that students answered the questions by using CT skills thanks to data practice activities and developed a product that gradually improved throughout the process. From the students' perspective, the concepts and relationships of climate change were learned through data practices, while from the researcher's perspective, it was investigated how computational practice was used in the learning process. Thus, the main purpose of a CT integrated lesson plan was to teach science subjects while developing CT practices. Also, the study demonstrated that the six steps of the STEM Integrated Teaching Framework (ITP) are suitable for using as a roadmap to CT integrated science courses because students improved their thinking process. It is also important in terms of integrating a tool that will contribute to the scientific research process as a computational tool.

1.1. The Purpose of the Study

The aim of the study is to investigate whether teaching about climate change with a STEM education approach by using a computational tool provides a significant change in eight grade students' CT skills and understanding of climate change.

1.2. Significance of the Study

STEM education is forefront since it supports students to integrate classroom learning into real-life contexts. As the need for skills to find solutions to complex problems in the twenty-first century increases, so does the trend of incorporating CT into STEM education disciplines (Barr and Stephenson, 2011; Swaid, 2015). Integrating a CT tool in learning STEM disciplines may both increase the quality of learning scientific concepts with a deepening understanding of the relationship between those concepts and provide significant changes in middle school students' CT skills (Bati et al., 2018; Wing, 2008). Moreover, CT and STEM education enable learning to take place more effectively while achieving the desired learning goals in a shorter time (Najibulla et al., 2018). Briefly, by following the computational process with a computational tool, concepts seeming more complex can be learned better.

While integrating CT into STEM disciplines, the topic should be convenient for applying the computational process. Human-induced climate change is unequivocal (Intergovernmental Panel on Climate Change (IPCC), 2023), but it is also challenging for teachers to utilize effective teaching strategies (Monroe et al., 2019). The issue of climate change requires more interdisciplinary skills to analyze and process large amounts of data. The data about the representation of the trends in climate change and weather events could be used to deepen understanding of global climate change. Therefore, this study aims to better understand complex, daily life problems and concepts like global climate change by using CT as a thought system (Wing, 2008), with the process steps for interpreting data practices (Weintrop et al., 2016).

CT skills and practices enable students to understand the relationship between complicated concepts in various contexts, such as climate change (Park and Green, 2019), water literacy (Caplan et al., 2021), and tidal heights change (Burton et al., 2020). Many studies have indicated that CT is not only applicable to computer education but also for other disciplines (Li et al., 2020). There are a variety of ways to integrate CT into STEM education (Barr and Stephenson, 2011; Batı et al., 2017; Bati et al., 2018; Hsu et al., 2018; Park and Green, 2019, 2020). The existing literature is extensive and focuses on diverse topics from different disciplines with many CT perspectives (Tang et al., 2020). The current study is distinguished from the literature by integrating the STEM approach and CT skills into the problem-solving process in data practices of the CT framework (Weintrop et al., 2016) by using a computational tool named LabStar™. Moreover, using an integrated STEM teaching approach (Corlu et al., 2014) to teach climate change with a CT tool is a new method. In the literature, studies conducted so far about CT indicate that participants of most studies are from secondary and higher education (Tang et al., 2020), but the participants of the current study were middle school students.

1.3. The Research Questions

The aim of the study is to investigate whether teaching about climate change with a STEM approach by using a computational tool provides a significant change in eight grade students' CT skills and understanding of climate change. The research questions are:

(i) Are there any significant differences in eighth-grade students' understanding of climate change after the intervention?

(ii) Are there any significant differences in the eighth-grade students' understanding of climate change between the control and experimental group?

(iii) Are there any significant differences in eighth-grade students' computational thinking skills after the intervention?

(iv) Are there any significant differences in the eighth-grade students' computational thinking skills between the control and experimental group?

(v) Which computational thinking skills do eighth-grade students' use throughout the intervention?

2. LITERATURE REVIEW

2.1. STEM Education Approach

Science, technology, engineering, and mathematics (STEM) education is a teaching approach that demonstrates how several objectives from different disciplines can be integrated to solve a real-world problem (Corlu et al., 2014). The STEM education approach allows students to put their knowledge from each subject into the context to develop solutions. Real-life experiences in the workplace require the use of multiple skills and competencies from different disciplines. It points to the need to integrate STEM education in schools across subjects to show how real-life applications involve science, technology, engineering, and mathematics as necessary skills that cannot be separated. Corlu and colleagues (2014) defined STEM education as the knowledge, skills, and beliefs that are collaboratively developed at the intersection of more than one STEM subject area. This definition of integrated STEM education is parallel with the purpose of this study by combining science, mathematics, and technology.

There are several models for STEM education, ranging from not integrated to fully integrated (Ring et al., 2017). Additionally, Bybee (2013) pointed out nine commonly accepted models that categorized STEM as either a single discipline or STEM as integrated disciplines. While some models require the use of engineering designs (Moore et al., 2014), others do not include engineering or technology in the curriculum (Davison et al., 1995; Fogarty, 1991). On the other hand, the common characteristics are the use of a real-world context (Breiner et al., 2012), the use of student-centered pedagogies to develop problem-solving, and connections of at least two STEM disciplines among the four disciplines (Ring et al., 2017).

With the growing significance of STEM education, current approaches to STEM implementation are diverse for an integrated approach to teaching (Dare et al., 2019). Integration can occur at multiple levels, including disciplinary, multidisciplinary, interdisciplinary, and transdisciplinary (Dare et al., 2019; Webb, 2013). It allows students to decide when to use their knowledge by stimulating them to investigate relationships among numerous concepts (Ring et al., 2017). Although the fundamental idea behind all of these approaches is the same—focusing on integrated complex problem-solving across discipline boundaries—there are frequently small but important distinctions between the concepts that prevent their interchangeability (Stock and Burton, 2011). While disciplinary studies focus on teaching a topic in a subject, multidisciplinary means "work in parallel or sequentially from a disciplinary-specific base to address the common problem" (Rosenfield, 1992, p. 1351). In this case, there should be a common problem that every discipline works independently. The results are brought together only at the end.

On the other hand, interdisciplinary means "work jointly but still from a disciplinary-specific basis to address the common problem" (Rosenfield, 1992, p. 1351). Different disciplines use their techniques and skills to address a common problem. The ability to bridge disciplinary viewpoints and permit the analysis of knowledge from the perspective of a neighboring discipline distinguishes interdisciplinarity from multidisciplinarity (Stock and Burton, 2011). Transdisciplinary means "work jointly using shared conceptual framework drawing together disciplinary-specific theories, concepts, and approaches to address the common problem" (Rosenfield, 1992, p. 1351). Since the shared effort goes beyond doing the same task utilizing distinct disciplinary methods, it is much more than collaboration (Goetze, 2023). The aim of synthesizing new theories separates transdisciplinarity from interdisciplinarity (Stock and Burton, 2011). Given the significance of the difference between integration concepts, interdisciplinary integration was used in this study since climate change is the central topic as a common problem of various disciplines, and students are expected to use CT skills to create solutions for this problem.

Turkey is one of the countries with a growing interest in STEM education (Akaygun and Aslan-Tutak, 2016). In the science curriculum published by the Ministry of National Education (MoNE), STEM applications were presented as "Science, Engineering and Entrepreneurship Applications" (MoNE, 2018, p. 10). According to Uzun and Delen (2018), a scientific thinking-oriented approach is emphasized by the current curriculum. STEM approach should be overlapped with educational practices in classroom settings for better outcomes. However, educational reform efforts have not deeply affected educational practices in Turkey (Aksit, 2007). There is a need for examples of educational practices in the classroom setting to implement curriculum objectives (Atkin and Black, 2003).

STEM Integrated Teaching Framework (ITP) aims to provide a theoretical roadmap for STEM education practitioners, teacher educators, and researchers for improved instruction based on different sources of information and data (Corlu et al., 2014; Corlu and Callı, 2017). The model in this framework links integrated STEM education to integrated teaching at all K-12 levels. Authentic Problems of Knowledge Society (APoKS) is placed at the center of the framework. The framework associates scientific inquiry with science, computational thinking with technology, project-based learning with engineering, and mathematical modeling with mathematics (Aşık et al., 2017). Contents of STEM lesson plans include APoKS and constraints, fact-finding, ideation, product development, testing, dissemination, and reflection.

Integrating with ITP enables teachers to use interdisciplinary objectives while linking with main disciplines without losing their unique characteristics, depth, and rigor (Yabas et al., 2020). Therefore, this study will focus on middle school students' CT skills with the computational tool and STEM education approach by using ITP. In this study, objectives and skills of the science, technology, and mathematics disciplines are included in the lesson plans. The framework is convenient for this study because it includes CT as methodological integration of STEM disciplines.

2.2. Computational Thinking Definition, Skills, and Characteristics

In the last decade, computational thinking (CT) has emerged as an umbrella term regarded as one of the essential skills of the digital era (Shute et al., 2017). CT has gained widespread attention for the next generation to become creative problem solvers in their daily lives (Kong and Abelson, 2019). CT has been integrated into education in different fields and Wing (2006) indicated that CT would become fundamental skills for all students to grow children's analytical ability by incorporating CT into educational programs. Accordingly, researchers put effort into defining its nature in various ways by conceptualizing CT in many different frameworks for different disciplines, which arouse different definitions in the literature (Barr et al., 2011; Grover and Pea, 2013; Li et al., 2020; Shute et al., 2017; Tsai et al., 2021).

One of the first definitions for CT in education was that "Computational thinking is a crucial skill for everyone, not just for computer scientists. To reading, writing, and arithmetic, we should add CT to every child's analytical ability" (Wing, 2006, p. 33). This definition is also parallel with the starting point of this study, as CT is an interdisciplinary thinking practice. Data analysis is a mathematical skill, but it can be included in science to better understand the concepts and their relationships. Students with CT skills can apply their disciplinary skills to interdisciplinary problem-solving (Weintrop et al., 2016). Thus, CT is considered as problem-solving and thinking like a computer scientist (Henderson et al., 2007). In this perspective, complex problems can be divided into sub-parts to manage effectively. This way of thinking can be used in various disciplines to solve complex problems. Wing (2008) stated not just mathematically well-defined problems whose solutions are completely analyzable, but also ill-defined, real-world problems whose solutions might be in the form of large, complex software systems can be formulated effectively by CT processes.

National Research Council (NRC) (2011) simply defined CT as "computational thinking is a set of skills that transfer across disciplinary boundaries" (National Research Council, 2011, p. 54). This definition highlights the common features of CT and STEM disciplines. Additionally, the International Society for Technology in Education (ISTE) (2011) has considered CT as a problem-solving approach that strengthens the combination of technology and thought, which concludes the CT literature in the aspect of STEM education. This study considered CT as a thought system that requires processes, and analytical ability to develop step-by-step solutions by breaking down huge problems into smaller ones to manage with a STEM approach by using multiple perspectives and technology (Henderson et al., 2010; International Society for Technology in Education (ISTE) and Computer Science Teachers Association (CSTA), 2011; Weintrop et al., 2016; Wing, 2006).

There are many approaches to using CT in the learning process. In the literature, plugged and unplugged approaches to computational thinking differ in their use of technology during the learning process (Brackmann et al., 2017). Unplugged computational thinking focuses on teaching and practicing computational thinking skills without the use of computers or digital devices. In other words, the unplugged approach leads to deeper understanding by regarding CT concepts as a mental tool for the problem-solving process (Yadav et al., 2018). Plugged computational thinking, on the other hand, incorporates digital devices such as computers, tablets or robots to explore and apply computational thinking skills. It involves using programming languages, coding platforms or software tools to design algorithms, code programs, and solve problems (Brackmann et al., 2017). While unplugged activities provide a tangible and interactive learning experience, plugged activities use technology to create more dynamic and practical applications of computational thinking concepts.

2.3. Theoretical Framework

Many computational practices are naturally linked with data analysis due to the need for thought processes in addition to critical thinking and problem-solving (Peters-Burton et al., 2021). CT can be regarded as a set of complex methods that students can utilize to become skilled in data analysis in scientific research (Weintrop et al., 2016). According to Burton and colleagues (2020), CT skills can assist students in comprehending what to do during data analysis in a scientifically accurate way. Data practices are convenient to the characteristics of CT stated by Barr ad colleagues (2011) as a problem-solving process:

> "(i) Formulating problems in a way that enables us to use a computer and other tools to help solve them; (ii) Logically organizing and analyzing data; (iii) Representing data through abstractions such as models and simulations; (iv) Automating solutions through algorithmic thinking (a series of ordered steps); (v) Identifying, analyzing, and implementing possible solutions with the goal of achieving the most efficient and effective combination of steps and resources; (vi) Generalizing and transferring this problem-solving process to a wide variety of problems." (Barr et al., 2011, p. 20)

In the current study, students were asked to develop a problem-solving process in line with the characteristics of CT. Students used the computational tool, LabStar™, to collect data and formulate the given problem, organize and analyze data, use representations to explain data, generalize the process and transfer what they learned to representation by graphical models.

Tang et al. (2020) pointed out that the distribution of the four major subject domains of CT for elementary and middle school levels are programming, robotics/game, STEM, and non-STEM. In the current study, CT was included in lesson plans as an interdisciplinary thinking practice of STEM education. This study has identified four CT concepts that were found to be highly useful in a wide range of studies of STEM education (Burton et al., 2020; Park and Green, 2019; Weintrop et al., 2016). Computational practices are significant to understanding students' thinking and learning process, moving beyond what they are learning to how they are learning (Brennan and Resnick, 2012). In this study, Weintrop and colleagues' (2016) data practices were used. Definitions of data practices created by Burton and colleagues (2020) based on Weintrop's framework (2016) were applied in this study (see Table 2.1). In the methods section, each concept was defined relating to the aim of the study with examples from the lesson plans.

Table 2.1. Data practices and definitions (Burton et al., 2020, p. 30).

Practices	**Meaning**
Creating data	"Generating data from tools or observation"
Collecting data	"Gathering and recording data"
Manipulating data	"Sorting, filtering, cleaning, normalizing, and combining data sets"
Visualizing data	"Communicating results with a representation such as a graph or a chart"
Analyzing data	"Extracting meaning from a data set for the purpose of drawing conclusions"

2.4. Computational Thinking and STEM Education

With the increasing importance of computational thinking in education, several studies have pointed out the strong relationship between CT and STEM education (D. Barr et al., 2011; Bundy, 2007; Hsu et al., 2018; Park and Green, 2019; Shute et al., 2017; Swaid, 2015). Najibulla and colleagues (2018) argued that CT concepts are relevant to STEM, and both can be applied at all grade levels to understand disciplines better and develop multiple skills. Swaid (2015) demonstrated the relationship between STEM disciplines and CT concepts (i.e., decomposition, pattern recognition, abstraction, evaluation, and algorithm thinking) by overlapping these concepts with the objectives and practices of disciplines. According to Arık and Topçu (2022), science learning is made more meaningful by constructing teaching procedures where science and CT processes overlap.

Several aspects of CT go beyond programming and computer science (Li et al., 2020) which diversifies the studies with CT in the context of STEM education in K-12 settings (Weintrop et al., 2016). In the literature, target audiences, theoretical foundations, scopes, types, and research designs used have diversified in line with different STEM fields and purposes (Kalelioglu et al., 2016). Therefore, there are many frameworks in CT and STEM education (Brennan and Resnick, 2012; ISTE and CSTA, 2011; Weintrop et al., 2016; Yadav et al., 2018). It has been integrated into lesson plans and curricula in different ways, such as unplugged activities, working with data sets, making games, coding by using drag-and-drop block styles, robotics, or maker (Weintrop et al., 2016).

Multiple models and frameworks of CT have been underlined with various aspects in different studies (Barr et al., 2011; Bundy, 2007; Gunckel et al., 2022; Park and Green, 2019; Shute et al., 2017). According to Kite and colleagues (2021), early CT frameworks (i.e., Brennan and Resnick, 2012; ISTE and CSTA, 2011) emphasized programming concepts and skills. The Next Generation Science Standards (NGSS), on the other hand, have taken a different tack by emphasizing an integrative and cross-disciplinary approach that goes beyond programming (the NGSS Lead States, 2013). Weintrop et al. (2016) developed the Computational Thinking in Mathematics and Science Taxonomy, which specifies applicable abilities that can be incorporated into math and science curricula, building on the NGSS idea (Kite et al., 2021). For that reason, the most common framework for STEM and CT is Weintrop et al.'s (2016) framework (Tang et al., 2020).

As Bati and colleagues (2018) stated that most studies have developed independently from educational programs, and they encourage primarily to improve students' CT skills. Although many programs claim to teach coding skills, rarely do they look deeply at the ways of thinking used in CT (Shute et al., 2017). For that reason, CT in K-12 settings can be divided into two parts as CT and programming with STEM education and CT and STEM disciplines in K-12 education (Kong and Abelson, 2019). Since many researchers have focused on the programming part of STEM education (Grover and Pea, 2013; Park and Green, 2019) to integrate CT, there is a gap in the literature to focus on improving both CT skills and interdisciplinary objectives of STEM disciplines (Tang et al., 2020). In this study, teaching K-12 STEM education and objectives by developing CT skills were the purpose of applying CT processes to teach climate change concepts. Students' way of thinking was assessed.

There are some examples from the literature that focuses on both STEM disciplines and CT skills. Bundy (2007) suggested that CT is a broader concept that changes the way people think by expanding their cognitive constructs like content learning or being proficient in skills (Kite et al., 2021). Aksit and Wiebe (2020) examined CT and simulation-based model building using block-based programming on 7th-grade students' understanding of CT and force and motion. The findings of a one-week-long intervention revealed that students significantly improved their conceptual learning as a result of creating computational models because the research enables students to simultaneously observe and interact with the target phenomenon in real time. There are many studies use CT to teach different science topics in biology like evolution (Christensen and Lombardi, 2023), natural selection (Peel et al., 2019), environmental sustainability (Christensen, 2023), digestive system (Arık and Topçu, 2022), climate change (Park and Green, 2019), and food web (Rachmatullah and Wiebe, 2022).

Recent studies designed in line with the necessity of CT integration in science teaching supported the idea that unplugged CT activities provide meaningful learning experiences compared to traditional teaching methods. Arık and Topçu (2022) showed that CT activities as a teaching strategy help students to create a better model for science content, especially for complicated processes like the digestive system. Moreover, Peel and colleagues (2019) highlighted that students' misconceptions about natural selection can be changed with the help of unplugged algorithmic explanations, enabling students to learn the process and correct the misconceptions.

CT makes it easier to ask new questions and find new answers while dealing with a large amount of data. Park and Green (2019) described the importance of CT in science and STEM education as equipping students to be creative solvers rather than answer-finders. Thus, this approach relates the purpose of science education and STEM programs by using CT. Additionally, Burton et al. (2020) conducted a study to use computational thinking for data practices in high school science with Weintrop et al.'s (2016) data practice sub-dimension of CT-related skills. Burton et al. (2020) emphasized the importance of gathering, organizing, cleaning, and analyzing data to form conclusions about a specific phenomenon like why tidal heights change. In the current study, students will engage in these critical data procedures during collecting valid and reliable data and making conclusions regarding the scientific phenomenon, which is climate change (Burton et al., 2020).

Several studies used Weintrop and colleagues' framework (2016) commonly to integrate CT into STEM education. Those studies are diverse in the way of integration, use of practices, levels, and disciplines. In the aspect of the framework, there are four practices: Data practices (Bati et al., 2018; Cruz Castro et al., 2021; Fortmann et al., 2020; Park and Green, 2019), modeling and simulation practices (Adler and Kim, 2018; Aksit and Wiebe, 2020; Bati et al., 2018; Caplan et al., 2021; Fortmann et al., 2020), computational problem-solving practices (Cruz Castro et al., 2021), and system thinking practices (Haas et al., 2020). The results of this study will shed light on the integration of CT into STEM education in the aspect of data practices and using a computational tool. Some studies focus on only one practice (Adler and Kim, 2018; Caplan et al., 2021), while others combine these practices in a study (Bati et al., 2018; Cruz Castro et al., 2021; Fortmann et al., 2020; Rachmatullah and Wiebe, 2022). In this study, the aim is similar to combining data practices and computational practices.

CT tools can be defined as instruments used to teach CT skills with approaches that incorporate CT concepts. Some teaching tools in the CT lessons are LOGO, LEGO, ViMAP, MATLAB, Alice, Turtle Art, Scratch, Code.org, AgentCubes, Scalable Game Design, Java, C, and C++ (Hsu et al., 2018). In this context, most of these tools highlighted CT and programming education. One of the benefits of using CT tools is saving time during the problem-solving process. For example, Uysal (2019) conducted a study to investigate the time spent using a CT tool in the mathematical problem-solving process. The results showed that the experimental groups, which used block-based visual programming software for mathematical problem solving, spent most of their time on problem formulation and very little time on calculations, which was different from the control group.

The tool should be convenient to teach CT skills in line with the CT perspectives in the current study (Tang et al., 2020). This study aims to use the CT tool to support both disciplinary understanding and CT skills apart from programming and coding language in K-12 STEM education. In light of the similar studies in the literature, LabStar™ can be included in STEM lessons as a computational tool to increase students' data literacy by using CT frameworks and concepts (Burton et al., 2020; Park and Green, 2019; Weintrop et al., 2016).

2.5. LabStar™

LabStar™ is a data collection device developed by a team of professors, teachers, and engineers (Inan and Corlu, 2015). It is a simultaneous data collection tool that enables data cleaning prior to analysis and allows the sharing of the analyses made (Yabaş et al., 2020). The primary aim of this device is to make Data Science an integral part of mathematics and science education by thinking, understanding, and communicating. LabStar™ collects continuous data through its sensors (i.e. distance, ambient temperature, ambient humidity, air pressure, altitude, ambient light, acceleration, and sound intensity). This tool enables students to think about and understand life with data. Students and teachers can collect data about different variables instantaneously or remotely, share it with others and analyze it on several platforms in line with the curriculum and learning objectives.

LabStar™ also facilitates students and teachers to represent, trim, analyze, and interpret the collected data through the mobile application. Students can advance to analysis, examine the descriptive statistics, the plotline of best fit, and carry out bivariate analyses. These analyses enable teachers and students to describe data, discuss graphical representations and create meaningful associations between representations and real-life situations (Yabas et al., 2020). It also creates an opportunity for interdisciplinary learning in STEM education by collecting scientific data from real life and analyzing data by engaging in basic statistics. In this study, LabStar™ was used as a computational tool to investigate its impact on students' computational thinking skills.

2.6. Computational Thinking and Climate Change

CT could be used in the implementation of complex, real-world problems with no single solution like climate change (Park and Green, 2019). Students need to analyze given situations about climate change to find the best solution to real-world problems by using procedural and thinking skills (Park and Green, 2019; 2020; Wing, 2006). Many examples focus on how CT can be incorporated into the classroom setting for different grade levels in the context of climate change on weather and climate, carbon dioxide level, global warming, melting ice, water shortage, and sea-level rise (Breslyn and McGinnis, 2019; Caplan et al., 2021; Fortmann et al., 2020; Park and Green, 2019, 2020; Park and Park, 2018).

Some studies in the literature used the Weintrop and colleagues framework (2016) for CT (Breslyn and McGinnis, 2019; Fortmann et al., 2020; Park and Green, 2019; Park and Park, 2018), while others used various frameworks to integrate climate change into lessons (Fortmann et al., 2020). Even though the framework is the same as the current study as Weintrop et al.'s framework (2016), researchers included CT by using the same framework from different perspectives. For instance, Park and colleagues had data practices perspectives, Breslyn and McGinnis (2019) had systems perspectives, and Caplan and colleagues (2021) had modeling and data perspectives. This study will have data perspectives of Weintrop and colleagues' CT framework (2016).

Moreover, computational practices are changing in classroom activities in line with the grade level and selected objectives. Park and Park (2018) integrated computational practices into different grade levels to teach climate change and water shortage with a STEM approach. The common computational practices used in the program for all grade levels are accordingly: Data collection, data analysis, data representation, and problem decomposition. The use of common computational practices in different grade levels indicates that computational practices with Weintrop et al.'s framework (2016) can be integrated into different grade levels to teach the same topic. Moreover, while abstraction, algorithms, and procedures were used at the middle school level, automation and simulation were used at the high school level.

Park and Green (2019) have revised a climate change intervention by integrating CT into teaching and learning climate change concepts which are greenhouse gases and rise in temperatures. It reveals the importance of additional procedural skills and thinking skills with tools to acquire concepts basically and why CT should be integrated into lessons. There are similarities between Park and colleagues' (2019) study in the aspects of the framework, perspectives, context, and grade level; however, there are differences between these studies in the aspect of computational practices due to the implementation of CT with STEM education and robotics.

Caplan et al. (2021) focused on the flooding variable of climate change as a real-world problem to combine hydrologic learning and CT. The study aimed to improve high school students' water literacy by involving them in CT and modeling activities (i.e., maps, graphs, and visualizations), CT tools, and large data sets. The current study's similarity is to strengthen disciplinary and CT skills by using data practices. Moreover, Fortman and colleagues (2020) integrated CT to teach regional sea-level rise into undergraduate economics courses through the combining of real-world data and modeling. It shows how disciplinary objectives can be taught while CT skills are integrated into economics. The divergent way is the guided inquiry approach into a computational framework like Excel. Breslyn and McGinnis (2019) investigated the understanding of climate change on the sea-level rise from CT systems perspectives with undergraduate students, but the current study investigates data perspectives with middle school students. Weintrop et al.'s (2016) framework has mostly been used to integrate CT into teaching climate change (Breslyn and McGinnis, 2019; Caplan et al., 2021; Fortman et al., 2020).

3. METHODOLOGY

This chapter contains information about the study's sample, data collection instruments, the design of the study, treatment, and data analysis.

3.1. Design of the Study

The current research is a quasi-experimental design that can be applied when the experimental design is impossible. In education, researchers might need to utilize existing groups in educational settings. The groups were randomly selected. Quasi-experiments include assignments, but not a random assignment of participants to groups (Cresswell and Cresswell, 2018). The quasi-experimental design with a pretest-posttest control group was used to determine the effectiveness of the intervention applied to the experimental group. For this purpose, two classes were selected and one was assigned as the control group, and the other one was the experimental group. Before the implementation, data on the dependent variables were collected from both groups as a pre-test. After the pre-test, the researcher introduced the LabStar™ device to the students in the experimental group. The experimental group was then taught using a STEM lesson plan and worksheets designed to develop the problem-solving process using computational thinking skills and the LabStar™ data collection tool. Simultaneously, the same topics were taught to the control group under the guidance of the MoNE science book (2018). At the end of the two weeks, the experimental and control groups were administered the post-test. The researcher was the main instructor of both groups.

3.2. Sample of the Study

The participants in this study were eighth-grade students in a public middle school with access to technological facilities. The school has a STEM laboratory, and the students are accustomed to STEM-related activities. It was chosen as the implementation school for the appropriate characteristics of students, like academic success and using STEM skills. In addition, since the researcher had previously conducted a STEM lesson plan with the students in the selected school, the students were familiar with STEM activities. This school was chosen for the implementation because the school has a STEM laboratory, and students are used to STEM lessons. Thus, purposive sampling was used to determine the participants (Mills and Gay, 2019). The middle school consisted of fifth, sixth, seventh, and eighth grades. The gender distribution in the classrooms was almost equal. The experimental and control groups consisted of students with low, medium, and high academic achievement. While determining the grade level for the intervention, the researcher considered the aim of the study and the content of the national curriculum. Climate change is included in the eighth-grade national science curriculum under the seasons and climate unit. Therefore, eighth-grade students were selected as a sample of this study.

