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EFFECT OF GASES IN TEMPERATURE CHANGE IN THE ATMOSPHERE: A STEM ACTIVITY

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ABSTRACT

This study aimed to plan and implement a lesson that focuses on the role of gases that are effective in global warming and to increase the middle school students' awareness about global warming. The case study method was used. First, a Science, Technology, Engineering, Mathematics (STEM) lesson that focused on the increased use of fossil-based energy and plastic was planned and the lesson was taught to a class of 5th grade students. In the lesson, a new prototype was developed with an alternative measurement technique designed with arduino, based on the measurement of global warming values using glaciers' color before the invent of advanced technological products. The effect of CO_2 and O_2 gases on global warming was then measured using the arduino program. According to the prototype developed with arduino, CO_2 caused more increment in the temperature. It was found that STEM education had a positive effect on students' attitudes.
Keywords: STEM, lesson plan development, global warming, science education.

ATMOSFERDEKİ SICAKLIK DEĞİŞİMİNDE ROL OYNAYAN GAZLARIN ETKİSİ: BİR STEM ETKİNLİĞİ

ÖZ

Bu çalışmada, küresel ısınmada etkili olan gazların ısınma üzerindeki rollerinin tespit edilmesini konu alan bir ders planı geliştirmek, planın uygulamasını incelemek ve dersin konusu hakkında ortaokul öğrencilerinde farkındalık oluşturmak amaçlanmıştır. Çalışmada örnek olay yöntemi kullanılmıştır. Öğretmen tarafından Fen, Teknoloji, Mühendislik, Matematik (STEM) ders planı oluşturulmuştur. Ders planında fosil kaynaklı enerji ve plastik kullanımının hızla arttığı günümüzde dünyanın en önemli problemlerinden biri olan küresel ısınma konusu ele alınmış ve ders planı 5. sınıf öğrencileriyle uygulanmıştır. Ders planında, bilim insanlarının teknolojik ürünler olmadan önce buzulların rengi ile küresel ısınma değerlerini tespit etmesinden yola çıkılarak, arduino ile tasarlanan alternatif bir ölçüm tekniği ile yeni bir prototip geliştirilmiştir. Ardından arduino programı ile tasarlanan düzenek kullanılarak CO_2 ve O_2 gazlarının küresel ısınmaya etkisi ölçülmüştür. Süreç öğrenciler ile birlikte gözlenerek sonuçlar paylaşılmıştır. Arduino ile geliştirilen prototipe göre CO_2 gazının daha fazla sıcaklık artışına sebep olduğu gösterilmiştir. Çalışmada, STEM eğitiminin öğrencilerin tutumları üzerine olumlu etkisi olduğu gözlenmiştir.
Anahtar kelimeler: STEM, ders planı geliştirme, küresel ısınma, fen eğitimi.

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INTRODUCTION

In education, the acronym STEM stands for the disciplines of science, technology, engineering, and mathematics (Gonzalez & Kuenzi, 2012). STEM education is the learning of these different disciplines through an integrated approach (Smith & Karr-Kidwell, 2012). STEM education was introduced for the first time as the students in USA had gradually decreased interest in science technology, engineering, and mathematics (Ostler, 2012). It is seen particularly after 1957 that quite a number of countries designed and implemented new science and mathematics programmes. What is essential for these programmes is to bring up individuals who have a good command in mathematics and sciences, are capable of associating them in daily life and make use of school knowledge in solving problems encountered in daily life just not to fail in the technological competition (Çepni, 2017). In 21st century, STEM disciplines are common in all aspects of modern life, playing a key role in finding solutions to present and future emergencies (Gonzalez & Kuenzi, 2012; National Research Council [NRC], 2012).

Engineering, as a discipline, plays a great part when it comes to initiatives of reorganizing sciences (Daugherty, 2012). The new approach wherein engineering design problems constitute the new context required for science teaching is called Design-Based Science Learning (Kolodner, 2002). Design-based science teaching is a new approach to learning equipped with both learning and teaching practices that intend to build problem solving skills to identify problems encountered in daily life, establish interdisciplinary communications, to work as a team, and to think out of the box (Bybee, 2010). In this sense, teaching activities involving STEM-based applications that allow individuals to unveil different interdisciplinary binaries, experience meaningful learning, encourage students to participate actively thanks to applied activities are emerging and developing in recent years (Elmalı & Balkan-Kıyıcı, 2017), however there is still need to develop more teaching materials in this developing field.

The 5E model is an instructional design model that helps to learn a new concept or comprehend an already learned concept in depth (Martin, 2006). The 5E model is composed of five stages: *engage, explore, explain, elaborate,* and *evaluate*. At *engage* step, students' pre-knowledge is relied on, snagging their interest before moving to a new topic, and a brief activity is performed involving a situation, incident or problem that would encourage the student to relate to pre-learned knowledge. At the *explore* step, students work as a team and come up with new opinions. These opinions may be responses given to a question or solution to a problem. At the *explain* step of the 5E model, students are encouraged to explain the concepts that have been explored. This step gives teachers the opportunity of bringing up concepts, processes, skills or attitudes, official glossaries, definitions and explanations. At the *elaborate* step, teachers challenge students' cognitive understanding and skills. Students acquire a more in-depth understanding through engaging in new experiences. Finally, the *evaluation* step is when students are encouraged to evaluate their learning and skills and it gives teachers the opportunity of evaluating the progress in accessing the educational outcomes.

