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PREDICT - OBSERVE - EXPLAIN - DO: CALCULATE YOUR CARBON FOOTPRINT ACTIVITY IN DISTANCE EDUCATION[1]

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ABSTRACT

Formal and informal education have transitioned to distance learning in many countries due to the Covid-19 pandemic. This study aimed to develop an activity for science lessons during distance education to increase students' knowledge of and awareness about environmental problems. The study was conducted with 7th grade students enrolled in a public school in Turkey. The activity was designed based on the predict-observe-explain-do (POED) method to promote students' inquiry-based learning. The activity engaged students in researching about and calculating carbon footprint, discussing the causes and effects of global warming, sharing ideas about how to protect the environment, and creating products to raise awareness about environmental issues. Data analysis suggested that the students were active participants in the learning tasks, were motivated to learn the concepts, and increased their awareness about global warming. A suggestion of the study is to design similar POED activities for other science topics.
Keywords: carbon footprint, predict-observe-explain-do method, distance education.

TAHMİN ET - GÖZLE – AÇIKLA - YAP: UZAKTAN EĞİTİMDE KENDİ KARBON AYAK İZİNİ HESAPLA ETKİNLİĞİ

ÖZ

Covid-19 pandemisiyle birlikte birçok ülke eğitim faaliyetlerini uzaktan eğitim yoluyla sürdürmektedir. Bu çalışmanın amacı uzaktan eğitim sürecinde öğrencilere fen dersinde farklı öğrenme ortamlarında etkinlikler yaparak derslerin ilgi çekiciliğini artırmak ve aynı zamanda öğrencilerde çevresel farkındalık oluşturmaktır. Çalışma Kocaeli ilinin Dilovası ilçesinde bir devlet okulunda öğrenim gören 7. sınıf öğrencileriyle yürütülmüştür. Çalışmada öğrencileri derste aktif kılacak ve sorgulama yapmalarını sağlayacak tahmin-gözlem-açıklama-yapma (TGAY) yöntemi uygulanmıştır. Bu yöntem ile öğrencilere kendi karbon ayak izleri hesaplatılmış, çıkan sonuçlar üzerinden küresel ısınma ve sera etkisi gibi konularda çıkarımlar yapmaları sağlanmış ve bu konularda nasıl önlemler alabilecekleri tartışılmıştır. Yapma aşamasında öğrencilerin öğrendiklerini kullanarak afiş veya maket tasarlamaları sağlanmıştır. Çalışmanın sonucunda uzaktan eğitim sürecinde öğrenciler derste daha aktif hale getirilmiş, derslere olan ilgileri artırılmış, aynı zamanda ortaokul çağında olan çocuklarda erken yaşta çevresel farkındalık oluşturulmuştur. Fen derslerinde farklı konular için de bu tür TGAY etkinlikleri yapılmasının öğrencilerin derse olan ilgilerini arttıracağı düşünülmektedir.
Anahtar kelimeler: karbon ayak izi, tahmin-gözlem-açıklama-yapma yöntemi, uzaktan eğitim.

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INTRODUCTION

Throughout the course of history, there have been many times when epidemic diseases have spread through the human population. An epidemic that has spread over a continent or several countries is defined as a major epidemic or pandemic (Turkish Language Association, 2021). The World Health Organization (WHO) declared the recent Covid-19 outbreak a pandemic on March 11, 2020 (WHO, 2020). The Covid-19 pandemic has particularly affected the educational systems worldwide. Formal and informal face-to-face education were suspended in many countries due to the pandemic and transitioned to distance learning. In Turkey, face-to-face education was suspended on March 16, 2020. As of this date, all schools have transitioned to distance education.

Distance education allows students and teachers to connect to and communicate with each other even though they are physically separated. It helps students benefit from different educational environments regardless of place and time (Graham & Scarborough, 2001). After the suspension of formal and informal face-to-face education due to the Covid-19 pandemic, distance education has been in place in Turkey similar to many other countries in the world. Distance education, which has now become a necessity, has positive aspects as well as some limitations. Research studies have revealed that according to the teachers, students' participation in online lessons was low, and one of the main reasons for this was low motivation (Bostan Sarıoğlan et al., 2020; Koçoğlu & Tekdal, 2020; Ünal & Bulunuz, 2020). The teaching methods most frequently used by teachers in the distance education were found to be question-answer, lecture, and problem solving (Bakioğlu & Çevik, 2020). On the other hand, students expressed that they had difficulties in comprehending the concepts during the online lessons (Başaran et al., 2020). These research findings indicate that different teaching methods and techniques should be used to increase the interest and motivation of students in distance education. Aligned with this idea, the current science curriculum emphasizes that the lessons should be taught in student-centered learning environments (Ministry of National Education [MoNE], 2018). For these reasons, it is important to design learning environments in which students actively participate in science lessons. Science lessons should be taught in a way that engages students in active learning by doing and experiencing. Learner-centered teaching methods such as conducting experiments facilitate students' learning and increase their interest and motivation towards the subject matter (Palmer, 2009). In a similar line of thought, using teaching approaches that engage students in active learning might increase their interest and motivation to learn the subject matter in distance education as well.