Two different classrooms were randomly selected as experimental and control groups. The average academic achievement of the two classes, as determined by school exams, was chosen to be close to each other. Experimental and control groups were assigned randomly. There were 30 eighth-grade students (between the ages of 14-15) in both the experimental group and the control group.

Table 3.1. Distribution of the study group.

Groups	Grade level	Gender		Total
		Female	Male	
Experimental	8	15	15	30
Control	8	20	10	30
Total		35	25	60

3.3. Definitions of Key Terms, Concepts, and Variables

This section consists of two parts. The first part indicates the conceptual definitions, and the second part describes the operational definitions of the terms and variables of this study.

3.3.1. Conceptual Definitions

- Computational Thinking: " solving problems, designing systems, and understanding human behavior by drawing on the concepts fundamental to computer science." (Wing, 2006, p. 33).
- STEM Education: "teaching and learning in the fields of science, technology, engineering, and mathematics. It typically includes educational activities across all grade levels -from pre-school to post-doctorate- in both formal (i.e., classrooms) and informal (i.e., afterschool programs) settings" (Gonzalez and Kuenzi, 2014, p. 1).
- Integrated STEM: "the ability to identify, apply, and integrate concepts from science, technology, engineering, and mathematics to understand complex problems and to innovate to solve them" (Balka, 2011, p. 7).
- Climate Change: "Climate change refers to a change in the state of the climate that can be identified (i.e., by using statistical tests) by changes in the mean and/or the variability of its properties, and that persists for an extended period, typically decades or longer" (IPCC, 2018, p. 544).
- LabStar™: "It is a simultaneous data collection device that offers the opportunity to clean the data before analyzing without the limitation of environment and distance, allows the sharing of the analyses made, and makes comments on daily life." (Yabaş et al., 2020).
- Decomposition: "Evidence that a complex problem is deliberately being broken down into less complex sub-problems. The goal is to reduce the main problem into manageable steps or subproblems" (Peters-Burton et al., 2022, p. 11).
- Pattern recognition: "The identifying, clustering, and modularizing of steps or

parts that repeat or can be repeated. Evidence that the individual is identifying repeated sequences or patterns." (Peters-Burton et al., 2022, p. 11).

- Abstraction: "Clarify the problem and generate generalizable solutions - evidence that the individual has created a "high-level" or generalized representation of the structure of a problem/solution. Maintain relevant information while removing as much unnecessary or distracting information from the problem." (Peters-Burton et al., 2022, p. 11).
- Algorithmic thinking: "The creation of a series of precisely defined steps or rules to use to solve a problem. It could be steps to collect certain data, steps to analyze that data or any other defined process." (Peters-Burton et al., 2022, p. 11).

3.3.2. Operational Definitions

- Computational Thinking Skills: The summated score of responses to the Computational Thinking Skill (CTS) test, based on a five-point summated rating scale identifying the degree of computational thinking and given a numerical value ranging from 1 to 5.
- Understanding of Climate Change: The summated score of responses to the Climate Change Knowledge Test (CCKT) based on a true/false/don't know response format and given a numerical value of 1 for a correct response, whereas given a numerical value of 0 for incorrect, "don't know", and blank response.

3.3.3. Variables

There are two dependent variables in the study that are computational thinking skill scores and climate change knowledge test scores. The methods of teaching climate change topics are independent variables of the study that are traditional and STEM-integrated.

3.3.4. Hypotheses

- H.1. The Climate Change Knowledge Test (CCKT) scores of eighth-grade students in the experimental group differ significantly after the intervention.
- Ho.1. The Climate Change Knowledge Test (CCKT) scores of eighth-grade students in the experimental group do not differ significantly after the intervention.
- H.2. Experimental group will differ significantly from the control group in understanding climate change.
- Ho.2. Experimental group will not differ significantly from the control group in understanding climate change.
- H.3. The computational thinking levels (CTS) scores of the eighth-grade students in the experimental group differ significantly after the intervention.
- Ho.3. The computational thinking levels (CTS) scores of the eighth-grade students in the experimental group do not differ significantly after the intervention.
- H.4. Experimental group will differ significantly from the control group in computational thinking skills.
- Ho.4. Experimental group will not differ significantly from the control group on computational thinking skills.

3.4. Data Collection Instruments

Data was collected using four different tools: The Computational Thinking Skill (CTS) Scale (Korkmaz et al., 2015), The Climate Change Knowledge Test (CCKT) Scale (Gezer and İlhan, 2021), student worksheets, and individual interviews.

3.4.1. Demographic Form

The demographic form was developed to collect participant information (see Appendix B). There are questions about the participants' gender, information about taking courses on environmental education and belonging to an environmental group or organization.

3.4.2. Quantitative Data Collection Tools

Quantitative data collection tools were implemented as pre-test and post-test to both experimental and control groups.

3.4.2.1. Computational Thinking Scale (CTS). The computational thinking scale (CTS) was originally developed to measure the CT abilities of university students (Korkmaz et al., 2015). Korkmaz and colleagues (2015) adapted the CTS Scale to middle school students (see Appendix C). The instrument has twenty-two items that participants can rate each item on a five-point Likert scale (1 = never, 2= rarely, 3= occasionally, 4=generally, 5 = always). The scale consists of five factors that are the following: creativity, algorithmic thinking, collaboration, critical thinking, and problem-solving. The minimum score is 22, which represents the lower computational thinking skill and the maximum score is 110, which represents the higher computational thinking skill for the instrument. The adapted scale was applied to 241 students studying in the 7th and 8th grades in a middle school, and Cronbach's alpha reliability value of the instrument was obtained as 0,8 (Korkmaz et al., 2015).

For the current study, the reliability of the scale was checked. The data's internal consistency and stability were analyzed to determine the scale's reliability. The Cronbach Alpha reliability coefficient was used to calculate the scale's reliability analysis. Table 3.2 provides a summary of the reliability analysis of each factor and the entire scale. The scale, which had 22 items and five sub-factors, has a Cronbach Alpha reliability coefficient of .878, as can be shown in Table 3.2. On the other hand, factor Cronbach alpha values range from .714 to .864. All of the factors and CTS's Cronbach alpha values are greater than .70, which shows that the scale has sufficient internal consistency.

Table 3.2. Reliability analysis.

Factors	Number of items	Cronbach's Alpha
Creativity	4	.803
Algorithmic Thinking	4	.776
Cooperativity	4	.864
Critical Thinking	4	.714
Problem Solving	6	.844
Computational Thinking Skills	22	.878

3.4.2.2. Climate Change Knowledge Test (CCKT). This scale was adapted from the climate change knowledge test (CCKT) developed by Dijkstra and Goedhart (2012) and translated into Turkish (Gezer and İlhan, 2021). The test could distinguish the levels of climate change knowledge. The knowledge test about climate change contains 12 items (see Appendix D). The instrument consists of two factors theoretical and newsworthy. The theoretical factor reflects the knowledge acquired through courses at school or environmental programs. On the other hand, the newsworthy factor reflects the knowledge about climate change acquired in daily life, on social media or in written or visual media. On the other hand, The 12 items have a true/false/don't know response format. The 'don't know' option was included to minimize random guessing. The knowledge items were assigned a score of 1 for a correct response and a score of 0 if incorrect. 'Don't know' responses and blank responses are scored as incorrect and assigned a weight of 0. Correct answers were summed and expressed in percentages correct answers, with a minimum-maximum score range of 0–100 percent. The internal consistency coefficients of the instrument were obtained as .85 and .84, respectively, in theoretical and newsworthy factors (Gezer and İlhan, 2021).

3.4.3. Qualitative Data Collection Tools

The qualitative data was evaluated by student worksheets and individual interviews.

3.4.3.1. Student Worksheets. In this study, activities were developed to teach middle school students climate change topics by using computational practices, specifically, abstraction, pattern recognition, algorithmic thinking, and decomposition concepts. The activities were designed to enable students to solve problems by using computational practices and computational tools. The computer science concepts utilized in the activities for data practices include creating, collecting, manipulating, visualizing, and analyzing data. According to Peters-Burton et al. (2020), collecting data entails obtaining or recording data, whereas creating data is generating data through tools or observation. Additionally, analyzing data entails making inferences from a data collection to draw a conclusion, while manipulating data entails sorting, filtering, cleaning, and combining data. Visualizing data entails creating representations like graphs or charts to explain results (Peters-Burton et al., 2020).

Examination of the learning process with data practices was done with the analysis of the questions in the worksheets (see Appendix F). For every step in the STEM framework, questions were matched with computational practices (see Table 3.3 and Table 3.4) and assessed using a rubric developed by the researcher (see Table 4.4). The lesson plans and questions in the worksheets were organized with an emphasis on data practices in STEM education, using Weintrop et al.'s (2016) framework in the context of data practices. Students were dealing with data practices, but they did not aware that they were using computational practices while answering questions. In contrast, the researcher focused on computational practices to analyze questions in the worksheets. In other words, the questions about data were organized so that each data practice includes the use of specific computational practices. Students were expected to benefit from questions embedded into worksheets throughout the lessons. For instance, students were asked to conduct research on weather and climate change concepts using data provided by LabStar^{TM}. For creating data, students benefited from questions that encouraged decomposition as a computational practice. It was crucial to identify the steps to carry out research by breaking down the problem into manageable parts. For that purpose, the following questions were asked: "If you were to carry out research to explain the concepts of climate and weather events, which steps would you follow? Explain with justification." and "What information should you use to understand whether there is climate change in your region?". The computational practices embedded in the questions would improve answering questions throughout the lesson while making inferences from data. For the analysis of the student worksheets, each step in the STEM Integrated Teaching Framework (ITP) was examined for specific computational practices. The questions in the worksheets and the way of analysis were given in Table 3.3. and Table 3.4.

Table 3.3. The outline of worksheet 1.

Worksheet	**Lesson contents**	**Questions**	**Computational Practices**	**Data Practices**
Worksheet 1: weather and climate concepts	1.APoKS and constraints	1a, 1b	Decomposition	Creating Data
	2.Fact-finding	2a, 2b, 2c, 2d, 2e, 2f	Abstraction	Creating Data
	3.Ideation	3a, 3b, 3c, 3d, 3e, 3f, 3g, 3h	Pattern recognition	Analyzing Data, Collecting Data
	4.Product development	4a, 4b, 4c, 4d, 4f	Pattern recognition	Analyzing Data, Manipulating Data, Visualizing Data
		4e	Algorithmic thinking	
		4g	Abstraction	
	5.Testing	5a, 5b, 5c	Pattern recognition	Analyzing Data, Visualizing Data
	6.Disseminate and reflect	6a	Abstraction	Visualizing Data
		6b	Algorithmic thinking	

Weintrop et al. (2016) emphasized that computational applications include data applications. From this point of view, during the lesson, the students would use both data practices and computational practices, but they would not learn definitions of them. Previously, they had only learned data practices in science and graph analysis in mathematics. Computational practices include data practices. In the APoKS part, there were 2 questions to assess students' decomposition skills. In the fact-finding part, there were 6 questions to assess students' abstraction skills. In the ideation part, there were 8 questions to assess students' pattern recognition skills. Students were asked to compare the average temperatures of different cities in Turkey (see Appendix J). In the product development part, students would use pattern recognition to answer 5 open-ended questions, which directs students to analyze the collected data and compare it with previous data to create meaningful graphs in the next question. Also, students would use algorithmic thinking to create a graph of concepts and abstraction to write a report. Although three different types of questions (i.e., comparing, drawing a graph, and creating a report) were in the product development part, computational practices were assessed separately. In the testing part, there were 3 questions and 1 self-assessment rubric for students to use the pattern recognition practice. However, the self-assessment rubrics were not included in the analysis of this study. Students only used the rubrics to assess their product and change some parts to finalize it. Finally, in the disseminate and reflect part, students used abstraction to answer one open-ended question about their understanding of the lesson. Students would remove the unnecessary details to answer the question briefly. The actual final product was the poster which included the necessary steps from the lesson, graphs, and report. Students used their algorithmic thinking practices to create a poster by including information from previous lesson parts.

Table 3.4. The outline of worksheet 2.

Worksheet	Lesson contents	Questions	Computational Practices	Data Practices
Worksheet 2: human-induced CO2 emissions	1.APoKS and constraints	1a, 1b	Decomposition	Creating Data
	2.Fact-finding	2a, 2b, 2c, 2d, 2e, 2f, 2g, 2h 2i	Abstraction	Creating Data
	3.Ideation	3a, 3b, 3c, 3d, 3e, 3f, 3g, 3h 3i, 3j, 3k, 3l 3m	Pattern recognition	Analyzing Data
	4.Product development	4a, 4b, 4c, 4d, 4f, 4g	Pattern recognition	Analyzing Data, Manipulating Data, Visualizing Data
		4i	Algorithmic thinking	
		4h	Abstraction	
	5.Testing	5a, 5b, 5c, 5d	Pattern recognition	Analyzing Data, Visualizing Data
	6.Disseminate and reflect	6	Abstraction	Visualizing Data
		6a, 6b, 6c, 6d	Algorithmic thinking	

In the LP2, there were 2 questions about planning research steps to show carbon emissions in the APoKS to assess students' decomposition skills. In the fact-finding part, there were 9 questions about understanding climate change and carbon emissions to assess students' abstraction skills. In the ideation part, there were 13 questions to assess students' pattern recognition skills. They were asked to compare the carbon emissions of different countries and continents (see Appendix J). In the product development part, students would use pattern recognition to answer 7 open-ended questions which directs students to create a report. They would use algorithmic thinking practice to create a graph of carbon emissions in their country and abstraction to write a report. Each practice was assessed separately in the same part of the lesson. In the testing part, there were 3 questions and 1 self-assessment rubric for students to use the pattern recognition practice. The self-assessment rubrics were not assessed. Finally, in the disseminate and reflect part, students used abstraction to answer 4 open-ended questions about their understanding of the lesson and elaboration. The final product was the poster which included the necessary steps from the lesson, graphs, and report. Students used their algorithmic thinking practices to create a poster.

3.4.3.2. Individual Interviews. The interview questions were formulated by considering both the questions asked in the literature and the content of this study. Expert opinion was taken about the questions. The interview questions were prepared in line with the CT framework of Weintrop and colleagues (2016). Interviews reflected on which computational practices have emerged during the implementation of the lesson plans from the perspective of students. The scores obtained from the CTS (raw scores) were transformed into categorical scores in the same way as used by Korkmaz and Xuemei (2019). The lowest categorical score was 20, and the highest categorical score was 100. The levels of the scale were as follows: 20-51: low level; 52-67: Medium level; 68-100: High level. The individual interview was conducted with 6 students, purposefully selected from the experimental group according to three levels of CT skills (low-moderate-high). The individual interviews were conducted face-to-face after the intervention and lasted on average 20 minutes. The interviews were audio-recorded and then transcribed by the researcher.

3.5. Procedure

After the review of the literature, the topic was selected, and the research questions were determined. By reviewing the literature, the demographic information form was composed, and the instruments were chosen to answer the research questions. Expert judgments were obtained to confirm the face and content validity of the lesson plans. Before data collection, the required permission for conducting research was taken from the Ethical Committee of Boğaziçi University, and participants were asked to sign the consent form (See Appendix A). After making the proposed changes, the pilot study was conducted to test the psychometric properties of the instruments. Following the data collection, the data was coded and entered into the statistical analysis software program (Statistical Package for the Social Sciences, SPSS), and the psychometric properties of the instruments were tested. The required time for implementation of the instruments was about twenty minutes and the researcher was present in the classroom during data collection to briefly explain the study and clarify the confidentiality of information.

3.6. Intervention

3.6.1. The Pilot Study

In this study, two lesson plans developed by the researcher were implemented for 8th-grade students. The pilot study was conducted informally with middle school students to increase the feasibility of the study. The aim was to get feedback about the instruction, questions, lesson design, and contents. Also, the time necessary to implement the lesson plan and instruments was monitored. The pilot study was implemented in the summer term with a group of 7th-grade students. It was implemented during six lessons to apply pre and post-tests as well as the intervention for the experimental group.

3.6.2. Main Study

Following the implementation of the pilot study, the main study was revised in line with the preliminary findings. The study was implemented in the first semester of the 2022-2023 academic year in a public middle school with 8th-grade students.

Two lesson plans in this study were developed by the researcher according to the STEM Integrated Teaching Framework (ITP). The first lesson plan focuses on the weather and climate concepts, whereas the second lesson plan focuses on carbon dioxide emissions as human-induced climate change (see Table 3.5).

Table 3.5. Groups and planning of the implementation.

	Week 1		Week 2		
Groups	Pre-test	Lesson	Lesson	Post-test	Interview
Experimental Group	Computational Thinking Skill Scale (CTS) Climate Change Knowledge Test (CCKT)	Lesson Plan 1 with STEM integrated teaching framework	Lesson Plan 2 with STEM integrated teaching framework	Computational Thinking Skill Scale (CTS) Climate Change Knowledge Test (CCKT)	Interview with 6 students from low, intermediate and high level of CT
Control Group	Computational Thinking Skill Scale (CTS) Climate Change Knowledge Test (CCKT)	Traditional Lecture 1	Traditional Lecture 2	Computational Thinking Skill Scale (CTS) Climate Change Knowledge Test (CCKT)	

3.6.2.1. Implementation with Experimental Group. The main study was implemented over two weeks. In the first week, the pre-tests were given to all groups. Then, the LabStar™ introduction and information about the use of the tool were given to the experimental group. Since group work is crucial for the end product, every lesson plan was applied during 6 lessons to the experimental group. Apart from the lesson content, students were asked to fill out the worksheets as a group. For that reason, students had enough time to discuss with their peers and write their ideas into the worksheets.

The students in the experimental group engaged with APoKS in the first lesson and fact-finding in the second lesson on the same day, which means related contents were paired for the flow of the lessons. At the end of the second week, post-tests were applied to both control and experiment groups (see Table 3.5). Table 3.6 and Table 3.7 present the outlines of the lesson plans and computational practices, including data practices and computational practices. Appendix E presents the lesson plans.

Table 3.6. The outline of lesson plan 1.

Time	Lesson contents	Activity	Data Practices	Computational Practices
30 mins	1.APoKS and constraints	Finding evidence from the regional data and illustrating it by using LabStar	Creating Data	Decomposition
50 mins	2.Fact-finding	Searching for relevant answers for understanding the topic	Creating Data	Abstraction
30 mins	3.Ideation	Collecting local data by using Labstar	Analyzing Data, Collecting Data	Pattern recognition
50 mins	4.Product development	Using collected data and creating a report about the effects of climate change on the region	Analyzing Data, Manipulating Data, Visualizing Data	Pattern recognition, Algorithmic thinking, Abstraction
40 mins	5.Testing	Testing data and graphs, calculation of temperature changes	Analyzing Data, Visualizing Data	Pattern recognition
40 mins	6.Disseminate and reflect	Sharing the products	Visualizing Data	Abstraction, Algorithmic thinking,

Table 3.6 shows the outline of the LP1. In the first lesson hour of the implementation, the APoKS content of the lesson plan was given. First, students were introduced to the daily life problem of global warming with an example reading. The daily life problem was understanding the difference between climate and weather events as well as climate change. Then, the researcher showed visual representations and videos about the signs of climate change. Finally, students were asked to determine a research question, steps to follow, and necessary information to conduct this research. The answers of students in the 1a and 1b in the worksheet were matched with decomposition for the analysis of the question because this step included breaking down a huge problem into manageable parts to conduct research.

In the second lesson, the fact-finding content of the lesson plan was given. Students were asked to find appropriate answers to the given questions in the second part of the worksheet using the suggested sources. They were searching for relevant answers by removing unnecessary information from the selected sources, and they wrote briefly in the worksheet. For that reason, the second part of the lesson plan was matched with abstraction. Students started to collect data with LabStar™ to use in the next parts.

In the third lesson, the students were given different sets of data created by LabStar™ so that they could infer from the graphs, tables, and visual representations to explain the relationship between the data in the worksheets (see Appendix J). This part of the lesson was crucial for understanding the patterns, similarities, and differences to draw a graph in the next lesson. The questions in the third part were matched with pattern recognition in the worksheet analysis.

In the fourth lesson, students answered the questions in the worksheet to prepare their product. They were asked to remember findings and patterns from the ideation part so that they use pattern recognition practice during product development. So, the answers to the questions in the worksheets in the fourth part were matched with pattern recognition, while creating a graph was matched with algorithmic thinking and summarizing understanding for the report as an abstraction.

In the fifth lesson, the products were tested by the groups. They assessed the graph with their report by using a performance assessment rubric. In that part, they were asked to read critically the points stated in the rubric to test their product. This lesson content was matched with pattern recognition. In line with the assessment, they could improve their work. But, their first product and report were kept the same while they could improve it in the next lesson, to disseminate and reflect the content.

In the sixth lesson, every group was asked to review their products to final changes and prepare a poster presentation with their graph and report (see Appendix H). This part was matched with abstraction since they used only necessary information for summarizing their understanding. In contrast, the steps of the poster and using all of the information learned so far were matched with algorithmic thinking.

Table 3.7. The outline of lesson plan 2.

Time	Lesson contents	Activity	Data Practices	Computational Practices
30 mins	1.APoKS and constraints	Finding evidence from the graphs by interpreting and creating graphs using LabStar with the downloaded data	Creating Data	Decomposition
50 mins	2.Fact-finding	Searching for relevant answers for understanding the topic	Creating Data	Abstraction
30 mins	3.Ideation	Creating a graph by using LabStar and analysing data	Analyzing Data	Pattern recognition
50 mins	4.Product development	Using collected data and creating a report about the CO2 emissions of assigned country	Analyzing Data, Manipulating Data, Visualizing Data	Pattern recognition, Algorithmic thinking, Abstraction
40 mins	5.Testing	Testing data and graphs, running the simulation	Analyzing Data, Visualizing Data	Pattern recognition
40 mins	6.Disseminate and reflect	Sharing the products	Visualizing Data	Abstraction, Algorithmic thinking,

Table 3.7 shows the outline of the LP2. In the first lesson of the second lesson plan, the APoKS content of the lesson was given with a story and a task. The problem was the increase in global carbon emissions. The researcher showed visuals and videos. Students were asked to create a plan to achieve net zero emissions by 2050. Students worked in groups, and each group represented a country to present some possible actions and their action plan with a graph. After students read the story, countries were assigned to groups. Graphs were distributed to students before deciding on a research question (see Appendix J). Students' answers in worksheet 1 were collapsed to analyze the question.

In the fact-finding part, students were asked to find answers to given questions about carbon dioxide emissions in order to better understand the concept and to be able to include necessary parts of their research. This part was paired with an abstraction, which required students to remove details from the findings and set out the essential ones in the worksheet.

In the third lesson, the students were given the graphs of the selected countries. All the questions in the worksheet were to be answered: making inferences from the graphs, stating the trend of the graph, explaining the meaning of the trends, finding similarities and differences between the graphs of two countries, understanding the changes over time, identifying the repetitions in the graphs and making a prediction for the future plan. This step was crucial in determining the steps to be used in their product in the next lesson. The questions in this section were combined with pattern recognition to analyze the answers.

The fourth lesson was about product development. For this reason, the questions in the worksheet were asked to guide the students in producing the report and the graph. For the report, students answered the following questions: an action plan to reduce carbon emissions, the impact of population, construction, use of private cars, and the amount of waste on carbon emissions. Students were then asked to include in the report their targets for reducing carbon emissions by 2050 and, using this action plan, the possibility of achieving net zero emissions by 2100. The questions in the worksheet were associated with pattern recognition, the creation of a graph with algorithmic thinking, and highlighting the significant part of the whole lesson in the report with abstraction.

In the fifth lesson, students were asked to test their report and graph by answering questions in the worksheet, using the interactive climate tool to see the visualization of their action plan, and evaluating their report using a rubric. This lesson content was linked to pattern recognition.

In the dissemination and reflection part, all groups finalized their products and presented them with the poster presentation (see Appendix H). This part was associated with abstraction, as they used only the necessary information to summarise their understanding, whereas the steps of the poster and the use of all the information learned so far were associated with algorithmic thinking.

3.6.2.2. The Traditional Treatment. The traditional instruction was used for the control group. It was designed as structured and curriculum-based (MoNE, 2018) instruction using the textbook distributed by MoNE (2018).

In the first week, the students in the control group learned the concepts of climate and weather events through the information in the textbook. Firstly, the definitions of the concepts in the text were found. Based on these definitions, they were asked to fill in the climate vs. weather events table drawn on the board. The students were asked to say the appropriate ones from the information they found in the book. Then, the students were asked to read the activity in the book in which a dialogue between the teacher and the students was stated in speech bubbles. In this activity, the teacher asked the students to explain the difference between climate and weather events. Thus, the students repeated the difference between the two concepts. Students were given time to complete the end-of-chapter evaluation questions. In the questions, students were asked to indicate which of the sample sentences given from daily life were weather events and which were climate. Then the answers were repeated with the students. Video about climate and weather events were shown.

In the second week, climate change and the effect of greenhouse gases were covered. In this lesson, carbon emission and its effects were emphasized. Firstly, a video about climate change and carbon emissions was shown. Then, students were asked to read the definitions in the book first. Students were asked to match the definitions given on the board with the correct concept. The gaps in the definitions written on the board were completed. The reading passage about the importance of weather forecasts in our daily lives was read. Then, the students were shown graphs describing the temperature increase in Turkey in the last few decades and the increase in carbon emissions. As an end-of-lesson activity, students were asked to summarise in a few sentences about climate, weather events, climate change, and carbon emissions.

3.7. Data Analysis

3.7.1. Statistical Analysis

In order to address the research questions, the SPSS statistical program was used for all statistical analyses required during the analysis processes of the Computational Thinking Skill (CTS) Scale and the Climate Change Knowledge Test (CKT). Before the data analysis, the data were examined for each dependent variable (computational thinking skills and climate change knowledge) regarding descriptive statistics such as normality, kurtosis, skewness coefficients, and homogeneity.

Research question 1: Are there any significant differences in eighth-grade students' understanding of climate change after the intervention?

To answer the first research question, the difference between the scores of the pre and post-tests was calculated with paired samples t-test. To apply the paired samples t-test in dependent groups, it was examined whether the Climate Change Knowledge test scores within the group showed a normal distribution (see Figure 3.1 and Figure 3.2). The homogeneity of variances of scores relating to the dependent variable for each group was tested by Levene's test. In this test, if the p-value is higher than .05 ($p>.05$), the variances are regarded as homogenous (Field, 2009). To statistically check for normality, the Shapiro-Wilk test was run. The observed p-value was significant ($p> .05$). Since there is normal distribution, the paired samples t-test was used. The following results were obtained for CCKT (see Table 3.8, Figure 3.1 and Figure 3.2).

Table 3.8. The normality table of experimental group.

	N	Min	Max	M	SD	Skewness	Kurtosis
Pre-test	30	33.30	75.00	51.66	9.6	.156	.126
Post-test	30	58.30	100.00	81.95	13.0	-.410	-.847

Figure 3.1 and Figure 3.2 show the graph of normal distribution for the pre-test scores and post-test scores of the experimental group on CCKT. Since the assumption for normal distribution was met, paired sample t-test was used to compare the difference between the pre and post-scores of the experimental group on CCKT.