The 5E instructional model serves as a roadmap for arranging the education and devising the educational programme in that it is based on structuring the learning concepts, concentrates on scientific process skills and highlights the problem-solving aspect of the educational programme (Öztürk, 2008). When this model is used, the learner concentrates on the topic, explores knowledge, organizes and categorizes it, adopts it to new conditions and conceptualizes it (Bybee, 1997).

Yurdakul (2004) indicates that the 5E instructional model has been more effective compared to the currently implemented teaching approaches in helping students to improve their problem-solving skills, metacognitive awareness and attitude towards the topic. Therefore, based on the literature, the teaching activity developed within the scope of this study was planned according to the 5E instructional model.

The purpose of this study is employing different interdisciplinary aspects in solving real life problems, to have students acquire scientific process skills and to convey the matter from the students' perspective. For this purpose, STEM instructional syllabus has been implemented centring on the sciences as a discipline and the lesson plan given in Appendix 1 is implemented. The topic of human and environment (Ministry of National Education [MoNE], 2018a) as discussed in the science curriculum will be integrated with the graph interpretation in mathematics, and once informatics is integrated, engineering design will emerge out of it. In the duration of the planned lesson, it has been intended to identify the roles of gases that are influential on human-caused global warming, to establish and raise awareness of middle school students once the instructional syllabus is implemented.

METHOD

The qualitative research method of case methodology was used for the current study particularly at the time of creating and implementing an instructional syllabus. The case methodology is an auxiliary method to derive learning by solving real life problems in class; hence theories turn into solid practices (Stensmo, 1999). This method is used for ensuring that students acquire a skill or make practice in a given topic. It can also be used for solving a real-life problem.

Sample

In this study, 17 fifth grade students studying at a private school in a district of Istanbul, Turkey has been selected. Students were organized to form heterogeneous subgroups by their academic standing and gender; hence five equal groups were created. It took 3 weeks (10 class hours) to apply the activities. All necessary legal permissions were obtained for implementing the activity.

Data Collection Tools

The method of semi-structured interview was used for this study in order to get students' opinions about the STEM activities. A semi-structured interview form (Appendix 2) composed of five open-ended questions was prepared. Once the questions were prepared, they were reviewed and corrected by one science teacher, one information technologies teacher and a subject-specialized teacher.

ACTIVITY IMPLEMENTATION

The research started by reviewing the Science Curriculum, and fifth grades' "Human and Environment" unit was picked for the study. The following instructional sequence were implemented for global warming so that students build skills for STEM practices. Science, mathematics, information technologies and engineering objectives that the developed lesson addresses are given in Appendix 3. The activity, which will be explained in detail in the following, is summarized as follows:

- Improving graph interpretation skills.
- Completing the graph for temperature projections for the next 100 years.
- Identifying variant influential on global warming by way of simulations.
- Taking a closer look at the changes in Alaska.
- Taking a closer look at the global warming measurements taken before technological advancement.
- Discussing as to how students can measure out by using lego EV3 and Arduino available at school.
- Drawing prototype designs.
- Making the prototypes.
- Evaluations.

Engage

At the engagement step, teachers share a part from an article with the students. The part is given in Figure 1. After the text, students are asked some questions: "What could be the factors that affect the quality of air?", "How does wind, rain and solar radiation affect the quality of air?", "How do you think the method of reducing some emissions affect the quality of air?"

Students write down their answers to these questions on the student development notebook prepared for them. For example, a student wrote "Gases from factories can be a factor affecting air quality. Reducing harmful gases can improve air quality." During the activity, students will be keeping a development

notebook, which will be more like a portfolio on which students will be writing down their answers, draw their designs and note down their solution offers during the process. An example is given in Appendix 1 for reference.

> In M. Tamer Özmen's article on Green House- Global Warming and Kyoto Protocol, the global average temperature increased by 0.3 - 0.6 C° from the mid-19th century up until today on earth. According to researches, it is estimated that every decade will witness an increase over by 0.1 C° in 40 years. Turkey will be adversely affected by global climate changes. According to a set of scenarios, it is estimated that the latitudes where Turkey is also positioned will be subject to temperature surge; precipitation regime will alter, sea-water level will rise and water content of soil will substantially reduce. To protect the nature and preserve ecological balance, to preserve the survival rights of living things and generations and to safeguard their future, all countries of the world should give up on their micro benefits, and sign and implement the KYOTO PROTOCOL for the good of humanity. Now that we have no other earth to live in, we have to win the struggle for existence if we do not want to extinct and live on happily and in health on this earth (Özmen, 2009).
>
> To win this fight, we have to be familiar with the challenges that we are now facing, and generate solutions so that the earth is a liveable place for all.

Figure 1. A Part of the Article

Explore

In this section, the graph given in Figure 2 is examined so that the students have a deeper knowledge about global warming. Based on the graph, the teacher addresses questions with a view to examine students' graphic reading skills in mathematics.

- What amount is given on the x-axis on the graph?
- Which colour of line refers to temperature in time?
- What is the reading for mean temperature variation for 2000 (in °C)?

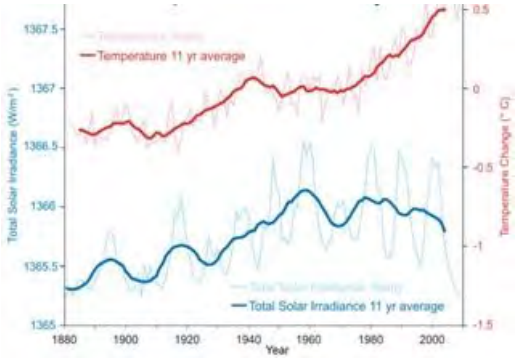


Figure 2. Heat and Solar Activity

Students could be remembered about the graph interpretation skills. Then, they are asked to write a discussion about the topic. Argumentation is the process of generating a claim, reasoning for thus generated claim, and coming up with series of reasonable justifications. In argumentation, students indicate their pre-learning about a given topic, set the initial questions prior to the activity and have projections about the activity. They compare their original observations with the resulting projections, present a claim based on their observations and eventually they support their claims with reasoning and evidences (Hand & Keys, 1999). An argumentation written during the implementation is given Figure 3.