Using the Predict-Observe-Explain-Do (POED) method in online science lessons promotes students' conceptual learning, inquiry-based thinking, and motivation (Chen, 2020). While the first three phases of the POED method, which is a method that can be used in distance education, are similar to the well-known Predict-Observe-Explain (POE) method, the fourth phase "Do" differs. The first step of the POED method is the *Predict* phase. In this phase, students are required to predict the outcome of an event and justify their predictions. Thus, they are encouraged to use higher order thinking skills (Hsiao et al., 2017). In the *Observe* phase, students conduct observations about the initial event and derive a cause-effect relationship regarding the initial event based on their observations (Hsu et al., 2011). This second phase helps students enhance their interpretation skills. In the *Explain* phase, students are asked to discuss the reasons for any conflict between their predictions and observations (Çınar & Bayraktar, 2014). Through the third phase, students learn that outcomes might be completely different from what they initially anticipated and that they need to make careful observations (Köklükaya & Güven Yıldırım, 2018). In the fourth phase, *Do*, students have the opportunity to apply what they have learned in the previous phases (Chen, 2020). The POED method provides students with opportunities to connect scientific knowledge with hands-on processes in distance education (Chen, 2020).

Similar to POED, using simulations in science lessons is one of the methods that can be used in distance education to make it easier for students to learn abstract concepts. Simulations are computer models that allow to conduct experiments digitally. They are particularly useful for activities that are difficult to observe,

high cost, and dangerous to implement. Through simulations, students can visualize abstract science concepts and make sense of theoretical topics (Özcan et al., 2020). It is difficult for students to make direct observations on issues such as global warming, greenhouse gases, and measurement of carbon footprint. To teach these types of topics, simulations can be used to plan and implement student-centered lessons. Oluk and Özalp (2007) suggested in their study that using animations could increase student curiosity and facilitate learning of the topics such as global warming. A simulation and an animation were used in the activity that will be shared in this paper.

As the world develops rapidly, human population also increases at a rapid pace. This leads to a higher demand for energy. With the increasing industrialization, urbanization, and developing technology in recent years, the Earth's ecosystem has started to deteriorate. For example, the Earth has started to get warmer. According to the last Intergovernmental Panel on Climate Change (IPCC) special report, the average global temperature on Earth has increased by 2 degrees Celsius compared to pre-industrialization period and will continue to increase rapidly if measures are not taken (IPCC, 2018). One of the most important factors that influence global temperature is greenhouse gases (Freije et al., 2017). The constant pollution of nature and the increase in the amount of greenhouse gases in the atmosphere cause global warming and related climate change (Şahin & Onurbaş Avcıoğlu, 2016). Research studies drawing attention to global warming have recently highlighted the concept of carbon footprint. Carbon footprint can be defined as a measure of the impact a person's daily activities have on the amount of carbon dioxide gas released through the burning of fossil fuels. With the increase in global warming and the decrease in natural resources, it has become extremely important to take measures to identify and reduce the carbon footprint (Argun et al., 2018). Related to this issue, many institutions and organizations calculate their carbon footprint and try to take measures to reduce it. When these measures are examined, it is found that factors such as the amount of natural gas usage, excessive electricity consumption, and high usage of personal motorized vehicles increase the carbon footprint (Kumaş et al., 2019). In addition, individuals can reduce their carbon footprints by taking measures such as turning off unused devices, using public transportation instead of private motorized vehicles, and purchasing organic local products (Gökçek et al., 2019).

The young generation will experience the adverse consequences of global warming (Jorgenson et al., 2019). Therefore, it is highly important to educate the new generation about various environmental problems as well as global warming and to teach them what can be done to solve these problems (Bozdoğan, 2011).

Research studies conducted with students at different grade levels show that students have limited and often erroneous understanding about global warming and its effects (Anderson & Wallin, 2000; Bozdoğan, 2011; Freije et al., 2017; Kilinc et al., 2008; Pekel, 2005). These findings indicate a need for future studies that focus on enriching students' knowledge of global warming and increasing students' awareness on environmental issues (Lester et al., 2006). It is important to nurture environmental awareness in students and help them build robust knowledge about environmental problems including global warming. Students' awareness of carbon footprint, which is an important factor in global warming, should also be considered in this respect. Demirer and Ören (2020) examined middle school students' perceptions of ecological footprint using a word association test. They found that the students had limited or incorrect knowledge about ecological footprint such as they were the remains of living creatures of the past. Keleş (2011) and Çetin (2015) reported in their studies that the teaching approaches they applied were effective in raising primary school students' awareness about environmental problems and reducing their ecological footprints. The related literature includes some studies on reducing the ecological footprints of undergraduate students (Keleş et al., 2008; Keleş, 2014). These studies show that effective teaching methods can help students build knowledge about ecological issues. Based on the related literature, this study aimed to develop an activity to increase students' knowledge of and awareness about environmental problems. Science teachers can use this activity to engage their students in active learning of the concepts of global

warming and carbon footprint in distance education. Additionally, the activity might increase students' curiosity and interest in online science lessons.