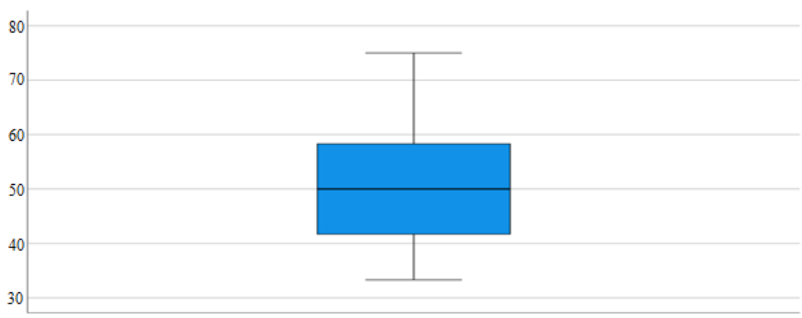


Figure 3.1. Distribution of pre-test for CCKT.

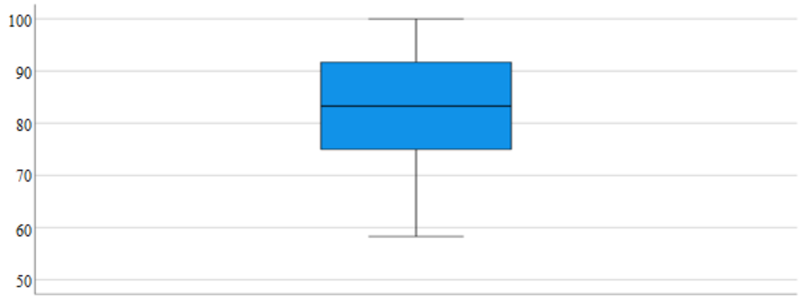


Figure 3.2. Distribution of post-test for CCKT.

Research Question 2: Are there any significant differences in eighth-grade students' understanding of climate change between the control and experimental group?

To answer the second research question, whether there is a significant difference between the post-tests of each group for the understanding of climate change was explored. In order to avoid the effect of the existing difference between the pre-test scores of the groups, the differences between the pre and post-test, which is the gain scores, were calculated. Because the data were not normally distributed for the control group, the Mann-Whitney U test was performed as a non-parametric test.

Research Question 3: Are there any significant differences in eighth-grade students' computational thinking skills after the intervention?

To answer the third research question, the normal distribution was checked. The difference between the pre and post-test scores was calculated with paired samples t-test. When one of the main assumptions of paired samples t-test as a normal distribution is violated, Wilcoxon signed ranks will be run as a non-parametric test (Pallant, 2013). To apply the paired samples t-test in dependent groups, it was examined whether the Climate Change knowledge test scores within the group showed a normal distribution (see Figure 3.3 and Figure 3.4). Pre-test scores were not normally distributed and assumptions of the paired t-test were violated. Wilcoxon signed ranks test was run as a non-parametric test. The following results were obtained for normality check (see Table 3.9, Figure 3.3 and Figure 3.4).

Table 3.9. The normality table of the experimental group.

	N	Min	Max	M	SD	Skewness	Kurtosis
Pre-test	30	43.60	94.54	77.99	13.97	-.966	.172
Post-test	30	55.45	100.00	83.69	13.38	-.823	-.342

Figure 3.3 and Figure 3.4 show the graph of distribution for the pre-test scores and post-test scores of the experimental group on CTS. Since the assumption for normal distribution was not met, Wilcoxon signed ranks test was used to compare the difference between pre and post-scores of the experimental group on CTS.

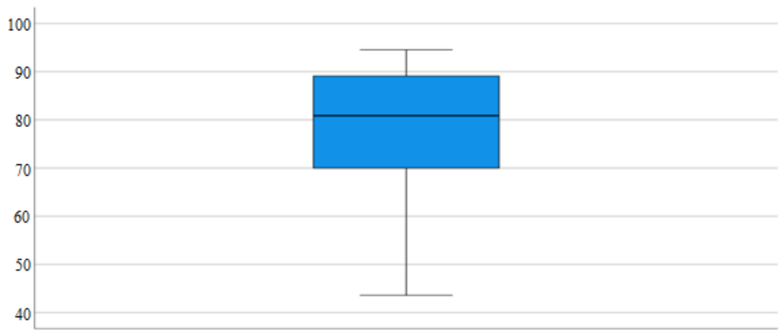


Figure 3.3. Distribution of pre-test for CTS.

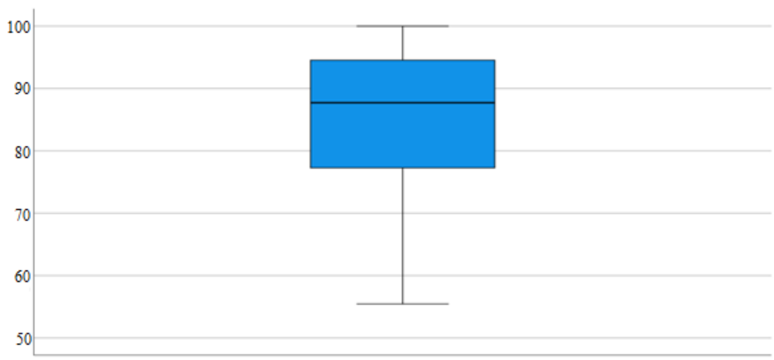


Figure 3.4. Distribution of post-test for CTS.

Research Question 4: Are there any significant differences in eighth-grade students' computational thinking skills between the control and experimental group?

To answer the fourth research question, whether there is a significant difference between the post-tests of each group for the computational thinking score was explored. In order to avoid the effect of the existing difference between the pre-test scores of the groups, the differences between the pre and post-test, which is the gain scores, were calculated. Because the test was not normally distributed, the Mann-Whitney U test was performed as a non-parametric test.

3.7.2. Qualitative Analysis

Research Question 5: Which computational thinking skills do eighth-grade students use throughout the intervention?

To answer the last research question, student worksheets and individual interviews were analyzed according to qualitative analysis techniques. Content analysis was performed to determine the existence of specific words, patterns, categories, themes, or concepts within the qualitative data (Cresswell and Cresswell, 2018). On the basis of the literature, deductive content analysis was used to construct the current study as consistent with the computational practices of Weintrop and colleagues (2016). Through interpretations and generalizations, inductive content analysis was utilized to make inferences from students' responses in order to extract concepts, patterns, or themes (Cresswell and Cresswell, 2018).

<u>3.7.2.1. Worksheet Analysis.</u> Given the analysis of computational processes in the literature, the most appropriate method for the current study was the use of open-ended questions (Tang et al., 2020). Considering the framework, the open-ended questions in the worksheets guided the students to think about the process. The answers given to the questions in every part of the worksheet as well as the end product, reflect how students use computational practices during the implementation.

All questions were linked to CT practices to assess the process. For example, in the worksheets, each part of the STEM lesson plan (i.e., ideation, fact-finding) was linked to specific CT practices. For example, in the fact-finding part, students were asked to answer the questions in the worksheet by using selected resources. By doing this, they were expected to write only related information by removing unnecessary details from the sources. This practice was matched with abstraction as a CT practice, and their level of such practice was determined by assessing students' answers for this part in line with the rubric. This rubric was developed by the researcher. While CT practices were only used for assessment of students' CT practices, the students used data practices during the courses. According to the framework, each data practice includes different CT practices, showing that both practices were paired in the framework.

For the assessment of each part of the lesson plan, Peters-Burton et al.'s (2022) rubric and Ceyhan et al.'s (2021) rubric were used to create a new rubric (see Table 3.10). Every question in the lesson parts was assessed separately. Also, the rubric was used to determine the level of the practices from 0 to 4 after calculating the average scores for all of the lesson parts for related CT practice. For instance, the APoKS part was only considered for abstraction as a computational practice, and both questions in this part were assessed separately from 0 to 4. The average score of every lesson part was determined for selected computational practices. Then, the level of computational practices was determined in line with the rubric (see Table 3.11). By doing this assessment, the researcher could understand which computational practices students were good at in which part of the lesson plans and how their progress was going during the lesson plan and between the lesson plans.

Responses were scored from 0 to 4 according to the overlapping codes from the definitions (see Table 3.10). If there were no relevant answers, the score was 0. If the students gave partially correct answers, 1 point was given. If students wrote the necessary information without explanation, the score was 2. If students included both the relevant information and explanation, but further explanation was needed, 3 points were given. Finally, 4 points were given if the relevant information, explanation, and examples were included as well as necessary connections from previous parts.

Table 3.10. The rubric used for worksheet assessment.

Score	Description
4	Correct answer with correct explanations
3	Correct answers with some explanations
2	Correct answers without explanations
1	Partially correct answer
0	Incorrect or Blank

Table 3.11 explains the categories for the lesson parts. After calculating the average score for all parts of the lesson separately, the categories were determined from level 4 to level 0. For example, if the average score in the ideation part of the lesson was 4, the level for that part was considered 4. If the average score in the fact-finding part was 1.3, the level was 1 in line with the rounding to the nearest whole number.

Table 3.11. Rubric used for determining the level.

Category	Level	Description	Average Score
Proficient (Critical) Explanation	Level 4	The explanations in general contain correct relationships and interpretations with evidence from data and elaboration	3.5 - 4
Relational Explanation	Level 3	The explanations in general contain correct relationships in data, but additional evidence is needed	2.5 - 3.5
Descriptive Answer	Level 2	The answers in general contain correctly interpreting data without stating a relationship	1.5 - 2.5
Beginning Answer	Level 1	The answers in general contain incorrect relationships or incorrect descriptions with partially correct information	0.5 - 1.5
No basis	Level 0	The answers in general contain incorrect information or blank	0.0 - 0.5

3.7.2.2. Interview Analysis. The entire data set was read and coded several times with open coding to ensure that all emergent codes and categories were identified. A rigorous external review of the data collection, analysis, and interpretation process was conducted. The researcher carried out the data analysis individually. Vertical and horizontal analyses were carried out. Then the common codes and categories were determined with the expert view. For example, the vertical internal analysis of the interview questions was done by comparing all the decomposition codes within a participant's data source to check the internal consistency of the assigned code. This process was repeated for all codes. Vertical and horizontal analysis continued until stability of the results was achieved. The reliability of the analysis was promoted. Two researchers discussed the coding of results and categories until full agreement was reached to ensure the intersubjectivity of the data and to facilitate the confirmability of the analysis. The dependability and confirmability of the codes and categories were also ensured by the researcher. Predetermined concepts were based on the computational thinking framework used to analyze the data.

3.8. Role of the Researcher

Based on the research strategy chosen for the current study, the researcher can be considered both a researcher and a teacher. In this study, computational practices were applied during the process, using the stages of the STEM Integrated Teaching Framework (ITP), and a CT tool for applying data practices was included in the intervention. There was a risk that a teacher other than the current researcher might change the process unwillingly, as the method was different from previous teaching methods in that classroom. For this reason, the researcher intervened in the teaching process. In addition, the researcher took an elective course to learn CT during her undergraduate years. During her master's degree, she participated in Bahçeşehir University BAUSTEM Center. The center also created the ITP and LabStar^{TM}, which were used in this study. In this center, the integrated STEM approach was learned, and lesson plans were developed. Therefore, the conduct of this study was influenced by the researcher's previous practical and research experiences.

3.9. Data Collection Procedures

After receiving approval from the Provincial Directorate for National Education of Edirne to conduct the study, the data of the study were gathered in November of the 2022-2023 academic year. The tests were administered to a group of eighth-grade students for pilot testing, and the lesson plans were revised in line with the implementation. The main study consisted of 60 eighth-grade students in the experimental and control groups. The implementation for both of them occurred during the science courses.

All participants in the experimental group were trained in the use of the computational tool, LabStar^{TM}, as a one-hour session prior to the study. During the implementation of the first and the second lesson plan (see Appendix E), the students worked in 5 groups with 6 students in each group. The worksheet exercises were made to help students create a report using computational practices. Students were asked to fill in the blanks in each worksheet containing questions designed with CT practices, namely abstraction, pattern recognition, algorithms, and decomposition. The framework developed by Weintrop et al. (2016), which includes the data practices of creating data, collecting data, manipulating data, visualizing data, and analyzing data, was taken into consideration when applying the computational practices associated with data science. Although the students were not given the names of the computational practices, they used all of them during the implementation. They were only aware that the lesson included data practices.

4. RESULTS

This chapter presents the results of the data analyses used to investigate the research questions. Firstly, the demographic information of the study sample is provided. Secondly, the descriptive statistics for the scores from the instruments, including range, mean, and standard deviation, are presented. Thirdly, a statistical analysis of the scores and comparison between group and within-group scores of the experimental and control groups on the computational thinking scale and the climate change knowledge test will be presented. Finally, the results of the worksheet analysis and the interview findings are presented as qualitative data.

4.1. Demographic Information

In this study, both the experimental and control groups included 30 students. There were 15 males and 15 females in the experimental group. In the control group, there were 10 males and 20 females. Among 30 students in the experimental group, one of them indicated s/he took a course about environmental education, whereas four students reported they participated in an environmental organization. On the other hand, among 30 students in the control group, none of them took a course about environmental education, whereas three of them participated in an environmental organization. For that reason, both of the groups were almost equal in the aspect of environmental knowledge before the intervention.

4.2. Descriptive Characteristics of the Participants

Totally 60 eighth-grade students participated in the study (30 control and 30 experimental). The Climate Change Knowledge Test (CCKT) and Computational Thinking Scale (CTS) were given to two groups of participants who were assigned to the control and experimental group as pre and post-test. The mean, standard deviation, minimum and maximum scores were calculated for the participants' test scores obtained from CCKT and CTS. The distribution of the total score of all students in both the experimental and control group on the pre-test were illustrated in Table 4.1, and the post-test were illustrated in Table 4.2. Table 4.1 shows the pre-test scores of students in both the experimental and control group on CTS and CCKT. The mean score of students in the experimental group was 77.99, while it was 71.43 in the control group on the CTS scale. The experimental group has a slightly higher mean score than the control group with a difference of 6.56. On the other hand, the mean score of students in the control group was 53.32, while it was 51.66 in the experimental group in CCKT. The control group has a slightly higher mean score than the experimental group, with a difference of 1.66.

Table 4.1. Descriptive statistics of the pre-test.

Instrument	**Group**	**n**	**Mean**	**SD**	**Min**	**Max**	**Range**
Computational Thinking Skill Scale (CTS)	Experimental Group	30	77.99	13.97	43.60	94.54	50.94
	Control Group	30	71.43	10.85	49.00	95.45	46.45
Climate Change Knowledge Test (CCKT)	Experimental Group	30	51.66	9.63	33.30	75.00	41.70
	Control Group	30	53.32	16.02	16.70	91.70	75.00

Table 4.2 shows the post-test scores of students in the experimental group after the CT-integrated instructions and the control group after the traditional lecture on CTS and CCKT. The mean score of students in the experimental group was 83.69, while it was 69.92 in the control group on the CTS scale. The experimental group has a higher mean score than the control group with a difference of 13.77. Also, the mean score of students in the experimental group was 81.95, while it was 60.83 in the control group in CCKT. The control group has a slightly higher mean score than the experimental group, with a difference of 21.12.

Table 4.2. Descriptive statistics of the post-test.

Instrument	Group	n	Mean	SD	Min	Max	Range
Computational Thinking Skill Scale (CTS)	Experimental Group	30	83.69	13.38	55.45	100.00	44.55
	Control Group	30	69.92	11.41	50.00	95.45	45.45
Climate Change Knowledge Test (CCKT)	Experimental Group	30	81.95	13.00	58.30	100.00	41.70
	Control Group	30	60.83	16.10	16.70	91.70	75.00

4.3. Statistical Analysis

4.3.1. Research Question 1

- Are there any significant differences in eighth-grade students' understanding of climate change after the intervention?

CCKT with true/false/don't know choices was administered to the experimental groups before and after the interventions. Throughout the lesson, activities were carried out to investigate the questions that students did not know in this test and to understand how much students could change their pre-knowledge about climate change concepts with the help of interventions. In other words, to learn whether the teaching method is sufficient to conceptual change about climate change concepts, the pre and post-test scores were compared. Comparing the pre-test and post-test scores of the students in the experimental group, all students have increased their scores.

Table 4.3 shows the paired samples t-test. The sig. value for the comparison of the pre and post-test was p=.020. Thus, the null hypothesis is rejected, and the difference between the pre and post-test is statistically significant. The score of the pre-test climate change knowledge test is lower (M=51.66, SD=9.632) than the score of the post-test (M=81.95, SD=12.97). A t-test for dependent samples showed that this difference was statistically significant, (t (29) = 13.30, p < .001, d = 2.21), 95 percent confidence interval [25.63, 34.94]. According to the means, post-test mean scores are higher than pre-test mean scores. The effect size is d=2.21 which means the effect size is very large (Cohen, 1988).

Table 4.3. Results of dependent-sample t-test of the experimental group.

	n	**Mean**	**SD**	**t**	**p**
Pre-test Experimental Group	30	29.73	13.43	12.12	.000
Post-test Experimental Group					

4.3.2. Research Question 2

- Are there any significant differences in the eighth-grade students' understanding of climate change between the control and experimental group?

Because the variances were unequal, the Mann-Whitney U test was performed to compare experimental and control groups as a non-parametric test. According to the Mann-Whitney U test, the mean ranks of the groups differ significantly on the CCKT. The post-test mean scores of the experimental group (M=81.95, SD=13.00) are significantly higher than the control group (M= 60.83, SD=16.10) on CCKT. According to Table 4.4, the gain scores of students in the experimental group have significantly higher mean ranks (42.18) than students in the control group (18.82) on the test, U = 99.5, p < .01, r = −.67, which, according to Cohen (1988), is a large effect size.

Table 4.4. Results of Mann-Whitney U test.

	Mean	**U**	**z**	**p**
Experimental Group (n = 30)	42.18	99.5	-5.220	.000
Control Group (n = 30)	18.82			
Total (n = 60)				

4.3.3. Research Question 3

- Are there any significant differences in eighth-grade students' computational thinking skills after the intervention?

The raw CTS scores were converted into categorical scores using the same methodology as Korkmaz and Xuemei (2019). The 20 categorical score was the lowest, and the 100 standard score was the highest. The scale had the following levels: Low level: 20–51; medium level: 52–67; high level: 68–100. In the pre-test of the experimental group, there were 24 high levels, 4 medium levels, and 2 low levels. In the post-test, on the other hand, there was no low level, whereas there were 25 high levels and 5 medium levels. Comparing the pre-test and post-test scores of the same students, 25 students in the experimental group increased their CT scores, while 3 students' CT scores decreased. The scores of 6 students remained the same. The score of the pre-test CTS is lower (M=77.99, SD=13.97) than the score of the post-test (M=83.69, SD=13.38).

The pre and post-test of the experimental group on the CTS test were compared to understand whether there was a significant difference between the CT skills of students. Since data were not normally distributed, the assumption for the t-test has been violated. Wilcoxon signed rank as a non-parametric test was used to compare pre and post-scores of students. 24 post-tests had higher mean ranks than pre-tests, whereas 3 pre-tests had higher mean ranks than post-test. There were 3 ties. This difference indicates the mean rank differences between pre and post-test are significant, N=30, z=-3.42, p= .001, r= -.62, a medium to large effect size (Cohen, 1988).

Table 4.5. Results of Wilcoxon Signed-rank test.

	Ranks	**n**	**z**	**p**
CTS Post-test scores- CTS Pre-test scores	Negative Ranks	3[a]	-3.424	.001
	Positive Ranks	24[b]		
	Ties	3[c]		
	Total	30		

4.3.4. Research Question 4

- Are there any significant differences in the eighth-grade students' computational thinking skills between the control and experimental group?

Because the variances were unequal and the assumptions for normal distribution were violated, the Mann-Whitney U test was performed as a non-parametric test to compare experimental and control groups' CT skills. The post-test mean scores of the experimental group (M=83.69, SD=13.38) have significantly higher than the control group (M= 69.92, SD=11.41) on CTS. The mean ranks of the groups differ significantly on the computational thinking skills test. According to the Mann-Whitney U test, students in the experimental group have significantly higher mean ranks (41.93) than students in the control group (19.07) on the test, $U = 107.0$, $p < .01$, $r = -.66$, which, according to Cohen (1988), is a large effect size.

Table 4.6. Results of Mann-Whitney U test.

	n	**Mean**	**U**	**z**	**p**
Experimental Group	30	41.93	107.0	-5.078	.000
Control Group	30	19.07			
Total	60				

4.4. Qualitative Analysis

4.4.1. Research Question 5

- Which computational thinking skills do eighth-grade students use throughout the intervention?

As seen above, when the CCKT and CTS tests of the students were compared, the experimental group's results were found significant. In order to determine the skills in the process, 2 worksheets were analyzed, and the interview results of 6 students were examined. First, the lesson plan analysis and then the interview analysis were given below.

4.4.1.1. Worksheet Analysis. The fifth research question was about the CT skills that students used throughout the intervention. To answer this question, students' performance on the worksheets in each step for each question was assessed to understand their level of computational practice and learning progression on climate change concepts. Students' CT skills for this part were assessed as a group, as STEM lesson plans include task sharing and group work. Students were randomly assigned to each group. The graphs to be interpreted were distributed specifically to each group to avoid copying the explanations of other groups. Two worksheets were qualitatively assessed using a rubric developed by the researcher. The expert view was obtained throughout the rubric development and data analysis parts. Table 4.7 shows the description of the scores in the rubric as well as examples of participants' responses. Each lesson plan included the same steps as mentioned in the ITP (i.e., ideation, fact-finding). Each step in the lesson plan was paired with a computational exercise through questions. Open-ended questions in these steps were scored separately according to the rubric (see Table 4.7). The average score for each step was used to determine the students' level of computational practice in each step (i.e., ideation, testing) for qualitative analysis. Table 4.7 shows examples from the worksheets to illustrate how responses were scored.

Table 4.7. Rubric for worksheet analysis.

Score	**Description**	**Example from worksheet 1**	**Example from worksheet 2**
4	Correct answer with correct explanations	Group 2: “I collect annual and daily air temperatures. I look at the differences between the past and the present and see whether this weather phenomenon is constant on average or whether it varies continuously.” (Yıllık ve günlük hava sıcaklıklarını toplarım. Geçmiş ve şimdiki zamanın farklarına bakarım. Bu hava olayı ortalama olarak sabit midir ya da sürekli değişkenlik mi gösterir bakarım.)	Group 5: “The similarities in the carbon emission graphs of different countries are mostly the increase in carbon emissions. The differences are that it remains constant for a while in Switzerland but not in Turkey.” (Farklı ülkelerin karbon emisyon grafiklerindeki benzerlikler çoğunlukla karbon emisyonunun artmasıdır. Farklılıklar ise Switzerland’da bir süre sabit kalıp Türkiye’de kalmamasıdır.)
3	Correct answer with some explanations	Group 5: “Once we have done some research and gathered the data, we will compare and interpret them all.” (İlk biraz araştırma yapıp verileri toparladıktan sonra hepsini karşılaştırıp yorumlarız.)	Group 3: “There are ups and downs between countries. This may be because the country is developing or not.” (Ülkeler arasında iniş çıkışlar vardır. Bunun sebebi ülkenin gelişip gelişmemesi olabilir.)

Table 4.7. Rubric for worksheet analysis (cont.).

Score	Description	Example from Worksheet 1	Example from worksheet 2
2	Correct answer without explanations	Group 1: “Increased at different rates.” (Farklı oranlarda artış göstermiştir.)	Group 5: “Population affects negatively.” (Nüfus kötü etkiler.)
1	Partially correct answer	Group 4: “I look it up on Wikipedia.” (Wikipedia’dan bakarım.)	Group 3: “ The fixed lines were the same, there were no emissions during these dates and they continued to increase at a constant rate.” (Sabit çizgiler aynı olduğunu, bu tarihlerde emisyon olmamış ve sabit oranda artmaya devam etmiş.)
0	Incorrect or Blank	Group 1: “Yes. Temperatures change, it demonstrates climate change.” (Evet. Sıcaklıklar değişir bu iklim değişikliğini ispatlar.)	Group 3: “It affects positively.” (Olumlu etkiler.)

The 6 steps of the STEM lesson plan were matched with different computational practices. But, product development and disseminate and reflect parts of the worksheets include more than one computational practice. In the worksheets created by considering ITP, each step includes questions of varying levels of difficulty. For instance, the questions in the APoKS and fact-finding are easier to answer than ideation and product development which includes data analysis. Also, after creating a product on the product development part, it was easier to answer questions on testing parts. Due to this, the content cannot be used to examine how the same computational practices develop over the course of this study. Thus, each step of the lesson plan was assessed separately in terms of the level of computational practices. The levels were determined according to their suitability to the desired answer in that section.

In this section, STEM lesson plan steps were evaluated separately. Below, the analysis of six steps which were APoKS, fact-finding, ideation, product development, testing, and disseminate and reflect parts, were shown by giving the scores with examples from students' responses and average scores of the computational practices.

The first step in the STEM lesson plans was APoKS, which requires the introduction of a real-life problem. In LP1, the problem was climate change due to the increase in global temperatures. In LP2, the problem was human-induced carbon emissions. The students were asked to create a research plan and define the necessary information to show the differences between weather events and climate change in LP1 and to create a carbon emission plan in LP2.

Table 4.8 shows examples from students' responses. The sample question was about the steps to research climate and weather events. Group 3 got 4 points because they explained the research process with enough explanations, from researching similar studies to visualizing data, which were also included in the lesson plan activities. Group 5 got 3 points because although they explained what they should do for the research, they need to explain more about how they will interpret and reflect at the end of the research. Group 1 mentioned the lower-level research process because they only mentioned writing similarities and differences on a table, which was already used in traditional lectures. They did not mention the research process other than highlighting differences between definitions. They got 2 points because some explanation is required. Group 4 got 1 point because they only stated that they would look at Wikipedia, which is not a credible source. Their answer could be accepted as partially correct.

Table 4.8. Example student responses (APoKS).

Decomposition		
Sample Question	**Score**	**Examples from Worksheet 1**
1.a. If you were asked to do a research on climate and weather events, how would you start your research?	4	Group 3: "After deciding on the subject and field of the research, I would examine the related similar researches and make notes. Based on the notes, I would create a draft for myself. Then I would support my notes and draft by doing research myself. I would make graphs from the data on the subject, I would support the research visually." (Araştırmanın konusunda ve alanına karar verdikten sonra ilgili benzer araştırmaları inceler, notlar çıkarırdım. Notlardan yola çıkarak kendime bir taslak oluştururdum. Sonra kendim araştırmalar yaparak notlarımı ve taslağı desteklerdim. Konu hakkındaki verilerden grafikler çıkarır, araştırmayı görsel olarak desteklerdim.)
	3	Group 5: "Once we have done some research and gathered the data, we will compare and interpret them all." (İlk biraz araştırma yapıp verileri toparladıktan sonra hepsini karşılaştırıp yorumlarız.)
	2	Group 1: "I write the definition of climate and weather events. I table their common aspects and non-common aspects." (İklim ve hava olaylarının tanımını yazarım. Ortak yönlerini ve ortak olmayan yönlerini tablolarım.)
	1	Group 4: "I look it up on Wikipedia." (Wikipedia'dan bakarım.)