> **Claim:** Carbon dioxide gas does not increase the temperature in the atmosphere.
>
> **Data:** In addition to carbon dioxide, water vapor, methane, nitrogen oxide and ozone gas are also greenhouse gases.
>
> **Reason and Support:** Greenhouse gases make our World liveable by preventing escaping the heat of the earth to space.
>
> **Refute:** Considering that carbon dioxide increases gradually, it can be said that it increases the temperature in the atmosphere.

Figure 3. An Example Argumentation

Once the argumentation part is complete, the teacher once again addresses questions to the students.

- What do you predict for the future climate on the planet?
- How warm will it get?
- How fast does the planet get warm? What will be the future climates like?

The teacher then gets the students watched a video on the subject (NASA Goddard, 2013). The teacher poses questions such as "What do the colours tell us about the average temperature variation from 1884 to 2012?", "Where is the maximum temperature variation seen for the last 50 years?" During the lesson in the current study, the students said the following ideas: "Global warming is increasing from 1884 to 2012." "The red areas indicate the temperature increases. In the northern regions the temperature increased further." "Over the years, global warming has increased. In some countries the temperature has increased more."

Then the teacher shares the graphs given in Figures 4 and 5 with the students and requires them to describe the average temperature change from 1880 to 2010. In the light of the educational syllabus applied, on addressing the question of "What will be the temperature variation like for the next 100 years?", it is observed that majority of the students assumed in favour of a temperature increase. A graph that was drawn a group of students is given in Photograph 1.

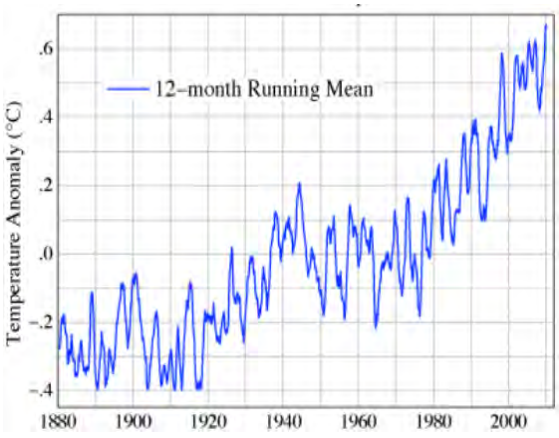


Figure 4. Temperature Variation from 1880 to 2010 According to the Reference Pointer of 1950-1980

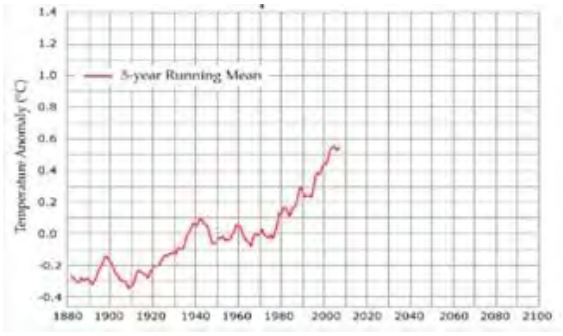
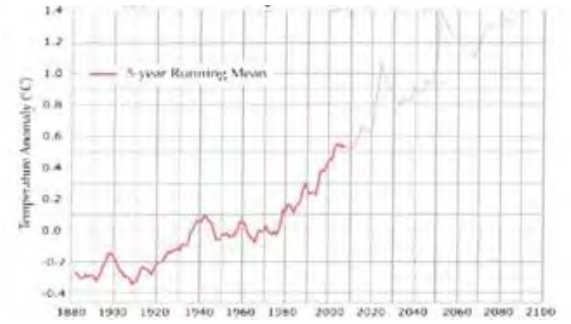


Figure 5. Probable Curve of Temperature Change



Photograph 1. A Group's Projection for Temperature Increase

Explain

At this part of the lesson, the teacher makes use of a virtual laboratory together with the students, and benefits from the simulations at Concord Consortium (2018a). Students change the factors such as temperature, solar light, rain, wind, vehicles, vehicle-driven pollution, electric car, power plants, power plant-driven pollution on the simulation, studying to see how each of them influence air pollution. In this way, students obtain different graphs in parallel to each change. They draw conclusions based on the resulting graphs. For instance, one group wrote "According to the changes we make in the graph, the temperature sometimes increases and sometimes decreases. Factories increased temperature. Increased cars cause air pollution."

After that, the simulations available at Concord Consortium (2018b) are used in order to explore how the CO2 level in the ocean and amount of water vapour in the air change as the temperature changes. Students examine the resulting temperature changes and CO2 concentration graphs (Photograph 2). Students are addressed questions such as "What do you think are some of the reasons for increased

carbon dioxide amounts for the last 50 years?", "How does carbon dioxide in the atmosphere affect the global temperature?", "What happens if all carbon dioxide present in the atmosphere is cast away?" in order to measure their pre-learning about the topic. Graphics examined so far demonstrate increased temperature rates only. However, the earth went through the ice age, consequently temperatures do not increase only. A few questions can be asked to trigger students to think about it: What kind of things would reduce the World temperature? What kind of cooling effect does light-coloured surfaces -such as snow, ice and some clouds- have on earth's temperature?