ACTIVITY IMPLEMENTATION

Calculate your own carbon footprint activity was designed to increase the effectiveness of online science lessons by providing different learning environments to middle school students in the distance education process. If students build robust knowledge about environmental issues such as global warming, greenhouse gases, and carbon footprint, they will be more likely to become responsible to take precautions for conservation of natural resources and energy consumption. Such learning experiences will also help to raise environmental awareness in students at an early age. The activity was planned using the student-centered teaching approaches to make the content more interesting and fun to learn. The students were asked to complete interesting, meaningful, and practical tasks that required active participation.

The activity was used with 27 seventh grade students who were enrolled in a public school in Dilovası district of Kocaeli province in Turkey. These students were the participants of the study. A science teacher (the second author) taught the activity during the online lessons with the participant students over the Zoom platform. The study was completed in 2 weeks and took 6 lesson hours in total. The reason why the study took 2 weeks is that the students were given time to make observations and to research the topics under study. The activity targeted the following curriculum standard in the "Energy Conversions and Environmental Awareness" unit within the science curriculum: "Discusses the causes and possible consequences of global climate change" (MoNE, 2018). The curriculum standard notes "Students are asked to calculate their ecological footprints (they can use secure sites ending with edu, org, or mil)." This curriculum standard and the related note guided the design of the activity described in this paper.

Prior to activity implementation, the tasks and questions to be included in each phase of the POED model were constructed by the researchers. Before the actual implementation, a pilot implementation was conducted with a group of seventh grade students enrolled in a public school in Gebze district of Kocaeli province through the Zoom application. Based on the pilot study, some minor revisions were made on the activity, and then the actual implementation took place.

Necessary permissions were obtained in accordance with the ethical guidelines in human research (Balıkesir University Social and Human Sciences Ethics Committee, document numbered E-19928322-302.08.01-10835). Prior to the study, the participation acceptance form and parental consent form were sent to the parents and their permission was obtained for the students' participation in the study. The identity of the students participating in the study and their personal data were not shared with third parties.

Calculate your own carbon footprint activity was implemented in four steps aligned with the phases of the POED model. Separate online lessons were carried out for each POED phase. The questions prepared previously were sent to the students at each phase, and the students were asked to send their answers to the teacher until the next phase. The implementation of each POED phase is presented in detail below.

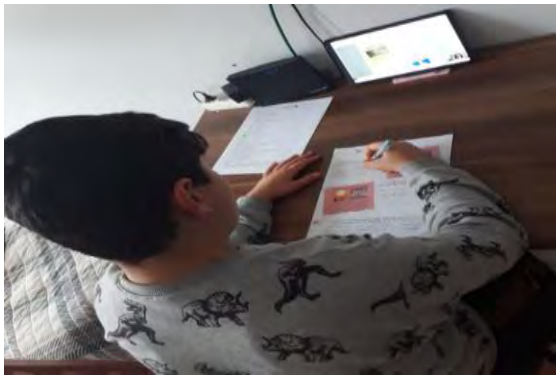
The Predict Phase

During the predict phase, the students were given parts of four news articles (Appendix 1) about some extraordinary natural events. They were asked to predict and think about the reasons for each news. An example news is given in Figure 1.

Figure 1. A Sample News from the Predict Phase

After the news articles were given to the students, the students were asked to inquire about the reason for the situations explained in each news and share ideas with each other. Images from the predict phase are presented in Photograph 1 and Photograph 2 below.

Photograph 1. The Teacher During the Predict Phase



Photograph 2. A Student During the Prediction Phase

The teacher did not interfere with the students' ideas at this stage. After the students shared their initial ideas, the teacher posed the question "Do you have any responsibility for the situations given in the news? What do you think about this?" Students first answered this question individually by writing their opinions on the worksheet. The worksheet designed for the predict phase was sent to the students by the teacher prior to the lesson via the WhatsApp application. The students wrote their answers and then send it back to the teacher. For the predict phase, interesting news articles on climate change were chosen to grab the students' attention. The aim here was to motivate the students, to encourage them to question and think, and to arouse their curiosity. Sample answers given by the students to the question above in the predict phase are presented in Figures 2 and 3 below. The student S8 whose answer is given in Figure 2 wrote "I might have responsibility for Eskişehir and Çanakkale, but I don't have responsibility for Antarctica or Germany." S19's answer is as follows: "I honestly think that everybody has some responsibility. I throw waste in open areas. So, yes, I do, but I don't have any responsibility in breaking off an iceberg as big as Malta."