To determine the level of computational practices, the average scores for each lesson step were assessed. In the APoKS part of Lesson Plan 1 (LP1), the decomposition levels of groups were listed in Table 4.9 from group 1 to group 5 as 3, 4, 4, 2, and 3 respectively. In Lesson Plan 2 (LP2), levels were 3, 4, 3, 1, and 2. In the APoKS part, the lowest level was 1, whereas the highest level was 4. Except for group 4 and group 5, they are mostly at level 3 and level 4.

Table 4.9. Average scores for decomposition in the APoKS.

Decomposition	**APoKS**									
	Group 1		Group 2		Group 3		Group 4		Group 5	
	LP 1	LP2	LP 1	LP2	LP 1	LP2	LP 1	LP2	LP 1	LP2
	Level 3	Level 3	Level 4	Level 4	Level 4	Level 3	Level 2	Level 1	Level 3	Level 2

Group 1 and Group 2 were at the same level within the group in LP1 and LP2, whereas Group 3, Group 4, and Group 5 were at a higher level in LP1 for decomposition. It shows that groups might decrease their level in another topic depending on the questions. On the other hand, Group 4 had the lowest levels in the decomposition. They might have problems breaking down the complex problem into manageable steps for an unfamiliar topic. The topic in LP1 was climate and weather events, whereas the topic in LP2 was carbon emissions. Students can predict research steps for the former, but the latter is not predictable for most students. This situation shows that the decomposition practices of the groups may be different in the APoKS step of two different lesson plans depending on whether they are familiar with the topic or not. To conclude, the average decomposition level for APoKS was 3, which indicates students showed high skills in relational explanation of dividing problems into manageable parts.

The second part of the lesson plan was fact-finding, which involved briefly answering the questions about the problem and concepts by removing unnecessary information from useful resources. In this part, it is important to answer the specific questions correctly. For that reason, it differs from other parts of the lesson plan, which require explanation and examples from data.

Table 4.10 shows students' responses to the definition of climate change. Students were expected to highlight dramatic changes in average weather conditions over several decades or longer. This definition would contribute to students' understanding that it is the longer-term trend differentiating climate change from natural weather events at the end of the lesson. In this section, since the students searched the answers on the internet and tried to answer the questions most shortly and descriptively, in the high-level score, the answers were evaluated according to the fact that they included all the words that should be in the definition rather than explaining relationships.

There were some keywords to define climate change, so students were expected to use the required words for the answer to the sample question. Group 3 got 4 points because they used the most important words for defining climate change, which were "changes in average" and "over decades". Also, they are aware that climate change can occur due to humans and natural causes. This definition was the closest answer to the expected answer. Group 2 also gave the definition and got the 3 points, but they did not mention that changes should be over decades to define the changes in average temperatures as a climate change. Group 4 mentioned the causes of the change as various reasons, but they did not explain the reasons for acceptable answers, so they get 2 points. Group 5 had a misconception about what climate change is because the anomalies in weather events do not directly indicate climate change.

Table 4.10. Example student responses (fact-finding).

Abstraction		
Sample Question	**Score**	**Examples from Worksheet 1**
2.b. What is climate change?	4	Group 3: "Changes in the average state or variability of climate over decades or longer due to human-induced or natural causes." (İnsan kaynaklı veya doğal nedenlerle iklimin ortalama durumunda veya değişkenliğinde onlarca yıl ya da daha uzun süre boyunca gerçekleşen değişiklikler.)
	3	Group 2: "Climate change is the increase or decrease in average temperature caused by humans." (İklim değişikliği, insanların neden olduğu ortalama sıcaklık artışı veya düşüşü.)
	2	Group 4: "Changes in climate over time due to various reasons." (İklimin zaman içinde çeşitli sebeplerle değişmesi.)
	1	Group 5: "It is colder or warmer than normal." (Normale kıyasla daha soğuk ya da daha sıcak olmasıdır.)

In the fact-finding part of the LP1, abstraction levels were listed in Table 4.11 from Group 1 to Group 5 as 4, 4, 4, 3, and 3, respectively. In LP2, levels were 3, 4, 3, 4, and 3. It demonstrates that students got level 3 and level 4 in the fact-finding part. Group 2 and Group 5 were at the same level within the group in LP1 and LP2. Group 4 increased their level from 3 to 4, whereas Group 1 and Group 3 decreased their level from 4 to 3 between the two lesson plans. In this step, the reason why some students' levels dropped in the second lesson plan may be due to the fact that they answered questions on a subject they were not familiar with. In general, there is no level below 3, which indicates that the student's ability to find the answers to the questions from the sources is high. This may be due to the fact that at the end of the traditional lectures, success is measured with open-ended questions. Overall, the average level for fact-finding was 4. The levels of the groups in the fact-finding part were proficient (see Table 3.11), which means they completed the process successfully by reducing complexity to define the main idea.

Table 4.11. Average scores for abstraction in the fact-finding.

Abstraction	**Fact-finding**									
	Group 1		Group 2		Group 3		Group 4		Group 5	
	LP 1	LP2	LP 1	LP2	LP 1	LP2	LP 1	LP2	LP 1	LP2
	Level 4	Level 3	Level 4	Level 4	Level 4	Level 3	Level 3	Level 4	Level 3	Level 3

The third part of the lesson plan was ideation, which included questions about comparing data sets, finding patterns, making sense of the patterns, and developing ideas before creating a product. Questions in this part required explanations with examples from the data to understand similarities and differences. In this part, students who had begun to analyze data were asked to demonstrate how well they could explain relationships between concepts using data. But, giving examples from data without explanation was not a complete answer for this part of the lesson plan since the researcher would assess students' explanations of the data. In LP1, the data included the average temperature graphs, which belong to different cities in Turkey, created by LabStar^{TM}. Also, there were some regional data and graphs from weather events and climate to do comparisons. The aim was to compare different data and prepare for using collected data in the product development part. In LP2, the data included the carbon emissions from different countries created by LabStar^{TM}.

The sample question was about using the average temperatures of the region to understand the concept of climate. Table 4.12 shows the students' responses to explain the data with average temperatures from different cities in the same region. Group 3's explanation was acceptable as 4, with explanations of the differences and similarities of regional data. However, Group 5 only gave an example from the data rather than an explanation of the data, which equals 2 points. The explanation is not enough to answer a question in the Idea part, because the relationships and trends are important in this part. The answer contains only descriptive data, but there should be explanations of the data. Group 2 made a comparison between two cities from the data, but they used the concept of climate for the data, which includes weather events. This response showed the students' misconception about the use of climate concepts. Although three cities have the same climate as a region, they said the climate of Istanbul and the climate of Edirne. Although their description is partially correct, the misconception meant that the answer was not accepted as fully correct. Also, none of the groups got 3 points in this part. Students either answer the questions in this section completely correctly or give incomplete answers without explanation. The reason might be that although they know the definitions and differences of the concepts, they might not be able to answer correctly the questions that require comparison. Students may find it difficult to write the expected explanations. Students are not used to explaining concepts with data. So the students answered some questions in the idea part with higher scores.

Table 4.12. Example student responses (ideation).

Pattern recognition		
Sample Question	**Score**	**Examples from Worksheet 1**
3.c. What can you conclude when you examine the average temperatures of the provinces in the Marmara Region in September according to years? Explain with justification.	4	Group 3: "When we look at the temperature values of different provinces of Marmara, it is understood that the temperature values are close to each other. In other words, we understand that climates are formed regionally. Different climates occur in different places. But the climate of that region is the same. This can only change with global warming." (Marmara'nın farklı illerinin sıcaklık değerlerine baktığımızda sıcaklık değerlerinin birbirine yakın olduğu anlaşılır. Yani bölgesel olarak iklimlerin oluştuğunu anlarız. Farklı yerde farklı iklimler oluşur. Ama o bölgenin iklimi aynı olur. Küresel ısınmayla ancak bu değişir.)
	2	Group 5: "The city with the highest temperature in September is Edirne with 23.7 degrees." (Eylül ayında en fazla sıcaklığa çıkan şehir 23.7 dereceyle Edirne'dir.)
	1	Group 2: "The climate of Edirne is warmer than the climate of Kırklareli and also the climate of Istanbul is warmer than the others." (Edirne iklimi Kırklareli'nin ikliminden daha sıcaktır ve ayrıca İstanbul iklimi diğerlerinden daha sıcaktır.)

In the ideation part of the LP1, pattern recognition levels were listed in Table 4.13 from group 1 to group 5 as 2, 3, 3, 2, and 2, respectively. In LP2, levels were 2, 4, 2, 3, and 4. The levels for pattern recognition were changing between 2 and 4. This result reflects that students do not have the highest level of pattern recognition, which requires identifying, clustering, and modularizing steps as well as finding repeated sequences to analyze the data. On the other hand, the lowest score was 2, which is better than decomposition in the first part. The average level for pattern recognition in the ideation part was 3, which means students show relational explanations by finding similarities, differences, and trends in data.

Table 4.13. Average scores for abstraction in the ideation.

Pattern Recognition	**Ideation**									
	Group 1		Group 2		Group 3		Group 4		Group 5	
	LP 1	LP2	LP 1	LP2	LP 1	LP2	LP 1	LP2	LP 1	LP2
	Level 2	Level 2	Level 3	Level 4	Level 3	Level 2	Level 2	Level 3	Level 2	Level 4

During the transition from the first to the second plan, group 3 decreased its level, while group 2, group 4, and group 5 increased it for ideation part. Group 1 remained at the same level. This may be due to the students' general misconception of the concepts of climate, weather events, and climate change in LP1. Therefore, it may have been more difficult for them to understand the difference between these concepts in the graphs in LP1. The difference between the trends in carbon emissions may be easier to recognize as LP2 focuses on a single concept. It is also possible that they progressed more easily in this part of LP2 because they understood how to follow a path in LP1. In general, when compared to the fact-finding part, students have a lower level in LP1 and LP2. For the ideation part, they were expected to write correct relationships and interpretations by using data and evidence. For that reason, the level of difficulty of the ideation part is higher than the other two parts of the lesson plans.

The fourth part of the lesson was product development, which involved briefly answering the questions to identify the human activities responsible for the increase in greenhouse gases in the atmosphere in recent decades and to discuss how they affect carbon emissions. In this part, there were three tasks to complete including different types of questions that were answering the open-ended questions (pattern recognition), creating a report (abstraction), and drawing a graph (algorithmic thinking). Every task was assessed separately. Firstly, students were expected to identify the patterns or examples from the previous parts to answer the questions about actions that increase carbon emissions. Secondly, they were asked to write a report on their understanding so far. Finally, they were expected to draw a graph to suggest future projections for carbon emissions by supporting the precautions written in their reports. Table 4.14 indicates the responses to the question about the effects of waste on carbon emissions with scores. The expected answer to the question was that more solid waste produces more methane, which directly contributes to the release of greenhouse gases. However, students only research the fact-finding part of the lesson, so they were not expected to answer completely correct. Both in ideation and product development, students would use their pattern recognition practice to answer the questions in product development. The main idea of pattern recognition is to detect, group, and modularize repetitive procedures.

According to Table 4.14, the sample question requires an explanation of the effect of the amount of waste on carbon emissions. Group 1 answered that the amount of waste increases carbon and pollutes the environment. Although this explanation does not include any additional explanation, it was acceptable for this part as it scored 4 points. Group 2 mentioned the excessive amount as having a negative impact on the global climate, but they did not explain the negative impact required for this question. Group 2 was therefore awarded 3 points. Group 4 got 2 points because they only mentioned that the amount had a negative impact. They should include carbon emissions or global climate change to show the relationship. There is no point 1 for the sample question because students' answers were correct in general.

Table 4.14. Example student responses (product development).

Pattern recognition		
Sample Question	**Score**	**Examples from Worksheet 2**
4.e. How does the amount of waste affect carbon emissions? Explain.	4	Group 1: "The amount of waste increases carbon and pollutes the environment." (Atık miktarı karbonu artırır hem de çevreyi kirletir.)
	3	Group 2: "Excessive amounts of waste material have a negative impact on global change." (Fazla atık madde miktarı küresel değişikliği olumsuz etkiler.)
	2	Group 4: "The amount of waste has a negative effect." (Atık miktarı kötü etkiler.)

In the LP2, even though students' answers met the requirements of the rubric, they generally responded to the same ideas both in this question and other questions in this part. It suggests that in order to provide persuasive reports on carbon emissions, students need to improve their products. For that reason, in the next lesson part, which is testing, students would assess their product and make improvements by using a simulation tool.

In the LP2, the creation of a report outlining the limitations for the nation's carbon emissions was the second type of question in the product development part. Students were asked to assess what knowledge was essential to completing their task and what was unnecessary to answer this question. Since the report requires summarizing what they have learned by taking the answers that are necessary from the different parts of the lesson, students filtered the extra information to answer this question. Table 4.15 shows students' answers for product development by using abstraction. Since students were asked to include only significant information, some students did not include an explanation of the action plan in their reports. It shows that students regarded explanations as unnecessary in the abstraction practice. For that reason, their answers were similar to each other, and most of them got 2 points on this question. However, to get the point 4 from the creation report, they were expected to briefly explain what they have learned so far with the necessary explanations. The group either wrote necessary explanations or did not write any explanations. Group 5 included the necessary precautions with the reason, so they got 4 points. Group 4 wrote only the precautions without explanation, so they got 2 points. On the other hand, Group 1 wrote information from the introduction but did not write any precautions and explanations, which they were asked to include.

Table 4.15. Example student responses (product development).

Abstraction		
Sample Question	**Score**	**Examples from Worksheet 2**
4.h. Write a report including action plan based on the information you learned in the lesson, what was discussed in the group discussions and your evaluations.	4	Group 5: “Filters can be installed in the factory chimneys to reduce the CO2 rate as in the table. Electric vehicles can be built instead of gasoline vehicles. We can avoid cutting down trees unnecessarily. Renewable energy sources can be made instead of coal. We must ensure that factory waste flows to other places instead of the seas. We should warn people about throwing garbage on the ground.” (Tablodaki gibi CO2 oranını azaltmak için fabrika bacalarına filtre takılabilir. Benzinli araçlar yerine elektrikli araçlar yapılabilir. Gereksiz ağaç kesimini önleyebiliriz. Kömür yerine yenilenebilir enerji kaynakları yapılabilir. Fabrika atıklarının denizler yerine başka yerlere akmasını sağlamalıyız. İnsanları yerlere çöp atma konusunda uyarmalıyız.)
	2	Group 4: “Reducing the use of coal, increasing the use of electric vehicles, reducing public transport.” (Kömür kullanımını azaltmak, elektrikli araç kullanımını arttırmak, toplu taşıma araçlarını azaltmak.)
	1	Group 1: “In the 1900s, there was a significant increase in human-induced carbon emissions.” (1900lü yıllarda insan kaynaklı karbon salımında ciddi artışlar olmuş.)

The third type of question in the product development part was drawing a graph to show future projections for carbon emissions in their country. Table 4.16 shows the description of scores for assessing students' graphs created in the product development step of the lesson plans. Drawing graphs was matched with algorithmic thinking since this practice requires the analysis of data and defining a process by using a series of steps. The rubric used for assessing open-ended questions in the worksheets (see Table 4.7) was adapted to the graph assessment and created a new rubric for this question (see Table 4.16). A correct graph includes the title (offers a short explanation of the graph), the label of the x-axis and y-axis (offers which data you include), equal intervals (writing continuous sets of real numbers on the graph), and data (the information that the graph contains). Graphs were scored from 0 to 4.

The graphic analysis took into account the ability to explain a concept with the graph (i.e., climate change, weather event, climate or carbon emissions), writing the components of the graph, its relevance to the previous graphs, and the rules for drawing graphs. 4 points if the graph contains all of the necessary steps given above, 3 points if it can explain the concept but some components are missing, 2 points if the graph components were not specified but a concept was partially explained, 1 point if a partially correct graph was created but the graph was insufficient to explain a concept covered in the lesson plans, 0 points if it was blank or incorrect.

Table 4.16. Rubric used for assessing the graphs.

Score	**Description**
4	Correct drawing with correct components and heading, explain a concept
3	Correct drawing with some correct components, explain a concept
2	Correct drawing without components or partially explain a concept
1	Partially correct drawing/ not enough to explain a concept
0	Incorrect or Blank

Table 4.17 shows examples from students' worksheets with scores in LP1, and Table 4.18 shows examples from students' worksheets with scores in LP2. According to Table 4.17, group 4 got the highest score with the graph to explain the climate change concept, including the heading, graph components, and the drawing in accordance with the sample graph. It shows that they were good at algorithmic thinking in product development for LP1. Group 2, on the other hand, drew a weather event graph with the drawing in accordance with the collected data, but they included graph components in the graph rather than on the y-axis. Group 1 only drew a graph without any components. Since it explains a concept, it was regarded as acceptable. Group 5 got 1 point because their graph was not completed to explain any concepts in the questions, which means the graph was partially correct.

Table 4.17. Example student responses (product development) in LP1.

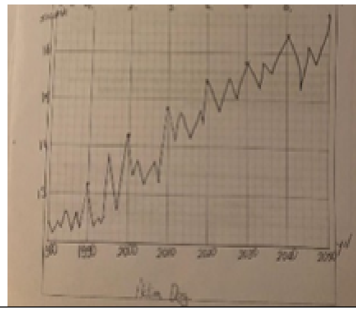
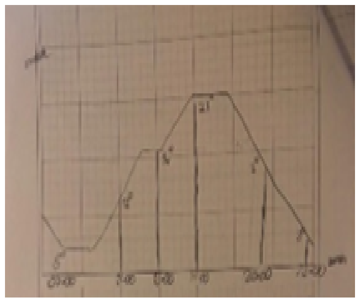
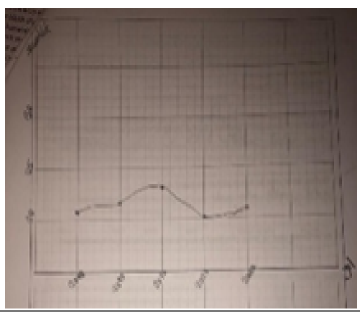
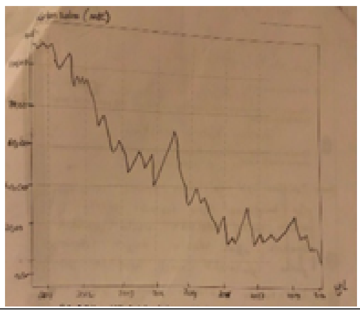
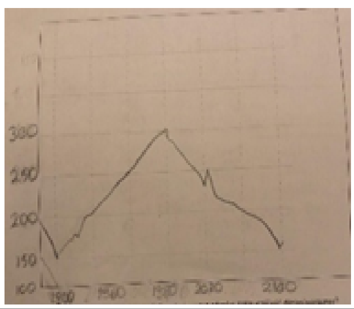
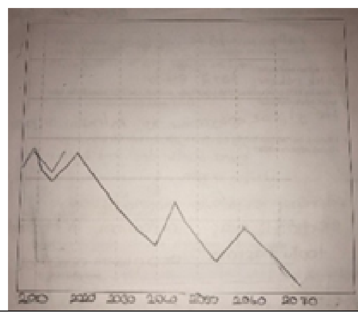
Algorithmic Thinking		
Sample Question	**Score**	**Examples from Worksheet 1**
4.e. Create your graphs explaining at least two of the concepts of climate, weather events or climate change.	4	Group 4: 
	3	Group 2: 
	2	Group 1: 
	1	Group 5: 

Table 4.18 indicates the graphs created by students during the product development part of the LP2 with scores. In this graph, the trends in future projections were significant to represent. Students used algorithmic thinking during drawing their graph because the process requires to create of a series of defined steps like analyzing given data, determining components to create a graph, writing headings for graphs, placing the data correctly, and meaningful trends in the graphs, and being related to previous graphs or data.

Table 4.18. Example student responses (product development) in LP2.

Algorithmic Thinking		
Sample Question	**Score**	**Examples from Worksheet 1**
4.i.In line with the measures, show your projections for the future carbon emission level of your country by drawing graphs.	4	Group 5: 
	3	Group 1: 
	2	Group 4: 

In the product development content of the LP1 and LP2, levels were listed in Table 4.19 from Group 1 to Group 5. In LP1, the lowest level was 3 for pattern recognition, 1 for algorithmic thinking, and 3 for abstraction. In LP2, the lowest level was 2 for pattern recognition, 2 for algorithmic thinking, and 1 for abstraction. The highest level was 4 for three of the computational practices in both LP1 and LP2. The average level for pattern recognition, algorithmic thinking, and abstraction was 3, which means students generally used relational explanations.

Table 4.19 shows that Group 2, Group 3, and Group 4 lowered their levels in the second plan for pattern recognition. Group 1 increased its level, while Group 5 remained stable. In LP1, the emphasis was more on presenting a report with a graph, whereas in LP2, students were expected to explain the precautions that could be taken and the effects of these measures. However, as students did not provide a sufficient explanation in their answers, they were at a low level in LP2 for pattern recognition practice.

The drawing a graph task was new for students in LP1, so they were lower lever except for Group 2 and Group 5. However, in LP2, Group 1 and Group 4 increased their level of algorithmic thinking, while other groups remained at the same level. In the second plan, it was observed that the level of pattern recognition decreased.

In the abstraction part, students generally tend to write answers without explanation. The abstraction also became lower level since they did not include necessary information on open-ended questions in this part. To conclude, students were not good at explanations for creating a report if there were no representations to explain, whereas they could use data to write the explanation of the graph in LP1 in abstraction. In the second plan, the report focused on precautions and reasons for carbon emissions that students are unfamiliar with. If they did not look for the necessary information in the fact-finding part to use in the next parts, their scores showed the missing information even though they got enough points on the fact-finding part. It shows the effect of the algorithmic thinking process throughout the lesson plans to support the level of practice. For that reason, Group 1, Group 2, Group 3, and Group 4 decreased their level in LP2, whereas Group 5 remained at the same level.

Table 4.19. Average scores in the product development.

Product Development										
	Group 1		Group 2		Group 3		Group 4		Group 5	
	LP 1	LP2	LP 1	LP2	LP 1	LP2	LP 1	LP2	LP 1	LP2
Pattern Recognition	Level 3	Level 4	Level 4	Level 3	Level 4	Level 2	Level 4	Level 3	Level 3	Level 3
Algorithmic Thinking	Level 2	Level 3	Level 4	Level 4	Level 2	Level 2	Level 1	Level 2	Level 4	Level 4
Abstraction	Level 3	Level 1	Level 4	Level 2	Level 4	Level 2	Level 4	Level 2	Level 4	Level 4

Moreover, in the product development part of the second lesson plan, the students were asked to explain the effects of population, construction, use of vehicles, and amount of waste on carbon emissions. However, it was observed that the students gave similar answers to these questions, even if their answers were correct. The originality of the reports they create using this information would be low. Therefore, a new testing tool was presented to the students. They were expected to develop their answers.

The fifth part of the lesson was testing, which included critically reviewing the current product and comparing this product to specific criteria using pattern recognition practice. In LP1, the questions were about the trends in the data for the last decade in the current region and the trends in the data for different cities. In LP2, the questions were about the precautions taken to prevent carbon emissions in the country, the global contribution of the report, the impact of the report on achieving zero emissions, and the possibility of achieving zero emissions. According to Table 4.20, in the testing part, Group 3 gave short answers and got 2 points for all questions in the LP1. Group 4 got 3 points because they explained why they stated no difference. Group 2 got 4 points because they stated the explanations with reasons.

Table 4.20. Example student responses (testing).

Pattern Recognition		
Sample Question	**Score**	**Examples from Worksheet 1**
5.b. When you compare your graph with the data of the last 10 years, can you see a significant difference in the climate of your region? Explain.	4	Group 2: "Yes. According to our graph, temperatures are higher in November. In other words, the climate of our region will change and there will be hotter summers and winters without precipitation." (Evet. Bizim grafiğimize göre kasım ayında sıcaklıklar daha yüksek. Yani bulunduğumuz bölgenin iklimi değişecek daha sıcak yazlar ve kışlar yağışsız mevsimler olacak.)
	3	Group 4: "The data is similar. So there is not much difference." (Benzer veriler olduğu için çok fark yok.)
	2	Group 3: "It has increased continuously." (Sürekli artmış.)

In the testing part of the LP1 and LP2, students were asked to assess their products by answering the questions. In LP1, pattern recognition levels were listed in Table 4.21 from group 1 to group 5 as 2, 4, 2, 3, and 3, respectively. In LP2, scores were 2, 3, 4, 2, and 3. The highest level was 4, whereas the lowest level was 2 in both LP1 and LP2. The average level for pattern recognition was 3, which means students generally used relational explanations to test.

According to Table 4.21, as the students started to write shorter answers, a lower-level score was obtained in the testing part. Even though they seem to be at a low level for pattern recognition, when considered as an algorithmic process throughout the course, the product has been improved thanks to the testing part. Especially for LP2, with the climate interactive tool, students included explanations and additional information. Group 1 and Group 5 remained at the same level. Group 2 and Group 4 decreased their level, while Group 3 increased the level from 2 to 4, which was the highest level in LP2 in the testing part. The results show that intragroup consistency was not observed in the testing part. According to the question, the groups gave answers on different scores.

Table 4.21. Average scores for pattern recognition in the testing.

Testing										
	Group 1		Group 2		Group 3		Group 4		Group 5	
	LP 1	LP2	LP 1	LP2	LP 1	LP2	LP 1	LP2	LP 1	LP2
Pattern Recognition	Level 2	Level 2	Level 4	Level 3	Level 2	Level 4	Level 3	Level 2	Level 3	Level 3

The last part of the lesson plan was disseminate and reflect, which required the presentation of the products developed during the lessons. In this part, students were expected to use abstraction to summarize and elaborate on what they had learned and algorithmic thinking to create a poster that included the necessary steps from the lesson parts. Students created a poster using algorithmic thinking to include the most important parts of the lessons by explaining the concepts and using a series of explanations from the lesson. Since what has been done throughout the process should be brought together in algorithmic thinking practice, it is necessary to evaluate the explanations and information obtained from all the steps separately. Then, the separate steps are expected to form a whole. In this part, students' posters (see Appendix H) were assessed using the codes from explanations in the lesson parts (see Appendix G). After the codes were determined, all lesson parts (i.e., ideation and pattern recognition) were assessed separately using the same rubric throughout the worksheet analysis (see Table 4.7). For example, in LP1, posters were expected to include explanations and information from APoKS, fact-finding, ideation, and product development parts. All parts were assessed with the rubric (see Table 4.7), then the average score was determined as the algorithmic thinking score. The same process was done for LP2 after including the testing part for assessment. Therefore, in LP2, posters were expected to include explanations and information from APoKS, fact-finding, ideation, product development, and testing.