Photograph 2. Students Record the Data Obtained from Simulations

Photograph 3 shows Bear Glacier in Alaska. The photo on the left was taken in 1909. The photo on the right was taken in 2005. The Bear Glacier seems to have retracted over 96 years of time, over passing the meadows shown in the photograph below. The question "Which photo shows that the land cannot reflect the incoming sunlight less?" is asked to the students. The aim is to enable students to recognize the effect of reflective surfaces on temperature rise. After the students answer the question, a video about Antarctica is shown to the students (Vanshize, 2019). The purpose of drilling a 650m-deep hole on the Antarctica surface is to collect data to project how global warming induced-melting glaciers are likely to be affected by the temperature increase in 50 years.

The graph given in Figure 6 is examined in order to help students understand the temperature change more deeply. This graph shows the temperature change measured from dissolved gases in the Vostok Ice Core by years. How do you think the curve shown on the graphic is likely to affect the earth's temperature by 2100? This question is addressed to students, asking for their projections for the future. A student's estimate was 'Glacial areas will melt and the temperature will rise.' The students wrote their estimates in their development books (Photograph 4).

Photograph 3. Bear Glacier in 1909-2005

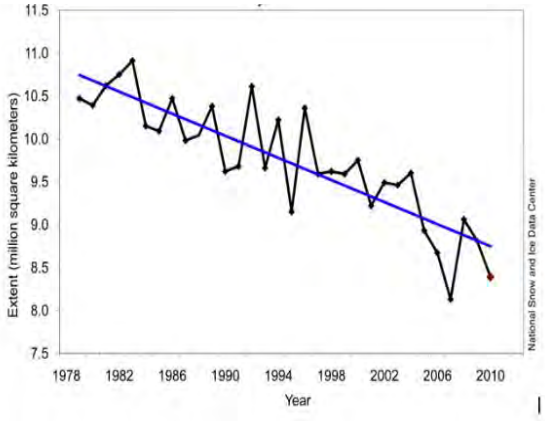


Figure 6. Temperature in the Vostok Ice-core

Photograph 4. Students Interpret the Graphs

Elaborate

A thermometer was used to collect the data presented in the graphs examined so far. How do the scientists proceed if they want to know the planet's temperature before people begin to collect data? Before thermometers came into use, the scientists resorted to many different

techniques to read the temperature. They examined glaciers, icecaps and gases for reaching global temperatures. Drilling a hole in the depths of glaciers and icecaps, they take out the glacier cores. Since the lower layers are older than the upper layers, the scientists can monitor variations in activated gases for a prolonged time. Figure 6 shows the annual layer structure of an icecap in Greenland. It was illuminated by a 19cm –long fiber optical source. Here, in the lesson, the students were asked the question "Why do you think winter layers are darker than summer layers in the ice core?" One student responded "since the lower sections are older than the upper sections, the gases inside may be more. Therefore, it may be darker."

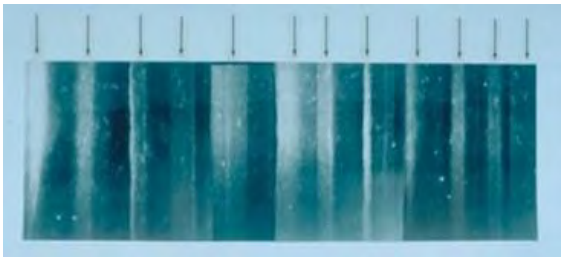
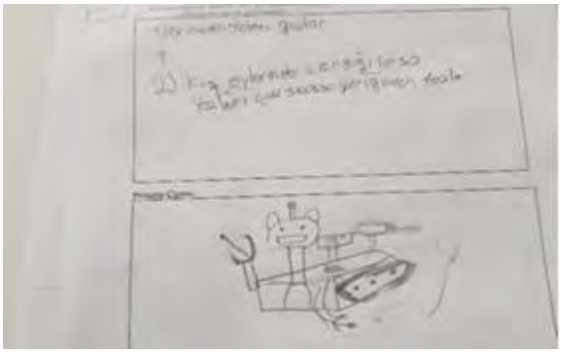


Figure 6. Annual Layer Structure of Ice Core

We want to predict the future climatic conditions, but it is now sufficient to check with the temperature variations only. The elaborate stage continues with the question "How can the scientists be sure that the earth gets warmer and warmer gradually even when they cannot be fully sure about the planet's future temperature?" Students were asked to develop an idea and draw their designs in order to be sure about the planet's future temperature at present time (Photograph 5).



Photograph 5. A Prototype Design

Materials are supplied by the teacher and the groups get the materials they need. At this point, students act as scientists and set to work to design a stand-alone prototype by using Lego sets (LEGO Group, 2019). Attaching a brain and temperature sensor onto their prototype, they add measuring and data recording features. A temperature sensor and Erlenmeyer are attached to the prototype, so CO_2 and O_2 gases' influence on the planet's temperature can be monitored. Students record the data throughout the observation process, and draw a temperature-time graphic for CO_2 and O_2. The results are written down on the development notebook. The materials used include

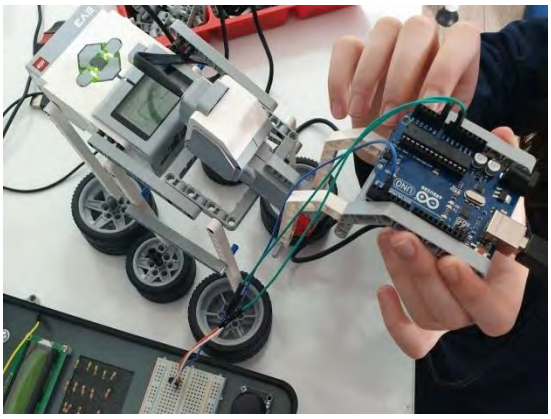
- Lego mindstorms EV3 education set,
- temperature sensor,
- erlenmeyer,
- cork,
- a large size bulb,
- plug socket,
- extension cord, and
- CO_2 and O_2 gases (CO_2 can be extracted from car exhaust or by a simple experiment involving vinegar and baking soda.).