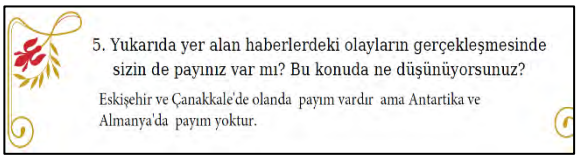


Figure 2. S8's Answer to a Prediction Question

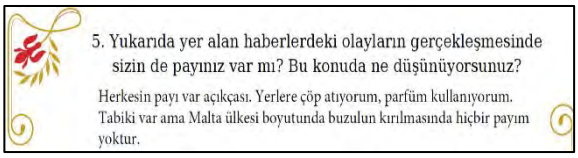


Figure 3. S19's Answer to a Prediction Question

Other students also shared similar perspectives. Students' answers indicated that they thought that they had limited or no responsibility for the events described in the news about global warming. Many of the students thought their effect on global warming to be limited to Turkey and that they had no influence on the natural events occurred in other countries. It was observed that the students lacked knowledge or had erroneous conception about global warming and the causes and effects of global warming. At this stage, the teacher was not evaluative and did not judge the correctness of the students' answers. The aim is to ensure that the students construct knowledge about global warming themselves by engaging in the activity tasks through POED phases.

The Observe Phase

A main goal of this phase is to have students make observations about the reasons of the situations. In line with this goal, the students were asked to calculate their own carbon footprint to actively examine their influence on the environment. During the activity planning process, the authors searched resources on the calculation of carbon footprint, and examined many web sites that calculate carbon footprint. They agreed on a web site ("Karbon Hesaplama", n.d.) after careful considerations about the students' age, language, and

developmental levels. Later, the researchers created a form entitled "House Information" (Appendix 2) by using the information and questions available on the web site. This form was created to calculate the carbon footprint. The students used the form to collect and record information that they will use to calculate their own carbon footprint. The online lessons were conducted during the observe phase as well. The house information form given in Appendix 2 was used to introduce the concept of carbon footprint to the students. The form contains detailed and clear instructions about what information students need to calculate their carbon footprint. Since the observe phase was completed during distance learning, the form was shared with the students via the Zoom application. Photograph 3 and Photograph 4 show images from the observe phase where the students collected data and calculated their own carbon footprint.

Photograph 3. A Student Filling the House Information Form

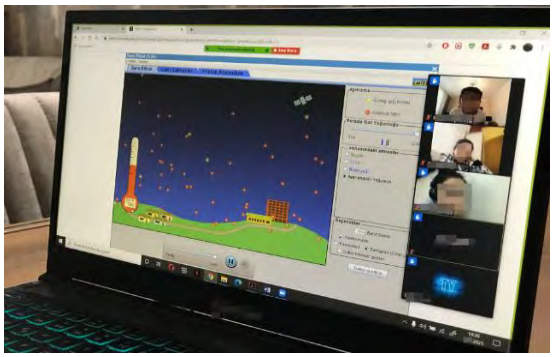
Photograph 4. A Student Calculating Her Carbon Footprint

After the students were introduced to how to calculate their carbon footprints through an example presented by the teacher in a synchronous online lesson, the students were given 2 days to calculate their carbon footprints by making their own observations and research. During this time, the students gathered the necessary information to calculate their carbon footprint. Since the calculations were to be made over 1 year, the students took this point into consideration while collecting the necessary data. Information such as annual electricity and natural gas consumption is among the information required when calculating the carbon footprint. With the help of their families, the students were able to access this information from monthly bills and calculated their average annual expenses by using their ratio and proportion knowledge (i.e., the ratio of 1 month to 1 year). The students received information and help from their families and the teacher when they had difficulty in collecting the necessary information.

After the students collected the necessary information and completed their calculations, the class got together in the next online lesson to discuss their findings. Students compared their carbon footprint values with one another. Some students noticed errors in their calculations during the online lesson and had an opportunity to correct those errors. The average annual carbon footprint value per person is 4 tons in the world, while the targeted value is 2 tons (Hitit University Presidency, 2019). The whole process of carbon footprint calculations and the related online discussions helped students to realize what factors influence the value of carbon footprint. The students learned about the targeted average carbon footprint value in the world and compared this value to their own carbon footprint. Thus, the students had the opportunity to make inferences about the size of their carbon footprint by comparing their own results to the target number.