In the disseminate and reflect part in LP1, abstraction levels were listed in Table 4.22 from Group 1 to Group 5 as 2, 4, 3, 4, and 4, respectively. In LP2, scores were 4, 4, 2, 4, and 2. The lowest level was 2, whereas the highest score was 4 in both LP1 and LP2. Group 2 and Group 4 had the highest abstraction level in lesson plans. The average level for abstraction was 3. Secondly, in LP1, algorithmic thinking levels were listed in Table 4.22 from Group 1 to Group 5 as 3, 3, 3, 2, and 3, respectively. In LP2, scores were 3, 4, 3, 2, and 3. The lowest level was 2, whereas the highest score was 4 in both LP1 and LP2. Group 2 had the highest level in LP2, whereas Group 4 had the lowest algorithmic thinking level in both lesson plans. The average level for algorithmic thinking was 3, which means students used relational explanation.

Table 4.22. Average scores in the disseminate and reflect.

Disseminate and Reflect										
	Group 1		Group 2		Group 3		Group 4		Group 5	
	LP 1	LP2	LP 1	LP2	LP 1	LP2	LP 1	LP2	LP 1	LP2
Abstraction	Level 2	Level 4	Level 4	Level 4	Level 3	Level 2	Level 4	Level 4	Level 4	Level 2
Algorithmic Thinking	Level 3	Level 3	Level 3	Level 4	Level 3	Level 3	Level 2	Level 2	Level 3	Level 3

The codes obtained from posters for each group are similar to the questions in the worksheet (see Appendix G). These codes help to decide which codes come from which steps of the lesson plan to give scores for information in the posters. The analysis supports the idea that computational practices develop students' deeper understanding of a concept in order to create a product. In the poster analysis, apart from codes, the levels were determined by using a rubric. For LP1, students were expected to include what they consider significant from APoKS, fact-finding, ideation, and product development in the poster. The information taken from the different steps (i.e., ideation, fact-finding) was assessed with the same rubric used throughout the lesson plans. After determining a score for four different steps, the average score was calculated, and the level was determined. In LP2, students were expected to include information from APoKS, fact-finding, ideation, product development, and testing parts. In LP2, the testing part was included because they developed a poster in line with the climate interactive tool. Each step was scored using a rubric, and the average score was calculated to determine the level. Except for Group 4, all groups created higher-level posters, which means that the instructional steps complete the development of the product at the end by improving algorithmic thinking (see Table 4.19).

Overall, groups received points at different levels for the same computational practices in different lesson plans. This was an expected result as practices require answering questions using specific computational practices at each step of the lesson plan. It was also expected that the same computational practice would appear at different levels for different lesson plans. According to the results of this study, computational practices do not have a certain level for the same groups. They can change according to the information requested in the question. In general, it can be said that the ability of eighth-grade students to explain concepts such as climate, weather events, climate change, and carbon emissions using computational practices in lesson plans with integrated data practices is at the average Level 3. Even though students have an average level, they were expected to be able to explain the similarities and differences and trends in the data or analyze data with better examples.

On the other hand, the whole lesson plan steps were assessed separately to determine the levels of groups in different computational practices. The average level of the groups was highest at the fact-finding step in general, while the other steps were at the same level as 3. On the other hand, the whole lesson plan steps were assessed separately to determine the levels of groups in different computational practices. The average level of the groups was highest at the fact-finding step in general, while the other steps were at the same level as 3. If all the steps of the STEM lesson plan are seen as algorithmic thinking, the average level of the levels in these steps and the posters shared in the disseminate and reflect part was found to be the same, that is, 3. This shows that the overall average in the process is consistent.

<ins>4.4.1.2. Interview.</ins> In the interview, it was aimed that students would determine the computational practices that they use unconsciously, by summarizing what they have done throughout the process (see Appendix I). The codes were determined by evaluating the students' views on teaching climate, weather events and climate change

with CT-integrated lesson plans as well as the computational practices and data practices determined by Weintrop et al. (2016) used as codes. 6 participants answered the twelve semi-structured interview questions. Only three questions were analyzed to answer the fifth research question on students' perspectives, while others were used to understand students' thoughts toward CT-integrated instruction. The analysis of the main interview questions is given below.

In response to three main interview questions were given as follows: "Can you briefly summarise what you remember from what you did in our class?", "What did you do in the group work? Can you explain in the order you remember? At what stages did you contribute to the group work? Can you explain the parts of your contribution?", and "What activities can you remember related to the definitions?" (see Appendix I). Students' responses to the main questions were analyzed to create codes considering computational practices from the literature (Weintrop et al., 2016). Questions focused on highlighting the unconsciously used computational practices from the students' explanations. For the question about the definition, students were asked to give examples from lessons after giving the definition of all four computational practices.

There were four categories which were decomposition (see Table 4.23), abstraction (see Table 4.24), pattern recognition (see Table 4.25), and algorithmic thinking (see Table 4.26) with codes and examples from the interview. Table 4. 23 shows the codes highlighted by students from activities in the lessons at the interview. Decomposition means reducing a main problem or idea into manageable steps (Peters-Burton et al., 2022). This computational practice was included in the APoKS steps of both lesson plans. The emerging codes from students' examples were creating data, determining the important data to use, interpreting data, planning data, distributing the roles, determining the research question, determining the method/necessary steps, and manipulating data. Since the decomposition step was included in LP1 and LP2 in APoKS part of the lesson plans, students gave expected answers for this CT practice. The codes highlighted by 6 participants were 3 for P1, 5 for P2, 3 for P3, 1 for P4, 4 for

P5, and 0 for P6, which means except for P6, all participants gave an example about a code related to decomposition throughout the interview. Overall, 15 codes emerged from students' responses. Emerging codes were grouped into 7 codes. P2 mentioned 5 codes as the highest number, while P6 did not mention any of the codes related to the decomposition practice.

Table 4.23. Codes of decomposition category.

decomposition	
Codes	**Examples from the interview**
Creating data (determining the important data to use)	P1: "Firstly, we observed weather forecast data. . . . We underlined important parts of the assigned reading passage." P2: "... We chose a country and determined what needs to be done to reduce carbon emissions."
Interpreting data	P2: "We did activities such as visual and graphic interpretation....." P5: "My friends and I have analysed and interpreted these data respectively based on the graphs, tables and information given to us by making use of the presentation opened to help us."
Planning data	P1: "At the beginning, we planned what to do as a group." P2: "Planning." P3: " We planned in advance how we should proceed."

Table 4.23. Codes of decomposition category (cont.).

Decomposition	
Distributing the roles	P1: "Then we shared our tasks according to professions." P2: "I distributed the tasks to my friends." P5: "....Then we determined who would work on which topic."
Determining the research question	P4: "After reading the text and identifying our research question, we proceeded more easily."
Determining the method/necessary steps	P3: "At first, we planned which steps we would follow to conduct the research." P2: "I created a road map at the beginning." P5: "Once we had determined what needed to be done, it was easy."
Manipulating data	P3: "We sorted the questions according to our occupational groups." P5: "Firstly, we cleared the given data."

Table 4.24 shows the codes highlighted by students from activities in the lessons at the interview. Abstraction means using necessary data while eliminating as much irrelevant or distracting data as possible from the problem (Peters-Burton et al., 2022). This computational practice was included in fact-finding and disseminate and reflect steps of both lesson plans. The emerging codes from students' examples were creating data/doing research, identifying common answers/ exchange of ideas, making infer-

ences from data, summarizing what has been learned/learning process, and focusing on important data.

Table 4.24. Codes of abstraction category.

Abstraction	
Codes	**Examples from the interview**
Creating data (doing research)	P2: "Visual and graphic review... In the animation, we examined the color representation of carbon emissions in the world according to years." P4: "We examined the results and effects of global warming from different sources."
Identifying common answers/ exchange of ideas	P1: "In the questions, we wrote down our common thoughts on the topics." P4: "We made a common decision... We exchanged ideas and produced common results."
Making inference from data	P1: "We made predictions about climate change... We were expected to anticipate how things would develop years later." P2: "In recent years, we realized that more releases were made because it was redder." P3: "We have summarised the information we have obtained and created our graph." P4: "We processed the information given to us according to different areas."

Table 4.24. Codes of abstraction category (cont.).

Abstraction	
Summarizing what has been learned/learning process	P1: "We spent this process as a learning process, as if the first stages of the lesson were enabling us to learn. Then we determined the parts we could use from what we learned as a group."
Focusing on important data	P1: "We found out what information was useful to us and write down shared decisions in the reports we produced." P2: "Identifying and presenting key ideas for the presentation. We discussed what information to include in the poster presentation. Our friends and I had different ideas about some parts. I tried to explain to them that we should not put everything. We had a discussion about what information should be written in our report." P3: "We searched for useful information on the internet and noted it down. Also, when we collected temperature data, we did not use all the data. In order to share what we have learned about this subject with our friends, we put the important parts of our research on a poster. P4: "We determined the information that should be used in our report from the sections we all wrote. Since we cannot write everything, we may have done this when determining which sentences to write. We shared the important parts." P5: "We tried to write important information." P6: "We did research and noted down what was useful to us."

Although this computational practice was analyzed in the lesson plan only for the fact-finding and disseminate and reflect parts, the students gave an example from the activities they made throughout the lesson. This shows that some practices were used during the lessons by students even though such practices were not scored by the researcher. The codes highlighted by 6 participants were 4 for P1, 3 for P2, 2 for P3, 4 for P4, 1 for P5, and 1 for P6 which means all participants gave an example of a code related to decomposition throughout the interview. Overall, 15 codes emerged from students' responses. Emerging codes were grouped into 5 codes. P1 and P4 mentioned 4 codes as the highest number, while P5 and P6 mentioned 1 code as the lowest number related to the abstraction practice.

Table 4.25 shows the codes highlighted by students from activities in the lessons at the interview. Pattern recognition involves recognizing recurring trends and creating more effective algorithms by grouping and modularizing steps (Peters-Burton et al., 2022). This computational practice was included in the ideation, product development, and testing steps of both lesson plans. The emerging codes from students' examples were manipulating data/organizing data, analyzing data/making inferences using data, examining the changes in data over time, adapting the common ideas to answer questions, comparing the data (understanding similarities and differences), drawing a graph/understanding the changes on data over time, taking notes from data, analyzing the data/graph to find patterns or repetitions, critical thinking, making an appropriate plan or program, and following the patterns. The codes highlighted by 6 participants were 5 for P1, 2 for P2, 3 for P3, 1 for P4, 3 for P5, and 1 for P6, which means all participants gave an example of a code related to pattern recognition throughout the interview. Overall, 15 codes emerged from students' responses. Emerging codes were grouped into 11 codes. P1 mentioned 5 codes as the highest number, while P4 and P6 mentioned 1 code as the lowest number related to the pattern recognition practice.

Table 4.25. Codes of pattern recognition category.

Pattern Recognition	
Codes	**Examples from the interview**
Manipulating data/organizing data	P5: "After everyone took on their duties, we organized the information we had cleared on that subject and shared our thoughts... We took notes for the important information we see and organise it later"
Analyzing data/ making inferences using data	P3: "Interpretation." P5: "I contributed to the graph interpretation phase. I analyzed the weather averages of the past 30-40 years."
Examining the changes on data over time	P1: "In the graph, I have analyzed how the temperature of our region changes in a week."
Adapting the common ideas to answer questions	P4: "I rather evaluated our common ideas and adapted them to the given questions."
Comparing the data (understanding similarities and differences)	P1: "Comparing rates of climate change in different countries." P3: "Understanding similarities and differences was something we did over and over again."
Drawing a graph/ understanding the changes on data over time	P1: "drawing a graph of temperature change.

Table 4.25. Codes of pattern recognition category (cont.).

Pattern Recognition	
Taking notes from data	P1: "Noting down all data." P5: "We took notes of the important information and utilized notes during practice."
Analysing the data/graph to find patterns or repetitions	P2: "Analysing weather patterns, temperature graphs and carbon emission graphs are something we do over and over again." P3: "In the graphs, we have determined that average temperatures are gradually increasing. In the one about countries, we tried to find out in which years carbon emissions were higher."
Critical thinking	P1: "Thinking too much."
Making an appropriate plan	P6: "We made a proper program and planning."
Following the patterns	P2: "Since we followed the same steps in both lessons, we better understood what to do in the second lesson."

Table 4.26 shows the codes highlighted by students from activities in the lessons at the interview. Algorithmic thinking means creating a set of detailed instructions to follow in order to address a problem (Peters-Burton et al., 2022). According to Peters-Buton et al. (2022), these steps might include collecting necessary data for problem-solving, analyzing data, or any other defined process which results in the correct explanation of the problem with possible solutions. This computational practice was included in product development and disseminate and reflect steps of both les-

son plans. The emerging codes from students' examples were analyzing data, drawing graphs, creating posters, creating/using a series of steps to solve problems, reusing similar processes, putting jigsaw puzzle pieces together, and following a certain sequence. The codes highlighted by 6 participants were 5 for P1, 3 for P2, 2 for P3, 5 for P4, 0 for P5, and 0 for P6 which means except P5 and P6, all participants gave an example about a code related to algorithmic thinking throughout the interview. Overall, 15 codes emerged from students' responses and were grouped into 7 codes. P1 and P4 mentioned 5 codes as the highest number, while P4 and P6 did not mention any of the codes related to the algorithmic thinking practice.

Table 4.26. Codes of algorithmic thinking category.

Algorithmic Thinking	
Codes	**Examples from the interview**
Analyzing data	P1: "In general, we worked on graphic analysis and drawing conclusions." P4: "I suggested solutions to my friends about this issue and explained to them what we could do."
Drawing graphs	P1: "We analyzed the graphs and created our graphs." P2: "We tried to draw graphs similar to the graphs we have already analyzed." P4: "We have drawn the temperature change graph according to days and the carbon emission graph of the selected country according to years."

Table 4.26. Codes of algorithmic thinking category (cont.).

Algorithmic Thinking	
Creating posters	P1: “We measured the weather in Edirne. We analyzed the graphs and created graphs according to ourselves. In general, we prepared a poster by working on graph examination and conclusion.” P4: “We measured the temperature of our region to see if we could understand climate change. We tried to examine the damage caused by different countries in the world from the graphs. We tried to reduce the damage by planning for the future. We created a poster according to the questions on the worksheet.”
Creating/using a series of steps to solve problem	P1: “According to our measurements and the information found by my friends in the previous sections, I helped to draw a common graph.” P3: “We followed the necessary steps by looking at the graph and then wrote it on paper… We exchanged ideas with our friends, produced solutions, discussed what could be done, and answered questions using scientific data.” P4: “We tried to reduce damages by planning for the future. We created a poster according to the questions on the worksheet.”

Table 4.26. Codes of algorithmic thinking category (cont.).

Algorithmic Thinking	
Reusing similar processes	P1: “ We tried to include what we paid attention to in the previous sections as problem-solving in the report preparation part. We followed similar processes in both of our reports. The second report was easier because we more or less understood what we had to do in the first one. We created an order and used it again.” P3: “We had no difficulty drawing the other one because we had developed our drawing skills beforehand. We analyzed the graphs given to us and tried to create similar ones, and it was not difficult.”
Putting jigsaw puzzle pieces together	P2: “We tried to write the important ones from the information we wrote on the worksheet.”
Following a certain sequence	P2: “We took care to make the report in order. First, we determined the titles of the report. I listed the events one by one. One of my friends visualized the results while others tried to deduce from the graphs.” P4: “We drew a meaningful conclusion from activities. We stated these observations in the report by listing them in chronological order.”

Findings also showed that P2 expressed all subthemes with examples from the process. It means that even though the computational practices and definitions were unfamiliar to students, the participant internalized the processes they used throughout the lessons. The description of the steps was essential for the use of such practices.

> Participant 2: "I remembered the activities and the presentations. We did activities such as visual and graphic interpretation. We interpreted the increase in climate change from past to present through graphs, we examined the situation of our region and measured the temperature, and we discussed whether it was climate change or a weather event. In the animation, we examined the color representation of carbon emissions in the world according to years. Since it was red in recent years, we understood that more emissions were made. Then we tried to draw graphs similar to the graphs we examined before. We discussed what information to add to the poster presentation and made a presentation. In another lesson, there was a study on the global temperatures of countries. We chose a country and determined what needs to be done to reduce carbon emissions."

On the other hand, not all of the participants described an activity that matched with all of the computational practices. The frequency of codes for each computational practice are: decomposition (7), abstraction (5), pattern recognition (11), and algorithmic thinking (7) in line with the answers of 6 participants. It means that the most internalized code was pattern recognition, whereas other codes have almost equal numbers of codes.

But, some participants might not include all of the practices during the interview. P5 gave an example of decomposition, abstraction, and pattern recognition. It means that this participant did not remember the steps for algorithmic thinking even though the most outstanding part was that. In general, the participant mentioned the activities at the beginning of the lesson plan. The other steps and practices were missing in the explanation or they were not stated clearly.

> Participant 5: "My friends and I have analyzed and interpreted these data respectively based on the graphs, tables, and information given to us by making use of the presentation opened to help us. I contributed to the graph interpretation phase. I analyzed the weather averages for the past 30-40 years. Then we determined who would work on which topic."

Even though some of the examples given by the students were not evaluated with the rubric during the lesson process, they were added to the relevant codes because they were stated by the students. For example, P5 stated the task distribution to make a plan for the research, but the researcher did not assess this process.

Another example was the codes, including the process of both lesson plans. Even though the researcher did not evaluate the practices from the different lesson plans, students highlighted the codes that emerged during the process. For instance, P1 and P3 mentioned that using a similar path on the LP1 helps them to understand what they should do in the LP2. So, in algorithmic thinking, the code that reuses similar processes emerged from students' explanations.

> Participant 1: "We followed similar processes in both of our reports. The second report was easier because we more or less understood what we had to do in the first one. We created an order and used it again."

> Participant 3: "We did not have any difficulty in drawing the other one because we had developed our graph drawing skills beforehand. We analyzed the graphs given to us and tried to create similar ones and it was not difficult."

Overall, as a result of the answers given by students from their perspective to the question of which computational thinking skills eighth-grade students used during the intervention, it was also emphasized which practice matched which data practice. Throughout the process, computational practices and data practices were shown from the students' perspective. However, different numbers of codes could be extracted for different computational practices from the answers of different students. For example, the total number of codes extracted from all categories from the participant with the highest number of codes to the participant with the lowest number of codes were P1 (17), P2 (13), P4 (11), P3 (10), P5 (8), and P6 (2), respectively. In addition, P6 did not mention any codes related to decomposition and algorithmic thinking practices, while P5 did not mention only algorithmic thinking practice. At least 1 code example for each practice was extracted from the answers of other participants. On the other hand, all computational practices had 15 codes that were extracted from different participants, which means even if not all students, according to the general answers, it was concluded that students were aware of the data practices they used during the process.

4.5. Summary of Results

(i) There was a significant difference in eighth-grade students' understanding of climate change after the intervention.

(ii) There was a significant difference in eighth-grade students' understanding of climate change between the control and experimental group.

(iii) There was a significant difference in eighth-grade students' computational thinking skills after the intervention.

(iv) There was a significant difference in the eighth-grade students' computational thinking skills between the control and experimental group.

(v) Findings of worksheet analysis, including computational practices used throughout the lesson plans as follows:

- The average decomposition level for APoKS was 3, which shows students have nearly higher skills in dividing problems into manageable parts.
- The average abstraction level for fact-finding was 4, which shows students have higher skills in reducing complexity to define the main idea.
- The average pattern recognition level for ideation was 3, which shows students have nearly higher skills in comparing data sets, finding patterns, making sense of the patterns, and developing ideas with explanations.
- The average pattern recognition, algorithmic thinking, and abstraction levels for product development were 3.
- The average pattern recognition level for testing was 3.
- The average abstraction and algorithmic thinking levels for disseminate and reflect were 3.

(vi) According to the interview results, the codes highlighted by the participants from the highest to the lowest number of codes are P1, P2, P4, P3, P5, and P6, respectively. Findings from the interviews in different categories are as follows:

- Decomposition: 15 codes emerged from students' responses. P2 mentioned 5 codes as the highest number, while P6 did not mention any of the codes related to the decomposition practice. Emerging codes were grouped into 7 codes.
- Abstraction: 15 codes emerged from students' responses. P1 and P4 mentioned 4 codes as the highest number, while P5 and P6 mentioned 1 code as the lowest number related to the abstraction practice. Emerging codes were grouped into 5 codes.
- Pattern recognition: 15 codes emerged from students' responses. P1 mentioned 5 codes as the highest number, while P4 and P6 mentioned 1 code as the lowest number related to the pattern recognition practice. Emerging codes were grouped into 11 codes.
- Algorithmic thinking: 15 codes emerged from students' responses. P1 and P4 mentioned 5 codes as the highest number, while P4 and P6 did not mention any of the codes related to the algorithmic thinking practice. Emerging codes were grouped into 7 codes.

5. DISCUSSION

Daily life challenges require interdisciplinary problem-solving skills by utilizing critical connections between the disciplines. It is crucial to understand how one discipline can support the learning of the other (Frykholm and Glasson, 2005). In the 21st century, students should learn disciplinary knowledge with interdisciplinary knowledge, skills, and practices. The Ministry of National Education (MoNE, 2018) has published a flexible curriculum that highlights the importance of STEM and engineering implementations to science objectives. Teachers should find an interesting and authentic way to integrate STEM education into science lessons. STEM Integrated Teaching Framework (ITP) is one of the effective ways to create authentic lesson plans by integrating more than one discipline (Corlu, 2017). The framework is used to create STEM lesson plans that are primarily focused on one STEM subject while also taking into consideration other STEM disciplines as means of developing creativity and doing research (Abanoz and Yabaş, 2022). Using ITP, teachers can incorporate global perspectives, themes, challenges, and concerns into their subject areas (Yabaş and Bozoğlu, 2022). Global Climate Change is an issue that all disciplines should address in their objectives using interdisciplinary knowledge and skills.

A quality educational experience entails more than just learning content, so students' classroom experiences should enable them to acquire a variety of thinking skills (Peters-Burton et al., 2015). In the literature, it is emphasized that not only those who are interested in computer science but also every child should develop computational thinking (CT) skills (Wing, 2006). Many studies supported the idea that CT can be integrated into science learning (Sengupta et al., 2013; Weintrop et al., 2016; Rich et al., 2020). As Kite and Park (2021) stated, although teachers know that CT integration for K-12 students was broadened in the core curriculum, CT integration remains uncommon.

There are different ways of using computational practices to teach a topic. Some are learning to use computational practices through block-based applications (Boulden et al., 2018; Aksit and Wiebe, 2020; Rodríguez-Martínez et al., 2020) while others involve teaching a subject in such a way that computational practices overlap the activities during teaching a topic (Arık and Topçu, 2022). If we want to popularise CT in all courses, it is necessary to demonstrate the integration of CT into science classrooms and the effects of using CT skills on students. Some teachers do not want to use block-based applications with computational thinking, which leads to avoiding including these skills in the teaching process.

There were mainly two aspects of this study: the former is to measure the difference between both CT skills and climate change knowledge of students in experimental and control groups as well as the difference between these groups, and the latter is to investigate the computational practices used during the learning process for the experimental group. The researcher designed the lesson plans to integrate computational practices in different parts of ITP. Thus, the study shows how to use computational practices in science classrooms using STEM as a roadmap. It was crucial to focus on teaching a science topic without highlighting CT concepts or definitions.

Just as writing down operations step by step in mathematics, developing thinking techniques in other disciplines allows us to answer questions more precisely and meaningfully. According to Rachmatullah and Wiebe (2021), students may engage cognitively in brainstorming various circumstances, potential outcomes, and potential solutions to solve certain challenges. The current study enables students to improve their skills by scaffolding them to use these skills with questions that target computational practices integrated with questions and activities. Thus, it supports the idea that computational practices could be applicable as unplugged. When students were asked to write a report or explain the relationship between concepts, they could not decide how much to explain. However, thanks to a lesson plan prepared with CT exercises, they produced a meaningful product at the end of the lesson. The study conducted by Arık and Topçu (2022) stated that students need to be able to identify relationships to make sense of this complexity to create models. They found that the pre-models of the experimental and control groups were identical, but the post-model of the experimental group included more precise explaining processes. Although the same group was explored in the current study, students' reports on product development and questions on different parts became more detailed in poster explanations.

Computational practices can be integrated into lesson plans when they show certain features (Weintrop et al., 2016). Integrating data practice also shows how it can be used in interdisciplinary studies. Students can learn how to analyze data in science topics using computational thinking techniques (Burton et al., 2020). This study is a lesson plan application that evaluates process skills by examining how students respond to each question using computational practice throughout the lesson. Students were not directly aware of the computational practices they used, as the aim was not to teach the definition of computational practices but to teach a topic using a step-by-step procedure. Students completed the steps of data analysis using computational practices. Students in the experimental group used ITP as a roadmap during the lessons.

With the help of CT integrated questions and lesson plan steps, the CT integration process and students' learning were analyzed by comparing with the control group. Students in the control group received traditional classroom learning based on lectures. The results showed that the post-test scores of the experimental group increased after the intervention. Also, students in the experimental group got higher scores than the control group. Although each sub-question instructed the students to use a specific computational practice, some of the students did not follow the instructions given with such questions. Therefore, they were considered lower-level practice. But, as a whole, all of the groups develop their product throughout the lesson with algorithmic thinking. The study proves that every step in the lesson plan contributes to algorithmic thinking.

In the lesson plans, even if each part includes a computational practice, they were evaluated independently since, as a process, some parts require answers with evidence-based explanations. In contrast, others only need to be brief explanations. When we compare ideation, product development, and testing, these sections have different requirements to answer the questions in that section. Thus, we cannot directly relate the progress in the same practice to different lesson parts. In this study, the fact that different scores were obtained in different sections within the same group indicates that a subject should be taught using different computational practices to understand the concept deeply. Because in this way, different data can be compared, and different results can be drawn instead of only reaching the definition of the concept and general inference. After a week-long intervention in science classrooms, Aksit and Wiebe (2020) highlighted that engaging computational models facilitates crucial gains in the conceptual learning of middle school students by encouraging them to observe and interact with the phenomenon. Similar to such findings, the current study also supports the idea that students can construct meaningful learning when they deal with the target phenomenon.

Christensen and Lombardi (2023) investigated that the interventions improved students' biological evolution and computational understanding. The current study also found that students' climate change knowledge was developed, which demonstrates the efficacy of CT. Arık and Topçu (2021) showed that CT could be integrated into science learning with model-based explanations to teach the digestive system. Similar to this study, they explored both experimental and control groups to show the strengths and weaknesses of integrating CT into science teaching. As they pointed out, it is important to show how CT integration contributes to science teaching, which is supported by a few studies so far (Sengupta et al., 2013; Arık and Topçu, 2021). They found that with the help of CT activities, students were enabled to use mechanistic reasoning to explain scientific concepts, which enhanced their understanding of science content.

Moreover, students' misconceptions can be revealed by using computational practices during instruction. Breslyn and McGinnis (2019) explore the ways to help get preservice teachers ready to teach climate change concepts using CT with a system thinking approach. Even though the sample of the study was different from the current study, the findings were similar in that participants were confusing weather events and climate since they had a limited understanding of climate concepts. So, complicated concepts like climate change might be taught by using computational practices to decrease misconceptions. It has been shown that computational practices can prevent misconceptions or naive conceptions since the process enables students to think deeply about the relationship between concepts, like similarities and differences. On the other hand, using CT integrated lessons, students' misconceptions might be detected. In this study, some students had misconceptions about climate and weather event concepts. With the help of CT instructions, teachers might enable students to learn by questioning. While looking at the first part of the lesson plans, misconception did not occur. But, throughout the lesson, the misconceptions were revealed. It shows the importance of CT instructions to understand students' way of thinking. According to Rich et al. (2022), CT integration is a higher-level thinking process that enables students to concentrate on broad ideas while directing teachers to anticipate student thinking and consider the connections between scientific and student thinking.