Students finish their design in 15 minutes and will not be able to use other materials than the ones provided by the teacher. The temperature sensor will be used for recording the readings when heating up CO_2 and O_2 gases with the bulb. Measurements should be placed on a graph paper, demonstrating a temperature-time chart. Both CO_2 and O_2 values should be referred to on the chart.

In the lesson, the students created a measuring instrument consisting of legos following the design they drew. They then mounted the Arduino component on this instrument as shown in Photograph 6. In this design, the Arduino component transfers the temperature measurement to the brain in the design. The code blocks for temperature measurement are given Photograph 7. The temperature measurement circuit connection diagram is shown in Photograph 8. The final version of the developed system is presented in Photograph 9.

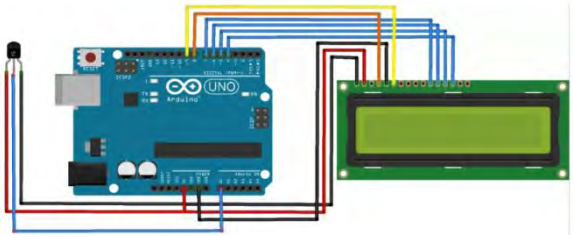
Based on the tests performed by using the prototype, it was observed that the heat in the erlenmeyer where CO_2 gas was present was higher than that of the O_2 gas. The observation time was 15 minutes. Initial temperature in both erlenmeyers read 25°C. At the end of the observation, the difference between the two

containers was 1°C. The temperature in the erlenmeyer filled with O_2 read 26 °C while the one filled with CO_2 gas read 27 °C.

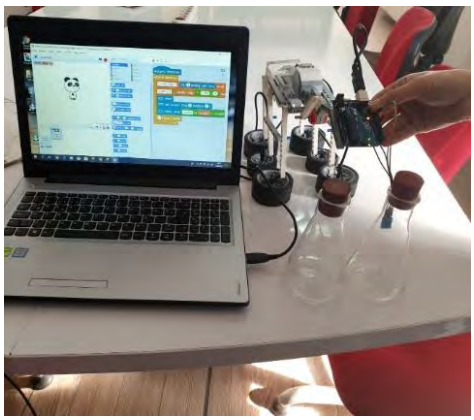


Photograph 6. Arduino Components

Photograph 7. Temperature Code Blocks



Photograph 8. Circuit Connection Diagram



Photograph 9. Final Version of the Devised Mechanism

Our planet used to be much warmer as a place than it is today. Figure 7 shows the temperature variation for the last 542 million years. The students were asked to examine the temperature variations in the geological time, and write down recommendations on their development notebook to reduce global warming. On taking a closer look at the solutions offered by students, it has been concluded that it is necessary to discuss the global climate change more often on the agenda with a view to reducing global warming and to give education on the topic, to equip houses with renewable energy sources, to encourage usage of power saving devices, to reduce waste of water, to use energy saving bulbs, to prefer fuel-saving vehicles, and to alleviate the carbon footprint individually. Also, the students considered that high intensity cooling would be able to prevent it.

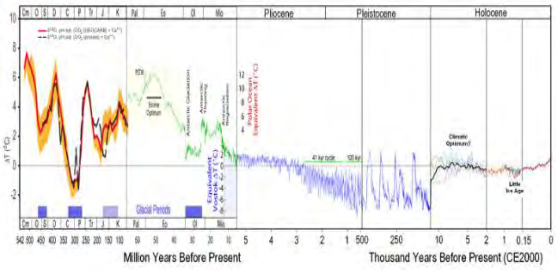


Figure 7. Temperature Variations Throughout the Geological Time

Evaluate

For the evaluation step, students presented their development notebooks on which they have been answering questions through graphs, drawing prototype designs and writing solution offers. They also explained which materials were chosen for the prototypes and why. After the lesson, the teacher evaluated the students' development notebooks using the analytical rubric in Appendix 4 and the group work evaluation rubric in Appendix 5.

FINDINGS

In this section, the results of the semi-structured interview form (Appendix 2) are presented. According to the interview forms applied after the activity, the students expressed that the daily life problem introduced at the engagement step was helpful as a guideline. Especially the fact that global warming is a current issue attracted students' attention. On taking a closer look at

the students' opinion on favourite parts of the activities given in Table 1, it has been found that computer use, simulations and prototype designing were the favourite parts. By comparison, discussing an environmental problem, development notebook and prototype drawing were the parts relatively less favoured.

Table 1. Students' Opinions on Favourable Parts of the Activities

Theme	Code Inputs	Number of View(s)	Theme Frequency Percentage (%)
Favourite Parts of the Activities	Computer use	5	29.41%
	Simulations	4	23.52%
	Prototype making	3	17.64%
	Discussing an environmental issue	2	11.75%
	Development notebook	2	11.76%
	Prototype drawing	1	5.88%

As a negative feedback, students expressed that they did not like writing down on the self-development notebook, suggesting that the act of writing down could be computerized. On taking a closer look at the students' opinion in Table 2 on unfavourable parts of the activities, it has been observed that prototype drawing, group works and computer use were less frequently selected than others.