In order to enrich the observe phase, the teacher had the students use a simulation about greenhouse gases (Physics Education Technology Project, 2021). The students used this simulation to change the density of greenhouse gases in the environment and to observe the related change in the temperature. In addition, pre- and post-industrial greenhouse gas density and the related earth's temperature were observed using the simulation. An important observation made during this task was that when the concentration of greenhouse gases is zero, the temperature of the earth will be very low. The goal of this task was to help students realize that greenhouse gases in the

atmosphere have an important role to balance the temperature of Earth and that the density of these gases increases or decreases with the effect of human activities. The simulation is shown in Photograph 5.



Photograph 5. The Simulation

The Explain Phase

In the explain phase, the questions given in Appendix 3 were asked to the students. The purpose of the explain phase is to compare the initial predictions with the actual observations and to explain the reason if there are any discrepancies. This process helps students consolidate learning of new knowledge. In the current study, the students answered several questions that required the use of higher order thinking skills. The first question was as follows: "Compare the predictions and comments you made about the news articles with the results you obtained from your observations. Did your predictions match your observations? Explain your answer." Sample student answers given to this question are presented in Figures 4 and 5. Students' original answers were written in Turkish. They were translated into English for the purpose of this study.

They do not match each other because I thought that I have an influence for Eskişehir and Çanakkale, but it happened to be that I also have influence for Antarctica and Germany, I was not expecting this at all.

Figure 4. S3's Answer for the First Question

No, they did not match each other because I was thinking that I would not have any effect, but I did. I noticed this as a result of the observations I made.

Figure 5. S22's Answer for the First Question

An analysis of the students' answers to the first question revealed that the students realized that their effect on global warming were more than they anticipated. Students who initially thought that their influence to the environment was limited to the country they lived in, that is Turkey, realized that their carbon footprint affects the whole world. The carbon footprint of most of the students was above the average value targeted by the world. This finding was quite surprising for the students who initially believed that they did not have any individual effect on global warming. In addition to this, students understood that daily human activities may also have an effect on global warming. At the beginning, students focused on more collective activities as the cause of global warming such as the smoke coming out of the factory chimneys, the smoke coming out of the car/bus exhausts, and water waste. In the initial stages of the activity, the students did not express that their individual activities could also have an effect on global warming, indicating lack of knowledge on the causes of global warming. By the end of the activity, the students realized that daily activities such as transportation and heating could also cause global warming. Students' answers indicated that they learned new knowledge about global warming by engaging in the activity tasks and revised some of their previous conceptions about the causes of global warming. At the end of the explain phase, the students were asked the question "What are the effects of your carbon footprint on global warming?" (Question 4 on appendix 3). After calculating their carbon footprint, the students said that they realized that they had effects on global warming individually. The answer given by the student coded S8 is presented in Figure 6 as a typical student response.

The effects of my carbon footprint on global warming are as follows: My carbon footprint turned out to be large because I use electricity, transportation, and heating. These factors cause carbon dioxide emissions that have an effect on global warming. Therefore, I have an influence on global warming with my carbon footprint.

Figure 6. S8's Answer for the Fourth Question

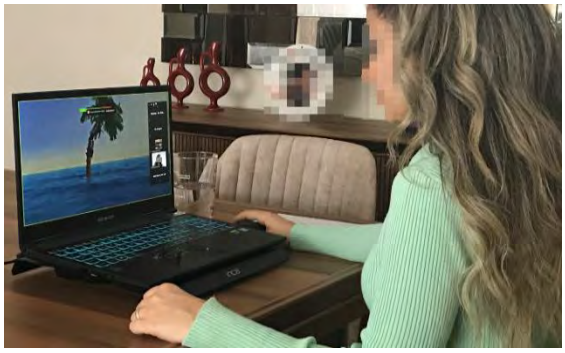
The last question posed to the students in this phase was "What measures will you take from now on to reduce your carbon footprint?"

(Question 5 on appendix 3). In general, the students expressed the view that they will be more responsible in electricity and water consumption, use public transportation instead of private vehicles with their families, and be more careful with recycling in order to reduce their carbon footprint. As an example, the answer given by the student coded S24 to this question is given in Figure 7.

> *Reducing electricity use, recycling all we can, preferring unpackaged or minimally packaged products, reducing deodorant use, travelling by public transportation, and not wasting water can reduce global warming.*

Figure 7. S24's Answer for the Fifth Question

After the students shared their answers to these questions, the teacher contributed to the discussion with additional explanations about carbon footprint, greenhouse gases, and global warming and its effects. She also answered students' questions about the topic. Finally, the students watched an animation that the researchers had previously examined and found suitable for the purposes of the activity (Fen Ailem, 2021). Photograph 6 shows a scene from this animation that the students watched through the Zoom application.