When students were asked to find relevant information from selected links, they used the given resources and focused on what was important for the answer (abstraction). The level was high for abstraction practice because students are used to answering questions in the exam-based school culture in the country. In another step, students used pattern recognition skills to draw their own graphs using the similarities, differences, and trends from the ideation part. However, in general, they created a graph by copying the ones they were given to check on the ideation part. Therefore, although the average pattern recognition level was 3 when assessed according to the rubric, students did not create authentic products in both lesson plans. This result could be seen as a reflection of the science objectives and curriculum, as they did not expect students to create authentic products. On the other hand, in the mathematics curriculum, the eighth graders learned the topic of data analysis at the same time as the implementation of this study. However, they were not good at data practices because the curriculum focused mostly on multiple-choice questions rather than implementing such practices in other lessons. If the lesson plans were developed in a similar way as in the current study, all students could develop their thinking processes with the help of computational practices. This study supported that as the different computational practices are well aligned with most data practices, combining them could provide students with a metacognitive roadmap for decision-making when conducting scientific investigations (Burton et al., 2020). Similar to the findings of Rich et al. (2022), examining CT in terms of data practices acts as a curriculum-embedded way to develop high-level skills during training.

The result that the same groups got different scores when different lesson plans were applied is due to the fact that the students responded to subject-specific computational practices integrated questions. Since the aim of this research is to provide a better understanding of the concepts with computational practices and to create a learning scaffold for students by creating a road map, it is not within the scope of this research that they are at different levels in different lesson plans or steps. The development of CT skills depends on the process. In this study, science subject was learned by using CT steps with STEM integrated teaching method for only 2 weeks. With this kind of application and rubric evaluation, students may be at different levels on the basis of different subjects, which is an expected situation in this study.

It has been concluded that all lesson plan steps in this study (i.e., fact-finding, ideation) contribute to developing algorithmic thinking separately. For instance, the end product as a poster was more detailed than the answers to the questions. In LP2, in the pattern recognition section of product development, students wrote similar examples to the same questions. However, with the help of the climate interactive tool in the testing part, they included more detailed precautions in the poster. For that reason, STEM Integrated Teaching Framework is a decent road map for integrating unplugged computational practices into science classrooms. Computational practices enriched questions in the STEM framework enabling students not only to learn a concept but also to gain a new skill. Rich and colleagues (2020) identified ways to integrate CT into science and mathematics lessons by inviting students to reflect on how they had already used computational practices in lesson activities. It is similar to the current study that aims to use already used practices with various activities to improve content knowledge and CT skills.

Lesson plans in the study incorporate cognitive process outcomes, social product outcomes, and planning instruction, the same as ITP (Aşk et al., 2017). Since the social product outcomes were determined as teamwork, collaboration, sharing materials and knowledge, distribution of tasks, product development, and ability to make effective presentations, groups were the focus of the study, in line with ITP, as considering the understanding of the groups about the climate change concepts throughout the lessons. The underlying framework of the STEM learning cycle includes (1) Engage, (2) Explore, (3) Explain, (4) Extend, and (5) Evaluate, which are necessary steps for understanding a concept (Corlu, 2017). When such steps are aligned with computational practices, students' thinking processes can be monitored. The current study shows how computational practices could be integrated into ITP and which computational practices students used throughout the intervention.

Although it may seem easy to teach some concepts by memorizing, understanding the concepts deeply requires different approaches that need to be supported whether the concepts are understood or not. The control group revealed that students expressed the concepts simply with a few sentences from the book and made visual interpretations based on rote memorization in traditional lectures where learning does not occur by understanding the connections. The current study is significant as it enables the thinking analysis of students in the experimental group throughout the instruction with CT riched activities. Using computational practices integrated approach to teach science concepts enables students to think through and understand how various scientific ideas are connected (Sengupta et al., 2013). This study found that when science is taught utilizing CT activities and STEM Integrated Teaching Approach rather than traditional methods, middle school students learn about themes and concepts linked to climate change more effectively. As this study's findings support, all learners are expected to be able to synthesize a lot of information by changing and applying concepts to produce new knowledge and solutions, which is a required skill not just for the current age but also for future ages (Nadelson and Seifert, 2017). Given the importance of CT, students can engage in more detailed thinking processes in STEM-integrated instruction.

In line with the philosophy of STEM education, students can acquire knowledge more easily if they have experienced it themselves. However, the questions in the lessons should encourage students not only to create a product and conduct an experiment but also to understand the process and the overreaching idea. Rich and colleagues (2022) found that computational practices were incorporated into disciplines to provide a more deliberately designed process for students. This learning process can be supported by more planned instructions, like in STEM education. The current study highlighted the connections between ITP and CT by integrating computational practices into different steps of the lesson plan for the purpose of clarifying steps, understanding the necessary information to use, recognizing the trends in data, and making inferences from data.

6. LIMITATIONS

This study has some limitations. The study was implemented only with the 8th-grade students of a public middle school who are used to STEM activities. It was applied in the first semester of the 2022-2023 academic year. Different results are likely to be obtained when applied to students from disadvantageous schools. For example, when the instruction was implemented in a school without access to computers, in that case, students might have difficulty in creating a product because they had not created posters with digital tools before. It might cause the practice levels to be low regardless of the lesson plan teaching process and content.

Also, the intervention of the current study for the experimental group consisted of twelve lessons. After the intervention, the post-test on CTS and CCKT was used to understand the differences within and between the groups. The current study does not measure the long-term effects of the implementation. Future studies could focus on long-term effects on students.

This study used the CTS scale, which is used in the literature on the integration of CT in different disciplines and was developed by Korkmaz et al. (2015). The results of the study were interpreted according to this scale. However, this scale is a self-reported scale that only explains the improvement in students' CT skills to what the students reported. Thus, CTS doesn't measure skills developed throughout the lesson plans. Future studies can investigate whether the skills increase with the lesson plans that integrate CT skills, using scales that measure skills in direct interdisciplinary studies.

7. CONCLUSION

This study played a crucial role in showing how to use crosscutting concepts in learning processes. Although there are many studies in the literature on the importance of CT and its integration in the classroom, there are few studies on how this integration should take place in the context of interdisciplinary studies. Integration into science teaching, especially at the secondary level, is important to enable students to develop these skills at an earlier age. Applications in this area continue to be made abroad. In our country, although STEM applications are mentioned in the curriculum, there are practical shortcomings in their application. It is important to prepare programs that develop computational thinking skills together with STEM applications. In addition, more research should be done on courses that incorporate computational practices into the teaching process.

There should be examples of how using computational practices enable students to understand a science concept with gaining new procedural skills. This study differs from the studies in the literature both as an example of teaching science subjects with computational practices and as an example of lesson planning. Since the parts of the STEM lesson plan, which are APoKS, fact-finding, ideation, product development, testing, and disseminate and reflect, were also planned as an algorithmic way of teaching interdisciplinary concepts. This study proves that students could develop more complicated products at the end of the intervention with the scaffold of questions developed for specific computational practice.

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APPENDIX A: CONSENT FORM

Consent form was obtained after getting the ethical permission from the university ethical committe.

Evrak Tarih ve Sayısı: 18.05.2022-66287

T.C.
BOĞAZİÇİ ÜNİVERSİTESİ REKTÖRLÜĞÜ
Fen Bilimleri ve Mühendislik Alanları İnsan Araştırmaları Etik Kurulu
(FMİNAREK)

Sayı : E-84391427-050.01.04-66287 18.05.2022
Konu : 2022/16 Kayıt no'lu başvurunuz hakkında

Sayın Dr. Öğr. Üyesi Gaye Defne CEYHAN
Matematik ve Fen Bilimleri Eğitimi Bölüm Başkanlığı - Öğretim Üyesi

"Using a STEM Education Approach with a Computational Tool: The Impact on Students' Computational Thinking Skills and Understanding of Climate Change" başlıklı projeniz ile Boğaziçi Üniversitesi Fen Bilimleri ve Mühendislik Alanları İnsan Araştırmaları Etik Kurulu (FMİNAREK)'e yaptığınız 2022/16 kayıt numaralı başvuru 02.05.2022 tarihli ve 2022/05 No.lu kurul toplantısında incelenerek etik onay verilmesi uygun bulunmuştur. Bu karar tüm üyelerin toplantıya on-line olarak katılımıyla ve oybirliği ile alınmıştır.

COVID-19 önlemleri nedeniyle üyelerden ıslak imza alınamadığından bu onam mektubu tüm üyeler adına Komisyon Başkanı tarafından e-imzalanmıştır.

Saygılarımızla bilginize sunarız.

Prof. Dr. Tınaz EKİM AŞICI
Başkan

Bu belge, güvenli elektronik imza ile imzalanmıştır.

Doğrulama Kodu :BS93RPUE4Z Pin Kodu :82192 Belge Takip Adresi : https://turkiye.gov.tr/ebd?eK=4787&eD=BS93RPUE4Z&eS=66287

34342 Bebek-İstanbul
Telefon No:0212 287 17 53 Faks No:0212 265 70 06
İnternet Adresi:www.boun.edu.tr
Kep Adresi:bogaziciuniversitesi@hs01.kep.tr

Bilgi için: Nurşen MUNAR
Unvanı: Mühendis

Bu belge, güvenli elektronik imza ile imzalanmıştır.

Figure A.1. Consent form.

APPENDIX B: DEMOGRAPHIC FORM

The following questions are designed to get information about who has taken this survey.

1. Student Number

....

2. Gender

a) Female b) Male

3. Have you ever taken a course about environmental education?

a) Yes b) No

If yes, please indicate the course(s):

....
....

4. Do you belong to, or have you ever belonged to an environmental organization or group?

a) Yes b) No

If yes, please indicate the name(s) of the organization(s):

....
....

Figure B.1. Demographic form.

APPENDIX C: COMPUTATION THINKING SKILL SCALE (CTS)

C1	Kararlarının çoğundan emin olan insanları severim.	1	2	3	4	5
C4	Yeni bir durumla karşılaştığımda ortaya çıkabilecek sorunları çözebileceğime inancım vardır.	1	2	3	4	5
C5	Bir sorunumu çözmek üzere plan yaparken o planı yürütebileceğime güvenirim.	1	2	3	4	5
C8	Bir sorunla karşılaştığımda, başka konuya geçmeden önce durur ve o sorun üzerinde düşünürüm.	1	2	3	4	5
A1	Bir problemin çözümünü verecek denklemi hemen kurabilirim.	1	2	3	4	5
A3	Matematiksel sembol ve kavramlar yardımıyla yapılan anlatımları daha kolay öğrendiğimi düşünürüm.	1	2	3	4	5
A4	Sayılar arasındaki ilişkileri kolaylıkla yakalayabileceğime inanırım.	1	2	3	4	5
A6	Sözel olarak ifade edilen bir matematik problemini sayısallaştırabilirim.	1	2	3	4	5
O1	Grup arkadaşlarımla birlikte işbirlikçi öğrenme deneyimleri yaşamaktan hoşlanırım.	1	2	3	4	5
O2	İşbirlikçi öğrenmede grupla çalıştığım için daha başarılı sonuçlar elde ettiğimi/edeceğimi düşünüyorum.	1	2	3	4	5
O3	İşbirlikçi öğrenmede grup arkadaşlarımla birlikte grup projesi ile ilgili problemleri çözmekten hoşlanırım.	1	2	3	4	5
O4	İşbirlikçi öğrenmede daha çok fikir ortaya çıkıyor.	1	2	3	4	5
T1	Karmaşık problemlerin çözümüne yönelik düzenli planlar geliştirmede iyiyimdir.	1	2	3	4	5
T2	Karmaşık problemleri çözmeye çalışmak eğlencelidir.	1	2	3	4	5
T3	Zorlayıcı şeyler öğremeye istekliyimdir.	1	2	3	4	5

Figure C.1. Computational thinking skill scale (CTS).

T5	Elimdeki seçenekleri karşılaştırırken ve karar verirken kullandığım sistematik bir yöntem vardır.	1	2	3	4	5
P1	Problemin çözümünü zihnimde canlandırma konusunda sıkıntı yaşarım.	1	2	3	4	5
P2	Problem çözümünde X,Y gibi değişkenleri nerede ve nasıl kullanmam gerektiği konusunda sıkıntı yaşarım.	1	2	3	4	5
P3	Tasarladığım çözüm yollarını sırasıyla aşamalı bir şekilde uygulayamam.	1	2	3	4	5
P4	Bir soruna yönelik olası çözüm yollarını düşünürken çok fazla seçenek üretemem.	1	2	3	4	5
P5	İşbirlikçi öğrenme ortamında kendi düşüncelerimi geliştiremem.	1	2	3	4	5
P6	İşbirlikçi öğrenmede grup arkadaşlarıma bir şeyler öğretmeye çalışmak beni yoruyor.	1	2	3	4	5

Figure C.1. Computational thinking skill scale (CTS) (cont.).

APPENDIX D: CLIMATE CHANGE KNOWLEDGE TEST (CCKT)

	Doğru	Yanlış	Bilmiyorum
1. Günümüzdeki iklim değişikliğinin büyük bir kısmı insanlar tarafından üretilen sera gazlarından dolayı meydana gelmektedir.			
2. Eğer bu yaz yaşadığımız şehirde sıcak bir hava dalgası oluşursa bu durum iklimin değiştiği anlamına gelir.			
3. İklim değişikliği sadece yeryüzündeki sıcaklık artışı olarak tanımlanır.			
4. İklim değişikliği ozon tabakasının incelmesinin bir sonucudur.			
5. İklim değişikliği kısmen ağır metal emilimindeki artıştan kaynaklanmaktadır.			
6. Deniz seviyesinin yükselmesi ve kuraklık artışı iklim değişikliğinin sonuçlarından bazılarıdır.			
7. İklim değişikliği ile cilt kanseri arasında doğrudan bir ilişki vardır.			
8. Okyanuslar, insanlar tarafından üretilen karbondioksitin emilimini gerçekleştirebilir.			
9. İklim değişikliği sebebiyle oksijen yetersizliği ortaya çıkabilir.			
10. İklim değişikliği nedeniyle deniz ve okyanus sularının kapladığı alan genişleyebilir.			
11. Orman asitlenmesi iklim değişikliğinin bir sonucudur.			
12. İklim değişikliği yüzünden bazı bitki ve hayvan türlerinin nesli tükenebilir.			

Figure D.1. The climate change knowledge test (CCKT).

APPENDIX E: LESSON PLANS

STEM Lesson Plan 1

Date:	**Subject:**Science	**Topic:** Climate and Weather Events
Grade:8	**Duration:**80+80+80	**Teacher:** Dilara Kara Zorluoğlu

1. Target Outcomes:

1.1 Cognitive process Outcomes:

Outcomes related to the main discipline:

SCIENCE

F.8.1.2.1. Students will be able to explain the difference between climate and weather events.

F.8.1.2.2. Students will be able to define that climate science (climatology) is a branch of science and experts working in this field are called climate scientists (climatologists).

- Students will be able to collect local weather data for a defined period of time, and then compare these data with longer-term climate data for their community.

MATHEMATICS

Students will be able;

- to find the answers to questions related to the interpretation of data shown with pie charts and graphs.

Figure E.1. Lesson plan 1.

TECHNOLOGY

Students will be able;

- to use simple steps in designing solutions (i.e., problem description and exploration, review of case studies, design, implementation, testing, and evaluation) when solving algorithmic problems.
- to use visual representations of problem statements, structures, and data (i.e., graphs, tables, network development charts, concept maps, and flowchart)

Outcomes of other STEM disciplines:

To do measurements about weather

To solve problems about weather

To compare the temperature in different weather types

1.2. Social Product Outcomes:

Students will be able;

- to realize the importance of working in a team.
- to create a product based on creativity.
- to present the designed product to their classmates in a clear and understandable way.
- to express and discuss their ideas and findings both to their teammates and to their friends in other teams clearly and consistently by using visual, written, and verbal communication methods.

Teamwork, collaboration, sharing materials, sharing knowledge, distribution of tasks, product development and prototype, ability to make effective presentations

Figure E.1. Lesson plan 1 (cont.).

2. Materials Used:

- Smartphone
- LabStar App: LabStar is used to support students' claims with data-based explanations to realize the difference between weather and climate change.
- Computer
- Smartboard

3. Resources:

- Appendix 1: https://www.google.com/maps

Suggestions:

https://public.wmo.int/en

https://www.climate.gov/

https://climate.nasa.gov/evidence/

https://climatescience.org/courses

https://bilimgenc.tubitak.gov.tr/makale/kuresel-isinma-ve-iklim-degisiklikleri

https://trends.google.com/trends/?geo=TR

https://bilimgenc.tubitak.gov.tr/gelecekte-yaz-mevsimi-alti-ay-surebilir

NASA: Indicators of climate change

https://climate.nasa.gov/interactives/climate-time-machine

Weather Data set:

https://www.kaggle.com/davidbnn92/weather-data/data

Weather data for Turkey (October):

http://www.emcc.mgm.gov.tr/monitoring-data.aspx

*Internet access needed

Figure E.1. Lesson plan 1 (cont.).

4. Authentic Problems of Knowledge Society (APoKS):

4.1. Authentic Problems of Knowledge Society:

Latest News

Global climate change is one of the most challenging issues for a few decades. According to the IPCC report, Since the Industrial Revolution, global temperatures have increased by about 0.2°C per decade. Global surface temperatures in 2021 are about 1.1°C warmer than in 1880. This trend of temperature rise is expected to rapidly grow, and will very likely rise above 1.5°C above by 2040, according to the landmark IPCC report. The impacts of the climate crisis are far-reaching, sparing no one. They include more frequent and intense weather phenomena such as floods, greater sea-level rise, threatened ecosystems, food insecurity, and adverse health effects. The urgency of climate mitigation led to the formulation of the Paris Agreement in 2015. Its objective is clear: to keep global warming to well below 2°C above pre-industrial levels by 2100 while pursuing a limit of 1.5°C global temperature increase.

The World Meteorological Organization (WMO) is looking for a team to teach the world the difference between climate and weather events. Can you help us communicate these concepts effectively by joining the WHO team?

Welcome, you are one of the team now!

- Compare the past and present graphs of your local region.
- Generate an argument for your observations
- Support your claim with evidence-based explanations
- Collect the data by using LabStar and analyze it
- Determine how your city has been affected by climate change over the years by making measurements.
- Create a report for Brief Executive Summary to Citizens.

Figure E.1. Lesson plan 1 (cont.).

The evaluations you make with your friends are very important to create a local climate change report. Let's do this together!

(As a result of the evaluations, the amount of increase or decrease according to the years will be calculated and various measures will be taken.)

4.2. Constraints:

- Students will be divided into groups of 4-5.
- Each group must have a smartphone, computer, and the LabStar app installed on the phone.
- LabStar devices and app should be used for representations.
- The report that students will develop should show clearly weather and climate data.

4.3. Occupation, Duty, and Responsibilities:

- **Climate Scientist:** Investigates climate data in the region
- **Weather Specialist:** Investigates weather events in the region
- **Earth Scientist:** Investigates the climate change in different regions and explain it by using evidence
- **Data Analysis Specialist:** Interprets the huge amount of data and makes explanations
- **Histrorian:** Predicts the changes in temperatures in time
- **Environmental journalist:** Presents the results of the report to the society

5. Lesson Content:

5.1. APoKS and Constraints:

At the beginning of the lesson, the teacher asks daily life questions to take students' attention.

- How is the weather today?
- Do you follow the weather forecast? How does a weather specialist predict the weather events?

Figure E.1. Lesson plan 1 (cont.).

- What was the weather like this time last year?
- How has the weather been for a few years?
- Have you noticed a change in the weather in the last few years?
- How do you think scientists evaluate the change in weather? How can changes in weather be determined by scientists?

The lesson starts with a video that gives the daily weather events of the region.

After stating the climate and weather events by answering questions, students' pre-knowledge about climate change will be assessed by following questions.

- Imagine that last summer was much hotter than usual where you live. Is this a sign of climate change? Why? (NO)
- Imagine that almost every summer for the past decade has been hotter than usual. Is this a sign of climate change? Why? (YES)

The teacher presents the story of the World Meteorological Organization to the students and asks them to create a report. Students are introduced to the occupational duties and they are asked to assign every member within the groups with one of these occupations.

5.2. Fact Finding:

Useful links:

- https://archive.epa.gov/climatechange/kids/basics/concepts.html
- https://archive.epa.gov/climatechange/kids/scientists/clues.html
- https://archive.epa.gov/climatechange/kids/impacts/signs/temperature.html

Figure E.1. Lesson plan 1 (cont.).

The teacher asks open-ended questions.

- How do scientists gather information about the Earth's current weather and past climate? (Ağaç halkaları, okyanuslar vs.)
- How does climate change occur?
- What are the clues of Climate Change?
- Why is it important to collect information about past climate?
- Which country's greenhouse gas emissions are the highest and lowest? What could be the reason?

5.3. Ideation:

Students reflect on the question of the difference between climate and weather events. They will use already collected data from the LabStar. By using graphs of different countries, they will define climate and weather events. Then, they will prove it by showing evidence from data next week.

Students will collect data for the temperature of their city by using LabStar during the week. They will also find the data for previous years to compare the temperatures. Students are expected to fill in the blanks in the report by showing evidence from data. Students will make an observation about temperature differences. They will plan to use LabStar to collect data during the week for product development (Preparation for the next class).

5.4. Product Development:

According to the occupations, duties, and responsibilities, every group member will contribute to the product development. Students will create a report for their city by using collected data with LabStar. They will show relationships between the graphs. Students are expected to create a product to show the effects of climate change on their region. They will create a report for Brief Executive Summary to Citizens.

- How could you use data sets to show the difference between climate and weather events?
- How is your city affected by climate change?

Figure E.1. Lesson plan 1 (cont.).

- Imagine that last summer was much hotter than usual where you live. Is this a sign of climate change? Why? (NO)
- Imagine that almost every summer for the past decade has been hotter than usual. Is this a sign of climate change? Why? (YES)

5.5. Testing:

Students will test their data and graphs. They will calculate the temperature increased by every decade for their region and compare the results. They will change some steps according to the teacher's questions.

Elaboration:

- According to your data, which trend have you observed in your region's climate in the last decade?

Students will analyze data of their city collected by LabStar. They will test the credibility of their reports by peer assessment. It should be included data, graphs, and scientific explanations.

Rubric: (Peer assessment)

The report is dual.	1	2	3	4	5
The report is effective.	1	2	3	4	5
The report provided evidence-based explanation.	1	2	3	4	5
The report is authentic	1	2	3	4	5

5.6. Disseminate and Reflect:

After the peer assessment, students can change their reports in line with the feedbacks. They will create a poster with a new report to reflect it. They are expected to include data-based explanations about climate and weather events. Students combine what they have learned during the lesson about the topic and summarize it in the poster. The posters will be shared on Padlet. Every group will present their reports in a minute. The environmental journalist will be responsible for the presentation.

Figure E.1. Lesson plan 1 (cont.).

STEM Lesson Plan 2

Date: **Subject:**Science **Topic:** Environmental Problems

Grade:8 **Duration:**80+80+80 **Teacher:** Dilara Kara Zorluoğlu

1. Target Outcomes:

1.1 Cognitive process Outcomes:

Outcomes related to the main discipline:

SCIENCE:

F.8.6.3.3. Students will be able to discuss the causes and possible consequences of global climate change.

a. Students will be able to explain the greenhouse effect.

b. Students will be able to question how environmental problems can affect the future of the world and human life in the context of global climate change.

c. Students will be able to calculate their ecological footprint (the extension can be used from secure sites such as edu, org, and mil).

MATHEMATICS:

Students will be able;

- to find the answers to questions related to the interpretation of data shown with pie charts and graphs.
- to do mathematical calculations and measurements.

Figure E.2. Lesson plan 2.

TECHNOLOGY:

Students will be able;

- to use simple steps in designing solutions (i.e., problem description and exploration, review of case studies, design, implementation, testing, and evaluation) when solving algorithmic problems.
- to use visual representations of problem statements, structures, and data (i.e., graphs, tables, network development charts, concept maps, and flowchart)

1.2. Social Product Outcomes:

Students will be able;

- to communicate effectively with groupmates and share their ideas.
- to actively participate in group work.
- to think and express ideas on current problems in the world.
- to have an idea about the areas where technology and industry meet (artificial intelligence, coding applications, etc.).
- to behave respectfully and tolerantly towards teammates for group work.

Teamwork, collaboration, sharing materials, sharing knowledge, distribution of tasks, product development and prototype, ability to make effective presentations.

2. Materials Used:

- Smartphone
- LabStar App
- Computer
- Smartboard

*Internet access needed

Figure E.2. Lesson plan 2 (cont.).

3. Resources:

Appendix 1: Video about climate change

- https://youtu.be/bWzrWqvRImQ

Appendix 2: Google Trends

- https://trends.google.com/trends/?geo=TR

Useful Links:

- https://www.climate.gov/
- https://climate.nasa.gov/evidence/
- https://climatescience.org/courses
- https://bilimgenc.tubitak.gov.tr/makale/kuresel-isinma-ve-iklim-degisiklikleri
- https://bilimgenc.tubitak.gov.tr/makale/insanlar-mi-yoksa-yanardaglar-mi-daha-fazla-karbondioksit-salimina-sebep-olur

CO2 emission

- https://www.economist.com/science-and-technology/2020/07/11/emissions-slashed-today-wont-slow-warming-until-mid-century?gclid=Cj0KCQiA7oyNBhDiARIsADtGRZaAkIkgLpGvn6PBoa4dSHKsa9FLMloO23yvN7QUDUNm5M1uFt01tRMaApd_EALw_wcB&gclsrc=aw.ds

IPCC

- https://www.ipcc.ch/2021/08/09/ar6-wg1-20210809-pr/

NASA CO2 emission data:

- https://climate.nasa.gov/vital-signs/carbon-dioxide/

CO2 change in time 2002-2016:

- https://climate.nasa.gov/interactives/climate-time-machine

Annual CO2 emission from fossil fuels

- https://ourworldindata.org/grapher/annual-co-emissions-by-region

Figure E.2. Lesson plan 2 (cont.).

4. Authentic Problems of Knowledge Society (APoKS):

4.1. Authentic Problems of Knowledge Society:

The urgency of climate mitigation led to the formulation of the Paris Agreement in 2015. Its objective is clear: to keep global warming to well below 2°C above pre-industrial levels by 2100 while pursuing a limit of 1.5°C global temperature increase. Achieving this entails halving global anthropogenic CO2 emissions by 2030 and reaching net-zero by 2050.

The first meeting after the Paris agreement will be at this meeting. If the countries continue with their actions without taking any precautions, emissions are expected to increase significantly. Imagine that you are representatives from different countries. Prepare a report on what can be done about the way your country is coping with the climate crisis.

The task: Assume that you are delegates from different countries coming to the COP 2022. You are expected to set a target plan to reduce the CO2 emission of your country until this meeting. You can decide in your report what is the current situation, when to start decreasing emissions, what rate to decrease emissions, and when to stop emissions.