Table 2. Students' Opinions on Unfavourable Parts of the Activities

Theme	Code Inputs	Number of View(s)	Theme Frequency Percentage (%)
Unfavourable Parts of the Activities	Graph reading	7	41.17%
	Measurement reading	4	23.52%
	Development notebook	3	17.64%
	Prototype drawing	2	11.75%
	Group work	1	5.88%
	Computer use	1	5.88%

Students further expressed that the videos and graphics used for the instructional syllabus are in support of the topic being discussed. On taking a closer look at the students' opinions on benefits of the activities, the activities being visual and easy to remember has been found useful (Table 3). The creativities being entertaining, interesting and communicative is less frequently mentioned to be useful compared to others.

Table 3. Students' Opinions on Benefits of the Activities

Theme	Code Inputs	Number of View(s)	Theme Frequency Percentage (%)
Benefits of Activities	Visual	7	41.17%
	Easy to remember	4	23.52%
	Entertaining	2	11.76%
	Interesting	2	11.76%
	Communicative	2	11.76%

Students referred to simulation examining, problem solving and prototype designing to be more useful during the lesson (Table 4). Presentation, prototype measurement, prototype drawing and graph reading were mentioned less frequently.

Table 4. Students' Opinions on the Most Useful Part of the Activities

Theme	Code Inputs	Number of View(s)	Theme Frequency Percentage (%)
Most Useful Part	Examining simulations	5	29.41%
	Generating solutions	4	23.52%
	Making prototypes	3	17.64%
	Presentation	2	11.76%
	Measuring with prototype	1	5.88%
	Drawing prototype	1	5.88%
	Graph reading	1	5.88%

Data presented in Table 5 shows that the students would love to see more similar activities in mathematics and social studies. It was expressed that activities as such were demanded less engaged in Turkish and religion courses compared to other courses.

Table 5. Students' Opinions About Having Similar Activities in Other Courses

Theme	Code Inputs	Number of View(s)	Theme Frequency Percentage (%)
Similar Activities in other Courses	Mathematics	9	52.94%
	Social studies	4	23.52%
	Turkish	3	17.64%
	Religion	1	5.88%

CONCLUSION and SUGGESTIONS

In this study, a STEM activity prepared according to 5E model was implemented. It has been observed during the entire instructional syllabus that all students have been edutained. For increased awareness, the prototypes devised by the groups were exhibited nearly for 15 days in different fields of the school and the students spent their time quite densely. The system was operated and trials were made. In this way, the widespread sphere of influence expanded, enabling us to evaluate the topics of the global warming and solution offers on a wider group of students. During the process of trial, it was observed that more students produced solution offers for fight against the global warming.

The findings of the research show that the developed activity was found to be beneficial by the students. During the activity, students attended the activities with high motivation. This is consistent with previous similar studies. For example, Gülhan and Şahin (2016) examined the effect of STEM education on students' attitudes. As a result, it was concluded that STEM education had a positive influence on students' attitudes. Another finding obtained in this study is that students became conscious about global warming. The observations show that students will make efforts to minimize greenhouse gas emissions and temperature increases in the fight against global warming and that their awareness is increased in this context and they will spread this awareness in their environment especially in their families. At the same time, it was observed that the awareness of the students with low theoretical knowledge about global warming before the participation of the project increased as a result of the project. Therefore, dissemination of such studies and encouraging similar activities by schools, youth centres and non-governmental organizations are considered to be beneficial.

During the activities, all students made use of all STEM disciplines effectively. The most effectively used dimensions out of sciences, technology, engineering, and mathematics has been the science, which is the central discipline. The engineering dimension was the discipline to which most of the time has been allocated. The students had hard times reading the graphs, which is included in the mathematics dimension. At the time of prototype drawing and designing, the groups produced different, creative and genuine produces. Likewise, in a study performed by Ceylan and Özdilek (2015) with the 8th grade students using the 5E learning model, the influence of STEM education on students' academic standing was scrutinized, and it was concluded that the activities had a positive influence on students' success rate. In a study by Yıldırım and Selvi (2017) with the 7th grade students, the influence of STEM applications and full learning on students' academic standing was examined, and it was concluded that STEM applications and full learning had a positive influence on students' academic success rate.

A change in the current lesson plan may be that the student comments are written on the paddlet page instead of the development book, a recommendation of the students. Padlet is a digital board where visual images, videos and articles can be inserted. It can be customized as desired and data could be transferred to the board digitally. Notes to be taken, as well as videos, visual images, and many other materials can be made into a board in a digital medium. The students can record thus acquired data via padlet application instead of writing them down on the development notebooks, hence they establish an engineering process wall for themselves. However, it can be said that such instructional syllabus may still be resumed by keeping the development notebooks at schools where computer laboratory and internet issues prevail.

A suggestion as a result of this study is that similar studies are designed for different topics of science courses and on different grade levels. It is crucial to have a correct STEM plan established in a given field, and what STEM is and how it can be applied should be known precisely. In-service teacher education can be planned and delivered more frequent and teachers should be encouraged to prepare STEM instructional syllabus. It should also be comprehended that STEM is applicable not only for science, mathematics, and technology courses but it can be used in all other disciplines as well.

REFERENCES

Bybee, R. W. (1997). *Achieving scientific literacy: From purposes to practices.* Portsmouth, UK: Heinemann.