Photograph 6. Watching Animation during the Lesson

The Do Phase

In the last phase of the POED method, the students were asked to create products that illustrate what they have learned about global warming in the first three phases of the activity. This phase was designed to give students an opportunity to do practical work that connects the science topics with real life. At this stage, it was stated that they could create different products such as a model, a poster, or a brochure (Appendix 4). The teacher taught students how to use Canva, one of the Web 2.0 tools, by having another online lesson on the Zoom platform in order to support the students' use of technological tools. Some students prepared posters on Canva. Examples of the products, a model and two posters, prepared by the students during the do phase are presented in Figure 8 and Photograph 7. In the posters given in Figure 8, the students emphasized melting glaciers and its effects as one of the consequences of global warming. These posters indicate a high level of environmental awareness among the students and a willingness to take responsibility towards environment. Photograph 7 shows a model eco house that uses renewable energy sources to generate energy and is intertwined with nature.

Figure 8. Sample Posters Designed by Students

Photograph 7. An Eco House Designed by S17

EVALUATION OF THE ACTIVITY

After the activity was completed, the activity evaluation form given in Appendix 5 were sent to the students. They were asked to fill in the form and return it to the teacher. The activity was evaluated based on the student comments on the activity evaluation form and the observations made by the teacher during the lessons. In the activity evaluation form, the first question is "What is your opinion about the

activity that you have just completed? Explain your answer." Some student responses to this question were as follows: “It was very good for me. I learned how responsible people should behave, what harmful things I do to Earth with my carbon footprint, and what I have to do for this." (S2). “It was very good, I learned the damage I did to the world and the environment. It was a helpful and fun activity for me.” (S13).

The analysis of the students’ answers to the first question showed that all students found the activity helpful. Some students explained that they did not have much information about the carbon footprint before and that they did not have an idea about the extent of the damage they could cause to the environment. Based on these findings, it can be concluded that the activity achieved its aim of raising environmental awareness in students at an early age.

The next question on the activity evaluation form is "Do you think that the activity was helpful for you? Why?" The answer given by S8 to this question was “Yes, I do. It was a very helpful activity for me. I learned which activities cause carbon dioxide emissions, thanks to this activity." S24 wrote the following:

> It was very helpful for me because now I am a more conscious and responsible person. Next month, I will do this calculation again and see the difference between the current and the next month. I'm sure that my carbon footprint will be smaller. Because now I'm more responsible.

All the students found the activity helpful and mentioned about being more responsible toward the environment.

The students were asked about their favorite part of the activity. To this question, the students gave different answers from each other. In general, the students wrote that they liked researching about and calculating their carbon footprint. Some students emphasized the simulation and animation parts, explaining that these tasks were entertaining and interesting, and made it easier for them to learn the concepts.

The fourth question on the activity evaluation form is "Would you like to do similar activities in the science lessons during distance learning? Explain your answer." Some students' answers were as follows: “Yes, I would like to because there are not many activities in distance education. These kinds of activities are fun." (S12). “Yes, I would. Because I love doing experiments, scientific research, and projects. It made me very happy to be able to study in this way in distance education. " (S5).

Students enjoy the science lessons in which they are active and these types of lessons are helpful to ensure the permanence of learning. The answers given by the students in the current study support this argument. Students’ responses to the activity evaluation form revealed that the distance education lessons did not typically involve student-centered activities, but the students stated that they wanted to take part in these types of activities more in the online science lessons. Moreover, the students explained that they would like to do such activities in other subject lessons as well. A related finding was that according to the students, they had difficulties in learning the concepts in distance education lessons, but they learned the concepts more easily in the current activity in which they were active. The students found the activity tasks very enjoyable as well as educative. There were also students who wrote that the lessons in distance education were generally boring and that such activities similar to the current activity made the lessons more enjoyable.

During the do phase, the students prepared posters with Canva, one of the Web 2.0 tools, and the teacher observed that the students were very enthusiastic in this part of the activity. It is important for students to use online resources and tools effectively in distance education. It is also very important for them to enhance their knowledge by experiencing different applications on the Internet. In this respect, the activity was effective by teaching Canva to students during the do phase and enabling students to create products on this platform.

CONCLUSION and SUGGESTIONS

The activity shared in this paper was designed to stimulate students' interest in lesson topics during distance education and to raise environmental awareness among young individuals. The teacher’s observations during the lessons and the students’ answers to the

questions on various activity worksheets confirm that the activity achieved its purposes.