4.2. Constraints:

- Students have to present a poster with graphs created by LabStar.
- Students can use only given data to create graphs.
- Students should use the given websites to search for research questions.
- The poster they presented should show clearly the relationship between climate change concepts.

Figure E.2. Lesson plan 2 (cont.).

4.3. Occupation, Duty, and Responsibilities:

- **Climate scientist (Climatologist):** Interprets and explains the climate change by using evidence
- **Policymaker:** Decides the proposal
- **Agricultural Engineer:** Deals with forest, agriculture, water management systems
- **Environmental Engineer:** Deals with transport, buildings, environmental planning
- **Industrial Engineer:** Deals with finance, strategy, consumption, technology
- **Economist and data scientist:** Makes the balance between economy and environmental precautions.

5. Lesson Content:

5.1. APoKS and Constraints:

At the beginning of the lesson, students' pre-knowledge will be assessed by a quiz. Then, students will watch a video about climate change (Appendix 1: https://youtu.be/bWzrWqvRImQ). The teacher will give information about COP (Appendix 2) and introduce the daily life problem.

- How does the Earth's temperature change over time?
- When did the earth reach the highest historical CO2 level?
- Is there any relationship between temperature rise and CO2 emission in graphs? Please explain.

(**https://climate.nasa.gov/vital-signs/carbon-dioxide/**)

After the engagement with the topic, the teacher recalls the use of LabStar. Students will look at the google trends (Appendix 2) for "climate change" to determine the period that global climate change occurs. The data taken from google trends will be visualized as graphs by using LabStar. Students are expected to induce from the graph and share their ideas in classroom discussion.

- When did people first become aware of climate change and start researching this word?
- Which actions of people in history might cause climate change?

Figure E.2. Lesson plan 2 (cont.).

Students will be divided into five groups by the teacher. APoKS is presented to students. The teacher will explain the procedure during the group work. The teacher introduces the procedure so that every group creates graphs using LabStar from the downloaded data and makes inferences about carbon emissions on a country basis or around the world with these graphs. They are expected to fill their worksheet with the information they will learn by searching the given websites to answer the research questions. Then, the teacher introduces the occupational jobs and their duties in group work. Students start group work by assigning responsibilities for every group member related to the selected occupation.

5.2. Fact Finding:-

The teacher asks open-ended research questions so that students can start working independently. They are expected to make predictions about the topic depending on their research. Also, they will look for what they are curious about the topic. Useful links will be used to search.

Questions:

- What are the primary causes of human-induced carbon dioxide emissions?
- How are emissions expected to change over time if nothing is done?
- What are the possible actions to reduce human-induced carbon emissions?
- What does zero carbon emission mean?
- How do countries reach the target of zero carbon emissions by 2050?

5.3. Ideation:

Students will work with their groups to determine the carbon emissions of their assigned countries. They will create a graph by using LABSTAR. Students are expected to answer the following questions by using data. Different occupations will determine the ideation part in line with their responsibility (economic effects, environmental effects, etc.).

https://data.worldbank.org/indicator/EN.ATM.CO2E.PC?end=2018&start=2018&view=map&year=1980

Figure E.2. Lesson plan 2 (cont.).

Students will answer the questions with the help of the data created by LabStar.

- What is the carbon emission trend in your country?
- Are carbon emissions balanced in your country?
- How are emissions expected to change over time if nothing is done?
- What would be the impact of such a carbon emission on the earth?
- What are the possible actions to reduce human-induced carbon emissions?
- What target will you set by 2022 to reduce your country's CO2 emissions by 2050?

5.4. Product Development:

Each group will prepare a report to determine the steps to be taken regarding the situation they have identified regarding the data created by LabStar. The teacher will share a useful link to create an outline of the task. Students are informed that they will use this tool to assess their reports and decide on a global plan. In the report, students will work in line with their occupations and duties.

- Write the sub-heading of your report.
- Which variables should be changed?
- How much should the variables that your profession deals with change?

5.5. Testing:

Use Climate Action Tool to test your report. https://www.climateinteractive.org/tools/

- What could your country do to prevent carbon emissions?
- What are the global contributions of your plan?
- Is that possible to reduce CO2 emission to zero point with your report?
- Does your report meet the needs for net-zero emission? Check your report.

Figure E.2. Lesson plan 2 (cont.).

Students should test their country's reports considering the balance of benefit and harm.

The economic and social interests of the country were taken into account.	1	2	3	4	5
The use of 21st-century technologies was taken into account.	1	2	3	4	5
Giving priority to green areas by protecting the interests of the country.	1	2	3	4	5
Planning the use of renewable and non-renewable energy, taking into account the factors such as climate and population of the country.	1	2	3	4	5
Environmentally friendly building and city planning	1	2	3	4	5
Taking measures that will not affect the production activities of the factories	1	2	3	4	5
Recognition of the steps that will prevent the development of the country	1	2	3	4	5
Taking care that the measures taken by the country are not at a cost that exceeds the level of economic development	1	2	3	4	5

5.6. Disseminate and Reflect:

Students will present their reports. To use simulation, they are asked to make a global assessment. Legal representatives of each country negotiate with other countries by defending their reasons. As a result, students are expected to understand that countries should act together. The proposal of the countries will be assessed in different categories.

- How does the CO_2 emission of developing countries and developed countries change over time?
- How do the low income and high income affect the change in CO_2 emissions over time?

Figure E.2. Lesson plan 2 (cont.).

APPENDIX F: WORKSHEET 1 AND WORKSHEET 2

ÇALIŞMA KAĞIDI 1

VERİLERLE İKLİM VE HAVA OLAYLARI

Başlamadan önce cevaplayalım:

- Geçen yaz yaşadığınız yerde normalden çok daha sıcak olduğunu hayal edin. Bu iklim değişikliğinin bir işareti mi? Neden?

- Son on yılda neredeyse her yazın normalden daha sıcak olduğunu hayal edin. Bu iklim değişikliğinin bir işareti mi? Neden?

1) Günlük Hayat Örneği

Son Dakika Haberler

Küresel iklim değişikliği, son yılların en zorlu sorunlarından biridir. IPCC raporuna göre, Sanayi Devrimi'nden bu yana küresel sıcaklıklar her on yılda yaklaşık 0,2°C arttı. 2021'deki küresel sıcaklıklar, 1880 yılından yaklaşık 1,1°C daha sıcak. Bu sıcaklık artışı eğiliminin hızla artması bekleniyor ve IPCC raporuna göre, 2040 yılına kadar büyük olasılıkla sıcaklıklar 1,5°C'nin üzerine çıkacak. İklim krizinin etkileri çok geniş kapsamlı ve bütün canlıları etkiliyor.
Sel, deniz seviyesinin yükselmesi, tehdit altındaki ekosistemler, gıda güvensizliği ve olumsuz sağlık etkileri, daha sık ve yoğun hava olayları...
İklim krizi ile mücadelenin aciliyeti, 2015 yılında Paris Anlaşması'nın formüle edilmesine yol açtı. Bu anlaşmanın amacı açıktır: **1,5°C'lik bir küresel sıcaklık artışı sınırını takip ederken, 2100 yılına kadar küresel ısınmayı sanayi öncesi seviyelerin 2°C'nin çok daha altında tutmak.**

Dünya Meteoroloji Örgütü (WMO), dünyaya iklim ve hava olayları arasındaki farkı öğretecek ve iklim değişikliği konusunda bilinç oluşturacak bir ekip arıyor. Ekibe katılarak bu kavramları etkili bir şekilde göstermeye yardımcı olabilir misiniz? Arkadaşlarınızla yapacağınız değerlendirmeler yerel iklim değişikliği raporu oluşturmak için çok önemli. Her bölümde yer alan sorulara verdiğiniz cevaplar ile raporunuzu oluşturmaya başlayacaksınız.

Araştırma Sorusu:

a) İklim ve hava olayları kavramlarını açıklayacak bir araştırma yapacak olsanız hangi adımları izlersiniz? Gerekçelendirerek açıklayınız.

b) Bulunduğunuz bölgede iklim değişikliği olup olmadığını anlayabilmek için hangi bilgileri kullanmanız gerekir?

Figure F.1. Worksheet 1.

- **<u>Günlük Hayat Örneği</u>** bölümünde hangi adım veya adımları takip ettiğinizi düşünüyorsunuz? Yuvarlak içine alarak işaretleyiniz.

Veri bulma/inceleme	Veri toplama	Veri düzenleme	Veri görselleştirme	Veriyi analiz etme/yorumlama	Hiçbiri

2) Bilgi Edinme

a) Bilim insanları, Dünya'nın mevcut hava durumu ve geçmiş iklimi hakkında nasıl bilgi toplar?

b) İklim değişikliği nedir? Açıklayınız.

c) İklim Değişikliğinin ipuçları nelerdir?

d) İklim değişikliğini belirleyebilmek için hangi verilere ihtiyaç duyarsınız?

e) Geçmiş iklimler hakkında bilgi toplamak neden önemlidir?

f) Bulunduğunuz bölgenin geçmişte ve şimdiki hava durumu arasında fark var mı? Nasıl?

Figure F.1. Worksheet 1 (cont.).

- **Bilgi Edinme** bölümünde hangi adım veya adımları takip ettiğinizi düşünüyorsunuz? Yuvarlak içine alarak işaretleyiniz.

Veri bulma/inceleme	Veri toplama	Veri düzenleme	Veri görselleştirme	Veriyi analiz etme/yorumlama	Hiçbiri

3) Fikir Geliştirme

a) Türkiye'de farklı şehirlerin aylara göre sıcaklık verilerini nasıl değerlendirirsiniz? Bu verilerden iklim değişikliği ile ilgili bir sonuca ulaşabilir misiniz? Neden?

b) Farklı şehirler için 2022 yılı aylara ait sıcaklık ve yağış bilgileri ile bu bölgelerin iklimi veya hava olayları ile ilgili bir sonuca varabilir misiniz? Tablodan örnek vererek açıklayınız.

c) Marmara Bölgesi'nde bulunan illerin yıllara göre eylül ayı ortalama sıcaklıklarını incelediğinizde nasıl bir sonuca varabilirsiniz? Gerekçelendirerek açıklayınız.

d) Labstar ile oluşturulmuş Türkiye'deki şehirlerin yıllara göre sıcaklık değişimi grafiklerini incelediğinizde nasıl bir sonuç çıkarırsınız? Bu grafiklerin benzer ve farklı yönleri neler? Farklı şehirlerden örnekler vererek açıklayınız.

Figure F.1. Worksheet 1 (cont.).

e) Labstar ile oluşturulmuş Dünya geneli yıllara göre ortalama sıcaklık değişimi grafiğini incelediğinizde nasıl bir sonuç çıkarırsınız? Açıklayınız.

f) Labstar ile oluşturulmuş yıllara göre sıcaklık değişimi grafiklerinden Dünya geneli, Türkiye geneli ve Edirne için oluşturulmuş grafikleri inceleyiniz. Bu grafiklerin benzer ve farklı yönleri neler?

g) Farklı yıllara göre küresel sıcaklık grafiği incelendiğinde 2020 yılı ile 2022 yıllarını karşılaştırdığınızda nasıl bir sonuç elde edersiniz? Küresel sıcaklıklar artmaya devam ediyor mu, azalmış mı veya değişmemiş mi?

h) New York, Los Angeles ve Houston için verilmiş olan yıllara göre ve aylara göre 2 farklı şekilde çizilmiş grafikleri inceleyerek iklim, hava olayları veya iklim değişikliği ile ilgili nasıl bir çıkarım yapabilirsiniz?

Figure F.1. Worksheet 1 (cont.).

- **Fikir Geliştirme** bölümünde hangi adım veya adımları takip ettiğinizi düşünüyorsunuz? Yuvarlak içine alarak işaretleyiniz.

Veri bulma/inceleme	Veri toplama	Veri düzenleme	Veri görselleştirme	Veriyi analiz etme/yorumlama	Hiçbiri

4) Ürün Geliştirme

Görev: LabStar'ı kullanarak bulunduğunuz bölgenin sıcaklık verilerini toplayın.

a) Toplanan verileri Labstar'ın oluşturduğu grafik üzerinden inceleyerek yorumlayınız. Grafik hangi verilerden oluşuyor?

b) Bu grafikteki bütün veriler tutarlı görünüyor mu? Deney hatalarını göz önünde bulundurarak inceleyiniz ve grafikten çıkarmak istediğiniz bir kısım varsa belirtiniz.

c) Grafikte tekrar eden bir durum görüyor musunuz? Açıklayınız.

d) Bu verilerden nasıl bir sonuç çıkardınız? Araştırma sorunuzu destekleyebiliyor musunuz?

Figure F.1. Worksheet 1 (cont.).

e) Labstar ile topladığınız verilerle elde ettiğiniz grafik, grafiğin elemanlarının belirlenmesi, hatalı verilerin çıkarılması, belirli bir örüntü oluşturulması gibi adımları takip ettikten sonra kullanmak istediğiniz veri aralığını seçerek iklim, hava olayları veya iklim değişikliği kavramlarından ikisini açıklayan grafiklerinizi oluşturunuz.

Figure F.1. Worksheet 1 (cont.).

f) Bulunduğunuz bölgenin geçmiş ve şimdiki sıcalıklarını inceleyerek çıkarımlarınızı yazınız.

g) Ders boyunca her bölümden öğrendiklerinizi 1-2 cümleyle özetleyiniz. Verilen grafikleri göz önünde bulundurarak bulunduğunuz bölgenin ikliminde gelecek yıllarda bir değişiklik olup olmayacağına dair tahminlerinizi yazınız.

RAPOR:

- **Ürün Geliştirme** bölümünde hangi adım veya adımları takip ettiğinizi düşünüyorsunuz? Yuvarlak içine alarak işaretleyiniz.

Veri bulma/inceleme	Veri toplama	Veri düzenleme	Veri görselleştirme	Veriyi analiz etme/yorumlama	Hiçbiri

Figure F.1. Worksheet 1 (cont.).

5) Test Etme

a) Verilerinize göre, son on yılda bölgenizin ikliminde hangi eğilimi gözlemlediniz? Açıklayınız.

b) Son 10 yılın verileri ile sizin grafiğinizi karşılaştırdığınızda bulunduğunuz bölgenin ikliminde anlamlı bir fark görebiliyor musunuz? Açıklayınız.

c) Bulunduğunuz bölgenin verileri ile diğer şehirlerin geçmiş verileri incelendiğinde her bölgenin aynı şekilde etkilendiğini söyleyebilir misiniz? Açıklayınız.

- **Test Etme** bölümünde hangi adım veya adımları takip ettiğinizi düşünüyorsunuz? Yuvarlak içine alarak işaretleyiniz.

Veri bulma/inceleme	Veri toplama	Veri düzenleme	Veri görselleştirme	Veriyi analiz etme/yorumlama	Hiçbiri

6) Paylaşım Yapma

a) İklim değişikliği ile ilgili yaptığımız derslerden çıkardığınız sonucu kısaca açıklayınız.

b) İklim değişikliği ile ilgili yaptığımız derslerdeki çalışmaları düşünerek iklim değişikliği ve hava olayları arasındaki farkı nasıl açıklarsınız? Derslerden örnekler sunarak posterde açıklayınız.

- **Paylaşım Yapma** bölümünde hangi adım veya adımları takip ettiğinizi düşünüyorsunuz? Yuvarlak içine alarak işaretleyiniz.

Veri bulma/inceleme	Veri toplama	Veri düzenleme	Veri görselleştirme	Veriyi analiz etme/yorumlama	Hiçbiri

Figure F.1. Worksheet 1 (cont.).

ÇALIŞMA KAĞIDI 2

VERİLERLE KARBON SALIMI

1) Günlük Hayat Örneği

Hatırlayalım

İklim değişikliğinin etkilerinin hafifletilmesinin aciliyeti, 2015 yılında Paris Anlaşması'nın formüle edilmesine yol açtı. Bu anlaşmanın amacı açıktır: 1,5°C'lik bir küresel sıcaklık artışı sınırını takip ederken, 2100 yılına kadar küresel ısınmayı sanayi öncesi seviyelerin 2°C'nin çok altında tutmak. Bunu başarmak, küresel antropojenik CO2 emisyonlarını 2030 yılına kadar yarıya indirmeyi ve 2050 yılına kadar net sıfıra ulaşmayı gerektiriyor.

Paris anlaşmasından sonraki ilk toplantı bu yıl olacak. Ülkeler herhangi bir önlem almadan eylemlerine devam ederse emisyonların önemli ölçüde artması bekleniyor.

- COP 2022'ye davetli farklı ülkelerden üyeler olduğunuzu düşünün. Bu toplantıya kadar ülkenizin CO2 emisyonunu azaltmak için bir hedef plan belirlemeniz bekleniyor. Ülkenizin iklim kriziyle nasıl başa çıktığı konusunda neler yapılabileceğine dair bir rapor hazırlayın.

Görev: Raporunuzda **mevcut durumun** ne olduğuna, hangi eylemlerin **emisyonları arttırdığına ve** bu eylemleri **nasıl sınırlamanız gerektiğine,** emisyonları **ne zaman** azaltmaya başlayacağınıza, emisyonları **hangi oranda** azaltacağınıza ve emisyonları **ne zaman durduracağınıza** karar verebilirsiniz.

Araştırma Sorusu:

a) Farklı ülkelerdeki karbon emisyonu seviyeleri nasıl farklılık gösteriyor? Gerekçelendirerek açıklayınız.

b) Karbon emisyonu ile ilgili yapılacak olan çalışmalarda hangi alt başlıklara yer verilmeli?

- **<u>Günlük Hayat Örneği</u>** bölümünde hangi adım veya adımları takip ettiğinizi düşünüyorsunuz? Yuvarlak içine alarak işaretleyiniz.

Veri bulma/inceleme	Veri toplama	Veri düzenleme	Veri görselleştirme	Veriyi analiz etme/yorumlama	Hiçbiri

Figure F.2. Worksheet 2.

2) Bilgi Edinme

a) Dünya tarihi en yüksek CO2 seviyesine ne zaman ulaştı?

b) Grafiklerde sıcaklık artışı ile CO2 emisyonu arasında bir ilişki var mı? Açıklayınız.

c) İnsanlar iklim değişikliğinden ilk ne zaman haberdar oldu ve bu kelimeyi araştırmaya başladı?

d) Tarihte insanların hangi eylemleri iklim değişikliğine neden olabilir?

e) İnsan kaynaklı karbondioksit emisyonlarının başlıca nedenleri nelerdir?

f) Hiçbir şey yapılmazsa emisyonların zaman içinde nasıl değişmesi bekleniyor?

g) İnsan kaynaklı karbon emisyonlarını azaltmak için olası eylemler nelerdir?

h) Sıfır karbon emisyonu ne anlama geliyor?

i) Ülkeler 2050 yılına kadar sıfır karbon emisyonu hedefine nasıl ulaşır?

- **Bilgi Edinme** bölümünde hangi adım veya adımları takip ettiğinizi düşünüyorsunuz? Yuvarlak içine alarak işaretleyiniz.

Veri bulma/inceleme	Veri toplama	Veri düzenleme	Veri görselleştirme	Veriyi analiz etme/yorumlama	Hiçbiri

Figure F.2. Worksheet 2 (cont.).

3) Fikir Geliştirme

a) Dünya üzerinde farklı kıtaların LabStar ile oluşturulmuş grafiklerini incelediğinizde karbon emisyonu ile ilgili ne söyleyebilirsiniz? Varsa farklılıkların sebepleri neler olabilir?

b) Farklı ülkelerin karbon emisyon grafikleri LabStar ile görselleştirilmiştir. Seçtiğiniz ülkenin karbon emisyonu eğilimi nedir?

c) Ülkenizde karbon emisyonları dengeli mi? Açıklayınız.

d) Hiçbir şey yapılmazsa ülkenizdeki emisyonların zaman içinde nasıl değişmesi bekleniyor?

e) Böyle bir karbon salınımının dünya üzerindeki etkisi ne olur? Açıklayınız.

f) Seçtiğiniz ülke ile diğer ülkelerin karbon emisyonları arasında benzerlik ve farklılıklar nelerdir? Varsa farklılıkların sebepleri neler olabilir?

g) Farklı ülkelerin grafiklerinde karbon emisyonu eğilimi nasıl? Her zaman artış mı yaşanıyor?

Figure F.2. Worksheet 2 (cont.).

h) Farklı ülkelerde artışlar hangi oranlarda gerçekleşmiştir? Karşılatırdığınız ülkeler arasından hangi ülke daha fazla karbon salımı yapıyor?

i) Grafikte ne zaman ani bir artış yaşanmıştır? Bu artışın nedenleri neler olabilir?

j) Grafikte azalma varsa bunun sebepleri neler olabilir?

k) Grafikte sabit çizgiler ne anlama geliyor olabilir? Bu tarihlerde karbon emisyonu olmamış mı yoksa sabit oranda artmaya devam ettiğini mi gösteriyor?

l) Farklı ülkelerin grafiklerinde ortak olarak gözlemlediğiniz artma veya azalma olan yıllar hangileri? Bu yıllar herhangi bir anlaşma öncesi veya sonrası olabilir mi?

m) Bu grafikler dikkate alındığında, seçmiş olduğunuz ülkenin geleceğe yönelik karbon emisyon seviyesini nasıl olabilir?

- **Fikir Geliştirme** bölümünde hangi adım veya adımları takip ettiğinizi düşünüyorsunuz? Yuvarlak içine alarak işaretleyiniz.

Veri bulma/inceleme	Veri toplama	Veri düzenleme	Veri görselleştirme	Veriyi analiz etme/yorumlama	Hiçbiri

Figure F.2. Worksheet 2 (cont.).

4) Ürün Geliştirme

Görev: LabStar tarafından oluşturulan verileri dikkate alarak seçmiş olduğunuz ülkede önlem alınması gereken durumlarla ilgili atılacak adımları belirlemek üzere bir rapor hazırlayın. Rapor basamaklarını daha önce cevapladığınız sorular doğrultusunda belirleyin. Önlemler doğrultusunda ülkenizin geleceğe yönelik karbon emisyonu seviyesi ile ilgili tahminlerinizi grafik çizerek gösterin.

a) İnsan kaynaklı karbon emisyonlarını azaltmak için olası eylemler nelerdir?

b) Nüfus karbon emisyonunu nasıl etkiler? Açıklayınız.

c) Yapılaşma karbon emisyonunu nasıl etkiler? Açıklayınız.

d) Taşıt kullanımı karbon emisyonunu nasıl etkiler? Açıklayınız.

e) Atık miktarı karbon emisyonunu nasıl etkiler? Açıklayınız.

f) Ülkenizin karbon emisyonunu 2050 yılına kadar azaltmak için hangi hedefi belirleyeceksiniz?

g) Ülkenizde belirlediğiniz hedefler doğrultusunda 2100 yılına kadar Sıfır Karbon emisyonu hedefine ulaşmak mümkün müdür? Açıklayınız.

Figure F.2. Worksheet 2 (cont.).

h) Ders boyunca edindiğiniz bilgiler, grup tartışmalarında konuşulanlar ve değerlendirmeleriniz sonucunda bir rapor oluşturunuz. Raporunuzda derste yaptığımız farklı bölümlerden gerekli gördüğünüz cevapları alarak öğrendiklerinizi özetleyiniz.

Rapor:

i) Önlemler doğrultusunda ülkenizin geleceğe yönelik karbon emisyonu seviyesi ile ilgili tahminlerinizi grafik çizerek gösterin.

- **<u>Ürün Geliştirme</u>** bölümünde hangi adım veya adımları takip ettiğinizi düşünüyorsunuz? Yuvarlak içine alarak işaretleyiniz.

Veri bulma/inceleme	Veri toplama	Veri düzenleme	Veri görselleştirme	Veriyi analiz etme/yorumlama	Hiçbiri

Figure F.2. Worksheet 2 (cont.).

5) Test Etme

Raporunuzu test etmek için İklim Eylem Aracını kullanın. Burada verilen değişkenleri göz önüne alarak raporunuzu tekrar değerlendirerek eklemeler yapın.
https://www.climateinteractive.org/tools/

a) Ülkeniz karbon emisyonlarını önlemek için ne yapabilir? Açıklayınız.

b) Planınızın küresel katkıları nelerdir? Açıklayınız.

c) Raporunuzla CO_2 emisyonunu sıfıra indirmek mümkün mü? Açıklayınız.

d) Raporunuz net sıfır emisyon ihtiyaçlarını karşılıyor mu? Açıklayınız.

Raporu aşağıdaki rubrik ile değerlendirin. Yeniden düzeltilecek yerleri belirleyin.

Raporu oluştururken:

1. Ülkenin ekonomik ve sosyal çıkarları dikkate alındı.	1	2	3	4	5
2. 21. yüzyıl teknolojilerinin kullanımı dikkate alındı.	1	2	3	4	5
3. Ülke çıkarlarını koruyarak yeşil alanlara öncelik verildi.	1	2	3	4	5
4. Ülkenin iklimi ve nüfusu gibi faktörleri dikkate alarak yenilenebilir ve yenilenemez enerji kullanımı planlandı.	1	2	3	4	5
5. Çevre dostu bina ve şehir planlaması dikkate alındı.	1	2	3	4	5
6. Fabrikaların üretim faaliyetlerini etkilemeyecek tedbirler dikkate alındı.	1	2	3	4	5
7. Ülkenin kalkınmasını engelleyecek adımlar dikkate alındı.	1	2	3	4	5
8. Ülkenin aldığı tedbirlerin ekonomik gelişmişlik düzeyini aşan bir maliyette olmaması dikkate alındı.	1	2	3	4	5

- **Test Etme** bölümünde hangi adım veya adımları takip ettiğinizi düşünüyorsunuz? Yuvarlak içine alarak işaretleyiniz.

Veri bulma/inceleme	Veri toplama	Veri düzenleme	Veri görselleştirme	Veriyi analiz etme/yorumlama	Hiçbiri

Figure F.2. Worksheet 2 (cont.).

6) Paylaşım Yapma

6.
Görev: Test etme bölümünde yaptığınız çalışmaları da dikkate alarak COP22'de ülkenizin alacağı önlemleri açıklayan bir poster hazırlayarak arkadaşlarınızla paylaşınız. Posterinize İklim Eylem Aracı'nda oluşturduğunuz grafiği, kendi çizdiğiniz grafiği ve raporunuza yazdıklarınızı ekleyerek bu derslerden öğrendiklerinizi özetleyiniz.

Aşağıdaki soruları sunumlar sonrasında cevaplayınız.

Farklı gruplar tarafından sunulan raporları incelediğinizde,

a) Gelişmekte olan ülkelerin ve gelişmiş ülkelerin karbon emisyonu zaman içinde nasıl değişiyor? Açıklayınız.

b) Düşük gelir ve yüksek gelir, zaman içinde CO2 emisyonlarındaki değişimi nasıl etkiler?

c) Karbon emisyonunu azaltmak amacıyla çözüm odaklı okulda ne yapılabilir?

d) İl bazında ne yapılabilir?

- **<u>Paylaşım Yapma</u>** bölümünde hangi adım veya adımları takip ettiğinizi düşünüyorsunuz? Yuvarlak içine alarak işaretleyiniz.

Veri bulma/inceleme	Veri toplama	Veri düzenleme	Veri görselleştirme	Veriyi analiz etme/yorumlama	Hiçbiri

Figure F.2. Worksheet 2 (cont.).