Bybee, R. W. (2010). Advancing STEM education: A 2020 vision. *Technology and Engineering Teacher, 70*(1), 30-35.

Ceylan, S., & Özdilek, Z. (2015). Improving a sample lesson plan for secondary science course within the STEM education. *Procedia-Social and Behavioral Sciences,* 177, 223-228.

Concord Consortium. (2018a). *Factors that affect air quality*. http://has.concord.org/air-pollution.html adresinden erişildi.

Concord Consortium. (2018b). *Exploring climate change.* Retrieved from http://has.concord.org/global-climate.html

Çepni, S. (2017). *Kuramdan uygulamaya STEM +A+E eğitimi [STEM+A+E education from theory to practice]*. Ankara: Pegem Akademi Yayıncılık.

Daugherty, J. (2012). *Infusing engineering concepts: Teaching engineering design.* National Center for Engineering and Technology Education. Retrieved from https://files.eric.ed.gov/fulltext/ED537384.pdf

Elmalı, Ş., & Balkan-Kıyıcı, F. (2017). Türkiye'de yayınlanmış FeTeMM eğitimi ile ilgili çalışmaların incelenmesi [Review of STEM studies published in Turkey]. *Sakarya University Journal of Education, 7*(3), 684-696.

Gonzalez, H., & Kunezi, J. (2012). *Science, technology, engineering, and mathematics (STEM) education: A primer.* Washington, DC: Congressional Research Service.

Gülhan F., & Şahin, F (2016). The effects of science-technology-engineering-math (STEM) integration on 5th grade students' perceptions and attitudes towards these areas. *Journal of Human Sciences, 13*(1), 602-620.

Hand, B., & Keys, C. (1999). Inquiry investigation: A new approach to laboratory reports. *The Science Teacher,* 66, 27-29.

Kolodner, J. L. (2002). Facilitating the learning of design practices: Lessons learned from an inquiry into science education. *Journal of Industrial Teacher Education, 39*(3), 9-40.

LEGO Group (2019). Mindstorms. Retrieved from http://www.lego.com/en-us/Mindstorms

Martin, D. J. (2006). *Elementary science methods: A constructivist approach.* Belmont, CA: Cengage Learning.

MoNE. (2018a). *Fen bilimleri dersi (3, 4, 5, 6, 7 ve 8. Sınıflar) öğretim programı [Science course (3rd, 4th, 5th, 6th, 7th and 8th grades) curriculum]*. Ankara: Talim ve Terbiye Kurulu Başkanlığı.

MoNE. (2018b). *Bilişim teknolojileri ve yazılım dersi (5 ve 6. sınıflar) öğretim programı [Information technologies and software course (5th and 6th grades) curriculum]*. Ankara: Talim ve Terbiye Kurulu Başkanlığı.

MoNE. (2018c). *Matematik dersi (1, 2, 3, 4, 5, 6, 7 ve 8. sınıflar) öğretim programı [Mathematics course (1st, 2nd, 3rd, 4th, 5th, 6th, 7th and 8th grades) curriculum]*. Ankara: Talim ve Terbiye Kurulu Başkanlığı.

NASA Goddard. (2013, January 15). *NASA's analysis of 2012 global temperature* [Video file]. Retrieved from https://www.youtube.com/watch?v=NnjTnUm9t-0

National Research Council. (2012). *A Framework for k-12 science education: practices, crosscutting concepts, and core ideas.* Washington DC: The National Academic Press.

Ostler, E. (2012). 21st century STEM education: A tactical model for long-range success. *International Journal of Applied Science and Technology, 2*(1), 28-33.

Özmen, M. T. (2009). Sera gazı - Küresel ısınma ve Kyoto protokolü [Greenhouse gas-Global warming and Kyoto proocol]. *İMO Dergisi,* 43-44.

Öztürk, N. (2008). *İlköğretim yedinci sınıf öğrencilerinin fen ve teknoloji dersinde bilimsel süreç becerilerini kazanma düzeyleri [Seventh grade students' level of scientific process skills in science and technology course]* (Yayımlanmamış yüksek lisans tezi). Eskişehir Osmangazi Üniversitesi Fen Bilimleri Enstitüsü, Eskişehir.

Smith, J., & Karr-Kidwell, P. (2000). *The interdisciplinary curriculum: A literary*

review and a manual for administrators and teachers. Retrieved from ERIC database (ED443172) at http://files.eric.ed.gov/fulltext/ED443172.pdf

Stensmo, C. (1999, August). *Case methodology in teacher education compared to 'traditional' academic teaching: A field experiment.* Paper presented at the 8th European Conference for Research on learning and Instruction (EARLI). Goteborg, Sweden.

Vanshize, (2019, February 14). *Dropping a camera down a 650m-deep hole drilled in the Filchner Ice Shelf to study the Antarctic* [Video file]. Retrieved from https://www.youtube.com/watch?v=Qtt7NbbjNg0

Yıldırım, B., & Selvi, M. (2017). STEM uygulamaları ve tam öğrenmenin etkileri üzerine deneysel bir çalışma [An experimental research on effects of STEM applications and mastery learning]. *Eğitimde Kuram ve Uygulama, 13*(2), 183-210.

Yurdakul, B. (2004). *Yapılandırmacı öğrenme yaklaşımının öğrenenlerin problem çözme becerilerine, bilişötesi farkındalık ve derse yönelik tutum düzeylerine etkisi [The effect of constructivist learning approach on learners' problem solving skills, metacognitive awareness and attitude towards the course]* (Unpublished dissertation). Hacettepe Üniversitesi, Sosyal Bilimler Enstitüsü, Ankara.