At the beginning of the study, the students were shown news about the consequences of global warming both inside and outside the country, and the students were asked to predict possible causes of the situations in these news and whether they had any responsibility on the occurrence of these situations. Students' answers to these questions showed that they had limited or inaccurate knowledge about the factors causing global warming. The students erroneously thought that their personal effect on global warming were limited to the environment they lived in. Similar to this finding, Erdoğan and Özsevgeç (2012) found that the students in their study had a lack of knowledge about the effects of their daily activities on global warming. In the current study, the use of POED method, supported with various animations and simulations, helped the students develop a more comprehensive and accurate understanding about global warming compared to their knowledge at the beginning of the study. This finding aligns with that of Atabey and Çiftçi (2019) who suggested POE as an effective teaching method to help students overcome their erroneous understandings. Chen (2020) reported that even the students with poor prior knowledge achieved the intended learning outcomes by using scientific inquiry skills in a learning environment designed based on the POED method. The students in the current study explained that the use of simulation and animation in the learning tasks made it easier for them to comprehend the concepts. This finding is parallel to previous research findings that showed positive effects of using animations and simulations in learning activities such as increasing student motivation, making the lessons more fun, and scaffolding conceptual learning of students (Oluk & Özalp, 2007; Özcan et al., 2020).

When students are given opportunities to construct knowledge actively by making observations and investigations, their learning tends to be deeper and more conceptual (Barron & Darling-Hammond, 2008). The findings of the current study support this idea. It was observed that engaging students in calculating their carbon footprint, researching about the topic, and making explorations through an online simulation were effective strategies to teach the subject of global warming and to raise environmental awareness in students. In their study, Rudd et al. (2019) emphasized the use of learning activities that require active student participation such as calculating their carbon footprint in order to raise the awareness of students about global warming.

It is not known how long the distance education process will continue. In order to increase the quality of education in online lessons and to prevent any learning losses, it is important to use teaching activities that engage students in active learning. The current study shared the implementation process of this type of an activity. As a suggestion for future implementation, the activity can be used with students at different grade levels after making some revisions. In the current implementation, the students expressed views about being more responsible for the environmental issues. Longitudinal studies can examine how long students maintain this awareness. A final suggestion is to design similar activities for other science topics using the POED method.

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Appendix 1

The Predict Phase

Dams almost ran out of water in Çanakkale, Water restrictions are in place

12 million cubic meters of water remained in the 54 million 115 thousand cubic meters capacity Atikhisar Dam, which meets the drinking and utility water needs of Canakkale. The municipality banned washing cars, carpets and rugs using city water.

1. What is your prediction about possible causes of the situation in the news?

.....

.....

.....

.....

Iceberg size of Malta breaks off Antarctica

Images taken by European Space Agency (ESA) showed that an iceberg about the size of Malta broke off Antarctica. The iceberg quickly broke into many pieces.

2. What is your prediction about possible causes of the situation in the news?

.....

.....

.....

.....

ATTENTION

3. What is your prediction about possible causes of the situation in the news?

.....

.....

.....

.....

Snowmen and snowballs in Eskişehir in the middle of summer!

The sudden hail fall in the middle of summer in Eskişehir almost formed a white cover over the city. After the hail fall, citizens tried to make snowman with the hail grains in the gardens.

Meteorologists warned! This summer will be very hot!

According to meteorologists, the summer of 2020 will be the hottest season of all years. Since the air temperature measurements were first recorded in 1881, the hottest summer ever was in 2016, and the air temperatures in Germany rose above 25 degrees Celsius for 75 days.

4. What is your prediction about possible causes of the situation in the news?

.....

.....

.....

.....

5. Do you have any responsibility for the situations given in the news? What do you think about this?

.....

.....

.....

.....

Appendix 2

The Observe Phase

First Name: **Last Name:**

HOUSE INFORMATION

Please enter your annual energy consumption according to energy types. If there is any type of energy that you do not use, type "not applicable". (How can you calculate your annual energy consumption by using the monthly bills?)

1. How many people live in your household?

…….

2. How much electricity does your house use? Write in kWh (kilowatt-hour).

Monthly Consumption…… Annual Consumption…….……

3. How many cubic meters is your natural gas usage?

Monthly Consumption…… Annual Consumption…….……

4. How many liters is your fuel oil usage? (Fuel oil can be used in central heating systems)

Monthly Consumption…… Annual Consumption…….……

5. How much coal does your house consume? Use ton as your unit of weight.

Monthly Consumption…… Annual Consumption…….……

6. Write your LPG usage in liters.

Monthly Consumption…… Annual Consumption…….……

7. How much is your propane consumption? (Propane cylinders can be used to cook food, a mid-size propane cylinder contains about 26 liters of gas.)

Monthly Consumption…… Annual Consumption…….……

FLIGHT INFORMATION

Please write down your annual flight information. (If you did not fly, write zero (0).)

1. The number of short-haul flights? (Domestic and Turkey-Europe flights)

……..

2. The number of medium-haul flights? (For example, Turkey-China)

……..