APPENDIX G: POSTER ANALYSIS FOR ALGORITHMIC THINKING

	Poster 1 in LP 1	Poster 2 in LP 2
Group 1	-Inference -Concepts -Definitions -Comparisions -Graph descriptions	-Current situation of the country -What emissions did the country make in history -Comparison with emissions from other countries -How many targets planned -How will actions be limited? -Chart drawing -Action plan image -Zero carbon target -By what percentage will it be reduced? -Sanctions for the implementation of targets
Group 2	-Concepts -Definitions -Research method -Graphs -Graph descriptions	-What actions of the country in the past have contributed to this increase? -Current situation -Problem sentence -Solutions/actions -By what percentage will it be reduced? -When will emissions be reduced -The current chart of the country and inference -Future planning -Action plan image -Graph
Group 3	-Concept -Research method -Inference -Graphs -Graph titles	-Graph -Status of the country's carbon emissions compared to other countries (current situation) -How should we limit actions (measures) -When will emissions be reduced -The effect of measures on global temperature increase -Zero emissions target -Action plan image

Figure G.1. Poster analysis.

Group 4	-Concept -Research steps -Inference -Graphs -Graph titles	-Causes of carbon emissions -Suggestions for solutions to reduce emissions -Sharing the future scenario -Comparison of the amount of carbon emissions of the two countries -Compared and inferred the carbon emissions of different continents -Emphasizing that climate change is a common problem of countries -When will emissions be reduced -Graph
Group 5	-Concept -Definition -Graph interpretation -Graphs -Graph descriptions	-The current situation -Since when is it considered -What actions should be considered for this country How should we limit actions? -By what percentage will it be reduced? -Graphic drawing -Action plan image

Figure G.1. Poster analysis (cont.).

APPENDIX H: POSTERS CREATED BY STUDENTS

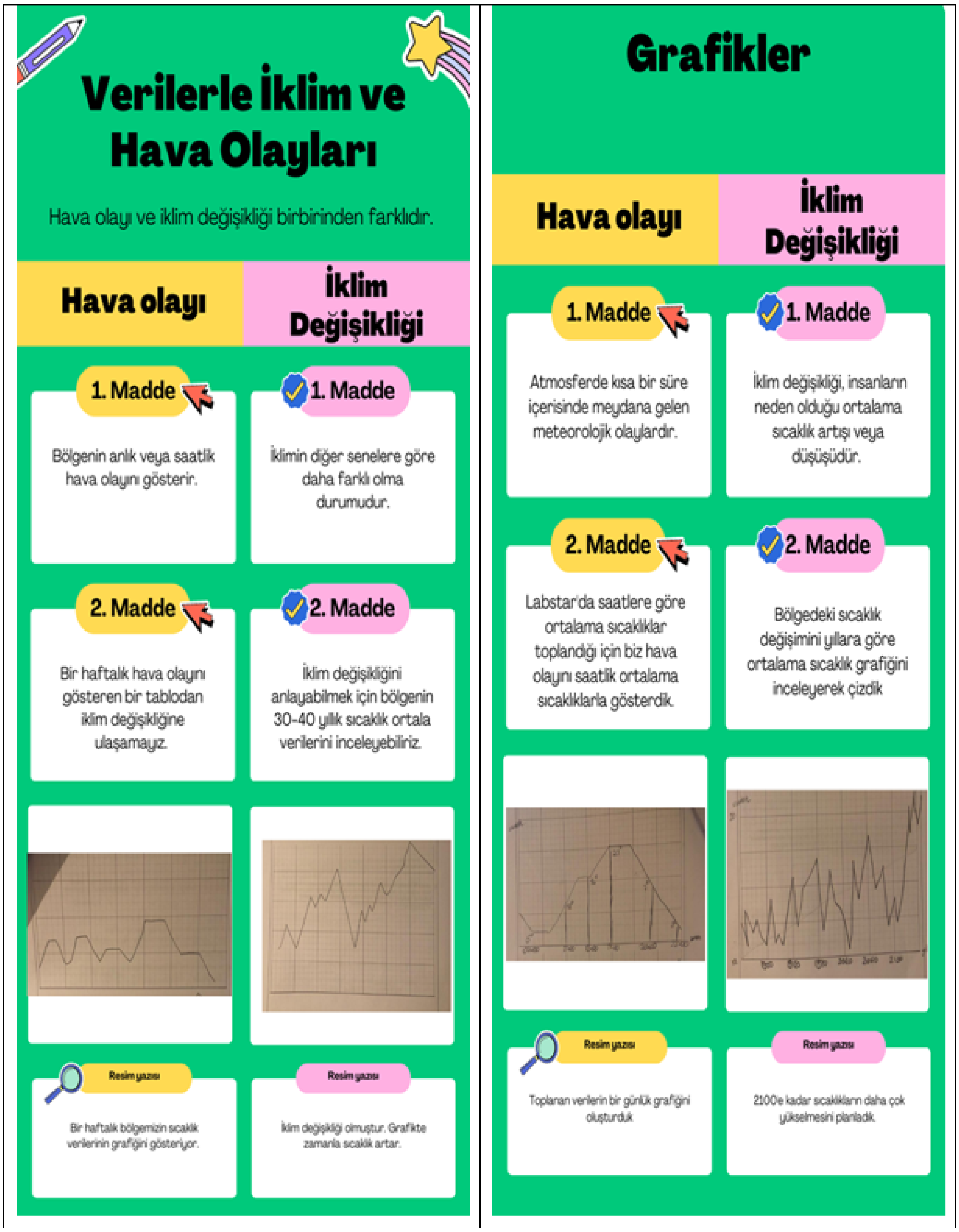


Figure H.1. Posters

Figure H.1. Posters (cont.).

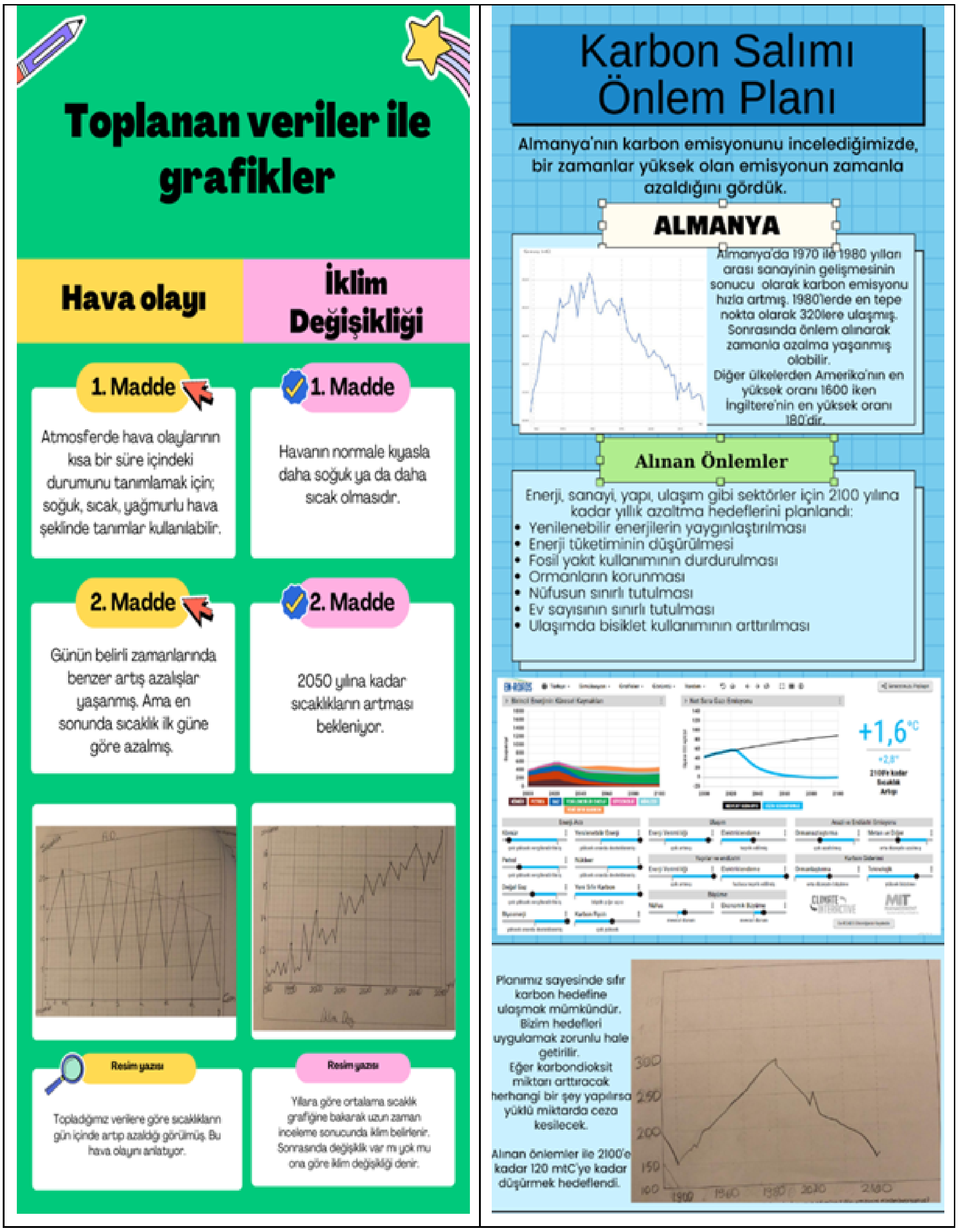


Figure H.1. Posters (cont.).

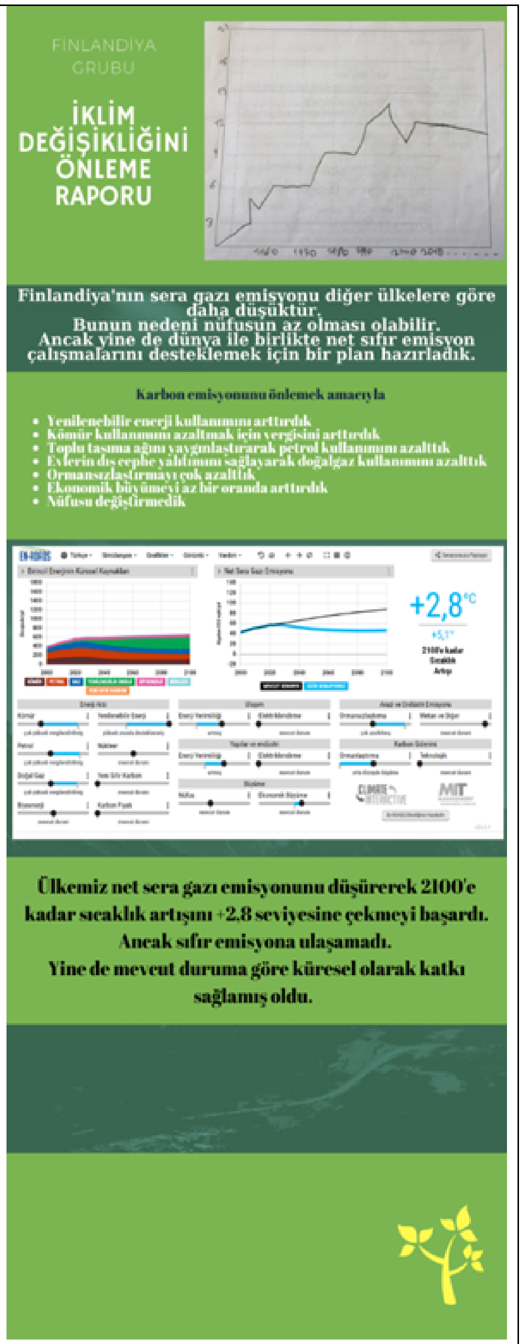


Figure H.1. Posters (cont.).

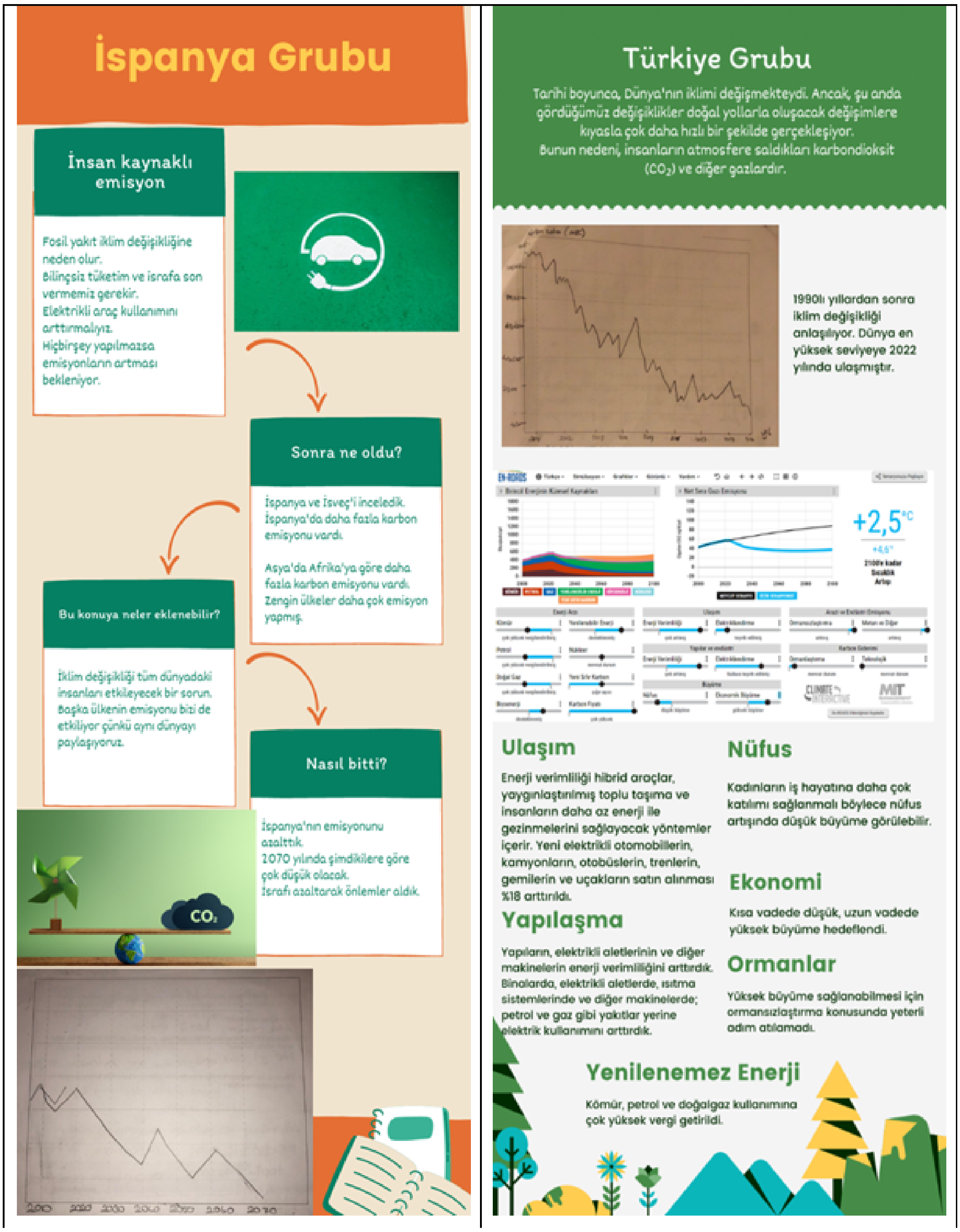


Figure H.1. Posters (cont.).

APPENDIX I: INTERVIEW QUESTIONS

1. Bu derslerde yaptıklarınızdan aklında kalanları kısaca özetleyebilir misin?

2.Grup çalışmasında neler yaptınız? Sırasıyla aklında kalan şekilde açıklayabilir misin?

- Grup çalışmalarında hangi aşamalarda katkın oldu? Senin katkının olduğu kısımları açıklayabilir misin?

3. Birlikte yaptığımız bu dersleri faydalı buldun mu? Nasıl? (Kendin için veya arkadaşların için)

4. Aşağıda verilen ifadeleri derslerimiz boyunca yaptığımız etkinliklerden örnekler vererek açıklayabilir misin?

"karmaşık bir görevi alt süreçlere bölmek" (Decomposition)

- Yaptıklarınız arasında sence karmaşık bir görev var mıydı? Ona göre nasıl bir çözüm ürettiniz?

"yinelenen öğelerin belirlenmesi" (Pattern Recognition)

- Etkinlik boyunca tekrar tekrar yaptığınız şeyler nelerdi?

"yararlı genellemeler oluşturmak için ayrıntıları çıkarma süreci" (Abstraction)

- Topladığınız verilerden anlamlı bir sonuç çıkarana kadar yaptığınız aşamalar nelerdi?

"belirli dizilerin oluşturulması" (Algorithmic thinking)

- Grup olarak oluşturduğunuz raporda verilerden anlamlı bir sonuç çıkarmanızı sağlayan süreçlerden bahseder misin? Rapor oluştururken nasıl bir planlama yaptınız? Bu sonuçları raporda hangi düzende belirttiniz?

5. Birlikte yaptığımız derslerde en kolay gelen kısım hangisiydi? Açıklar mısın?

a-Grup olarak

b-Bireysel olarak

6. Birlikte yaptığımız derslerde en çok zorlandığınız kısım hangisiydi? Açıklar mısın?

a-Grup olarak

b-Bireysel olarak

Figure I.1. Interview questions.

7. En zor yorumladığınız kısım sizce nasıl daha kolay yorumlayacağınız hale getirilebilir?
   - Zorlandım çünkü talimatlar eksik/hatalıydı
   - Zorlandım çünkü süreç çok karmaşıktı
   - Zorlandım çünkü bu konuya ilgim yok
   - Zorlandım çünkü çok fazla aşama vardı

8. Bu derslerin iklim değişikliği hakkında bilginize katkı sağladığını düşünüyor musun? Açıklar mısın?
   - Bu derslerin iklim değişikliğini verileri kullanarak yorumlamana etkisi oldu mu? Nasıl?

9. Bu dersler bilimsel düşünme becerilerini etkiledi mi? Nasıl? Etkilemediyse neden?

10. Birlikte yaptığımız dersler verileri anlama, analiz etme ve yorumlama becerilerini etkiledi mi? Nasıl?

11. Bu derslerde öğrendiklerin veya kullandığın araçlar bundan sonra bilimsel düşünme süreçlerinde kullanacağın yöntemlere herhangi bir katkı sağladı mı? Açıklar mısın?

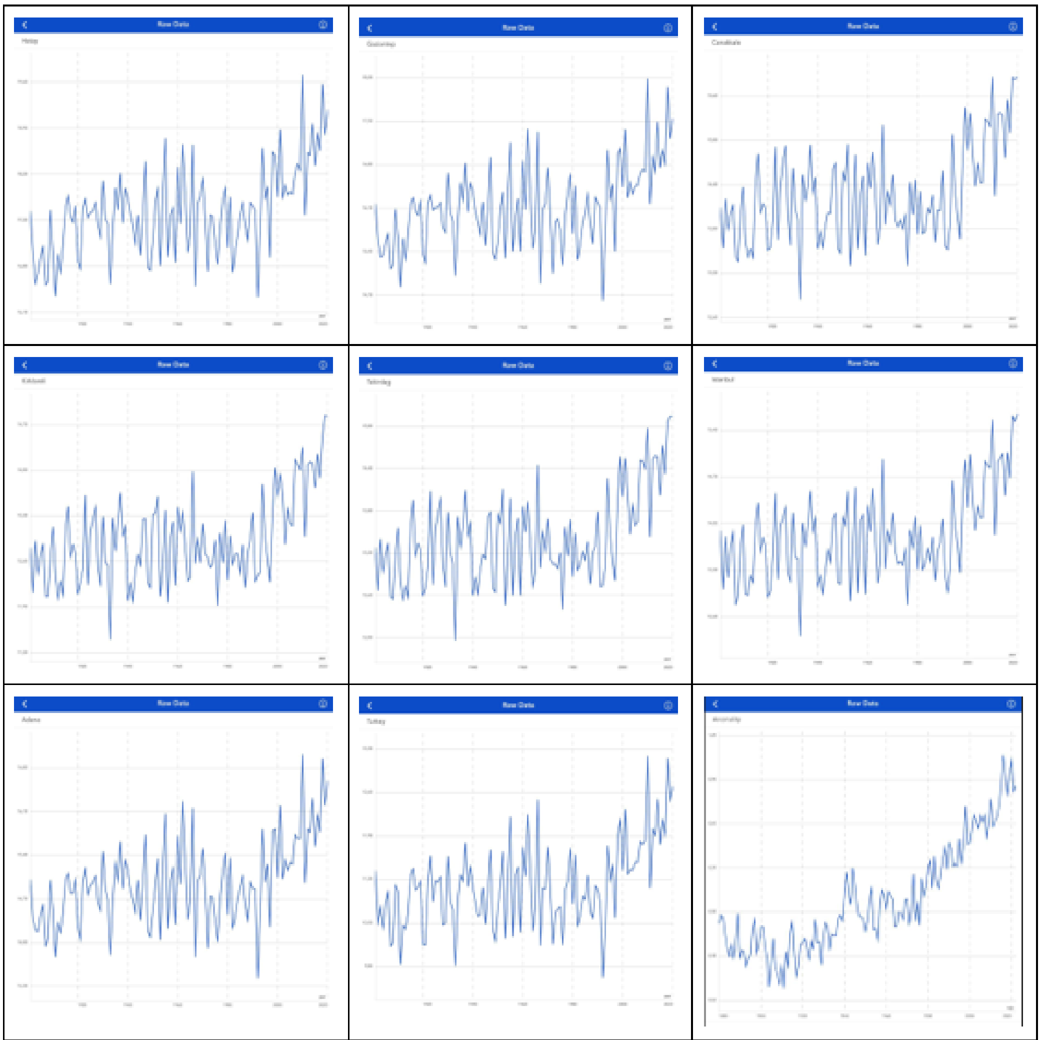
12. Son olarak çalışmayla ilgili eklemek istediğiniz bir şey var mı?

Figure I.1. Interview questions (cont.).

APPENDIX J: GRAPHS CREATED BY LABSTAR™

Figure J.1. LabStar™ graphs.

Figure J.1. LabStar™ graphs (cont.).



Eylül Ayı Yıllara Göre Sıcaklık Tablosu

EDİRNE		KIRKLARELİ		TEKİRDAĞ		İSTANBUL	
Yıl	Sıcaklık	Yıl	Sıcaklık	Yıl	Sıcaklık	Yıl	Sıcaklık
2010	21	2010	20.6	2010	21.6	2010	21.4
2011	22.6	2011	21.6	2011	22.3	2011	22
2012	22.2	2012	21.2	2012	22.1	2012	21.2
2013	21.1	2013	19.9	2013	21.6	2013	21
2014	19.8	2014	19.4	2014	20.6	2014	21.3
2015	19.3	2015	17.5	2015	16.8	2015	21
2016	21.5	2016	20.5	2016	21.6	2016	21.7
2017	22.1	2017	21.8	2017	21.6	2017	22.4
2018	21.6	2018	20.9	2018	21.8	2018	21.9
2019	21.7	2019	20.8	2019	21.6	2019	21.8
2020	23.7	2020	22.3	2020	23.1	2020	23.5
2021	20.7	2021	19.3	2021	20.6	2021	20.8
2022	21.3	2022	19.9	2022	21.5	2022	21.4

Figure J.1. LabStar™ graphs (cont.).

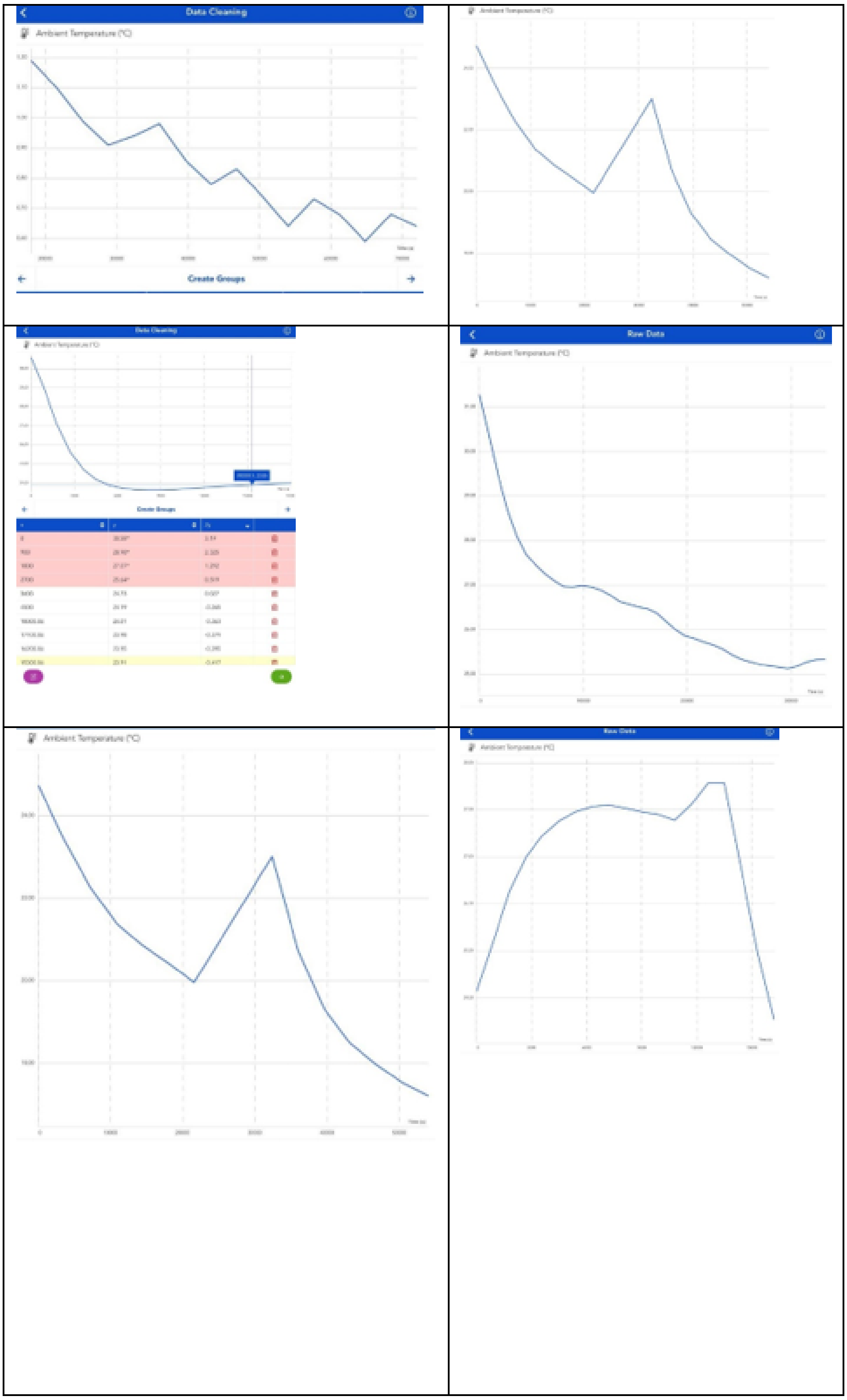


Figure J.1. LabStar^{TM} graphs (cont.).