3. The number of long-haul flights you? (For example, Turkey - America)

……

HOUSEHOLD CAR

Please answer the following questions based on one car model.

1. How many kilometers do you travel by car in a year?

……..

2. What is the model of your car?

……

3. How many cc is your car engine?

……..

MOTORCYCLE

If you have a motorcycle in your family, write your data accordingly. (If no family member uses a motorcycle, write zero (0).)

1.Total annual distance travelled by motorcycle in km.

……..

2. Engine size (small-size motorcycle up to 125cc)

……..

3. Engine size (mid-size motorcycle 125cc-500cc)

……..

4. Engine size (big-size motorcycle bigger than 500cc)

……

BUS AND TRAIN

1.How many kilometers do you travel by bus in a year?

……..

2. How many kilometers do you travel by train in a year?

……..

3. How many kilometers do you travel by light rail transit in a year?

……..

4. How many kilometers do you travel by metro in a year?

……

LIFE STYLE

1. Diet style
   a) I am a vegetarian.
   b) I usually eat fish.
   c) I usually eat white meat.
   d) I eat red and white meat.
   e) I eat red meat every day.

2. Organic food consumption
   a) I only buy organic products.
   b) Some of the products I buy are organic.
   c) I never buy organic products.
   d) I did not know that consuming organic products was important.

3. Seasonal food consumption

   a) I only eat seasonal food.
   b) I occasionally eat seasonal food.
   c) I only eat early grown food.

4. Imported food and product consumption

   a) I buy only local products.
   b) I usually buy local products.
   c) I occasionally buy local products.
   d) Local or imported does not matter to me.

5. Choice of clothing

   a) I only wear second hand clothes.
   b) If I need new clothes, I will buy.
   c) I follow the latest fashion trends.

6. Preference for packaged products

   a) I prefer unpackaged or minimally packaged products.
   b) I prefer less packaged products.
   c) I prefer only nicely packaged product.

7. Preference for furniture and electronics

   a) I only buy second hand products.
   b) I usually buy new products, but I use them for at least 5 years.
   c) I buy the latest technology or trendy products.

8. Recycling

   a) All my waste is recycled.
   b) Most of my waste is recycled.
   c) Some of my waste is recycled.
   d) I do not recycle.

9. Entertainment and activities

   a) I do activities that do not emit carbon (e.g., walking, cycling).
   b) I usually go to movies, cafes, restaurants.
   c) I participate in intensive carbon-producing activities (e.g., flight, motorcycle).

10. How many cars does your family have?

……..

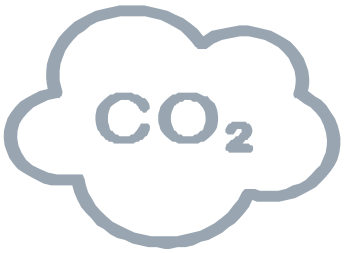
11. Financial services

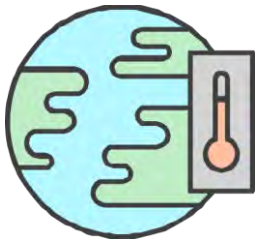
   a) I do not have any bank accounts.
   b) I use standard financial services.

Appendix 3

The Explain Phase

Name:





1) Compare the predictions and comments you made about the news articles with the results you obtained from your observations. Did your predictions match your observations? Explain your answer.

2) You calculated your carbon footprint as a result of your research and observations. Based on these explorations, explain what a carbon footprint means.

3) What are the effects of carbon footprint on nature?

4) What are the effects of your carbon footprint on global warming?

5) What measures will you take from now on to reduce your carbon footprint?

Appendix 4

The Do Phase

TIME TO APPLY WHAT YOU HAVE LEARNED!

In the activity tasks that you just completed, you have learned about global warming, greenhouse gases, and carbon footprint. Now, based on what you have learned, how about creating some products to raise awareness about global warming?

At this final phase of the activity, you can prepare remarkable posters and/or brochures about global warming and its effects using Canva, one of the Web 2.0 tools that you have recently learned about. Or you can design a model of your dream eco house that is environmentally friendly and does not contribute to global warming. Alternatively, you can work on a different idea that is related to reducing global warming or carbon footprint after consulting your teacher. You will present your product to your classmates during an online lesson.

Appendix 5

Evaluation Form

ACTIVITY EVALUATION FORM

1. What is your opinion about the activity that you have just completed? Explain your answer.

……
……
……
……

2. Do you think that the activity was helpful for you? Why?

……
……
……
……

3. What was the favorite part of the activity? Explain your answer.

……
……
……
……

4. Would you like to do similar activities in the science lessons during distance learning? Explain your answer.

……..
……..
……
……

5. What is your opinion about engaging in similar activities in different subject lessons during distance learning? Explain your answer.

……
……
……
……