Citation Information

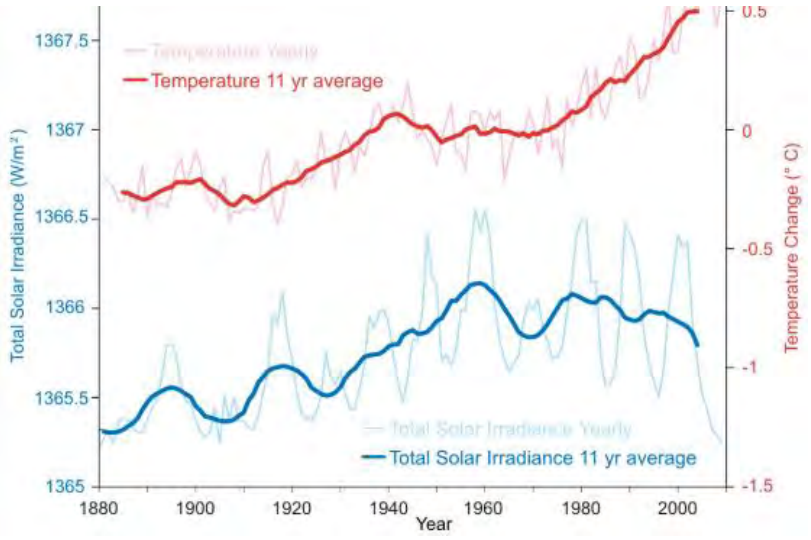
Çilek, E. (2019). Effect of gases in temperature change in the atmosphere: A stem activity. *Journal of Inquiry Based Activities, 9*(2), 109-131. Retrieved from http://www.ated.info.tr/index.php/ated/issue/view/19

Appendix 1

Human and Environmental STEM Lesson Plan

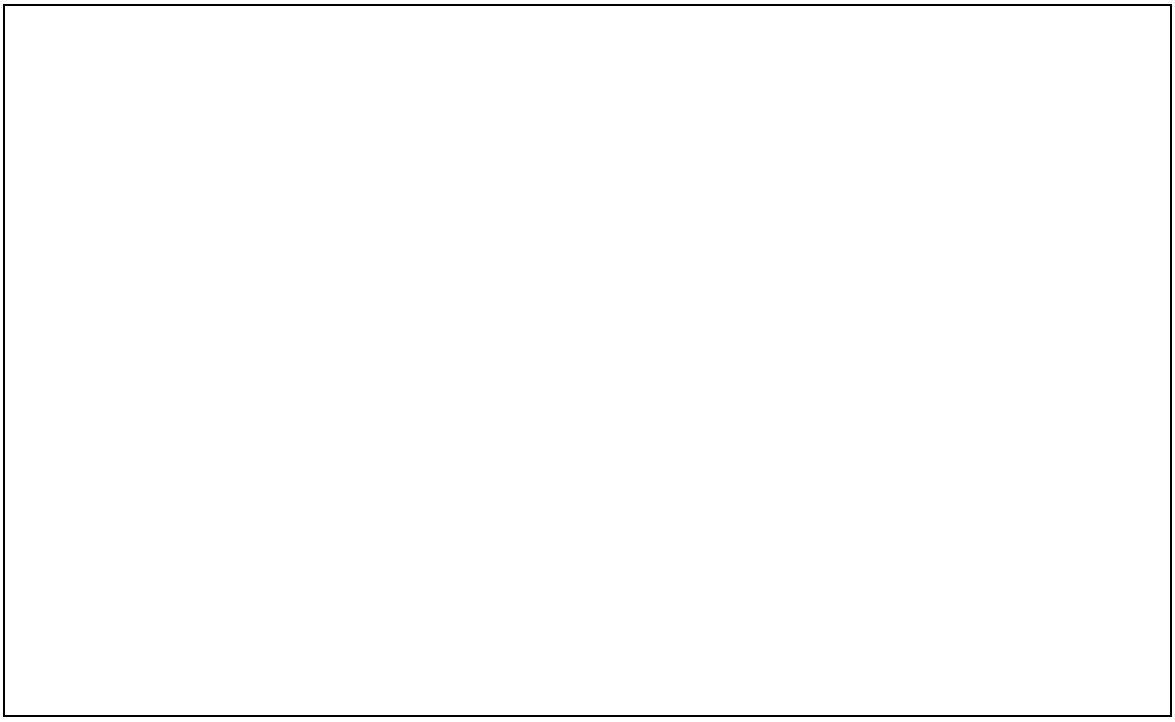
STUDENT DEVELOPMENT BOOK

In M. Tamer Özmen's article on Green House- Global Warming and Kyoto Protocol, the global average temperature increased by 0.3 - 0.6 C° from the mid-19th century up until today on earth. According to researches, it is estimated that every decade will witness an increase over by 0.1 C° in 40 years. Turkey will be adversely affected by global climate changes. According to a set of scenarios, it is estimates that the latitudes where Turkey is also positioned will be subject to temperature surge; precipitation regime will alter, sea-water level will rise and water content of soil will substantially reduce. To protect the nature and preserve ecological balance, to preserve the survival rights of living things and generations and to safeguard their future, all countries of the world should give up on their micro benefits, and sign and implement the KYOTO PROTOCOL for the good of humanity. Now that we have no other earth to live in, we have to win the struggle for existence if we do not want to extinct and live on happily and in health on this earth (Özmen, 2009)

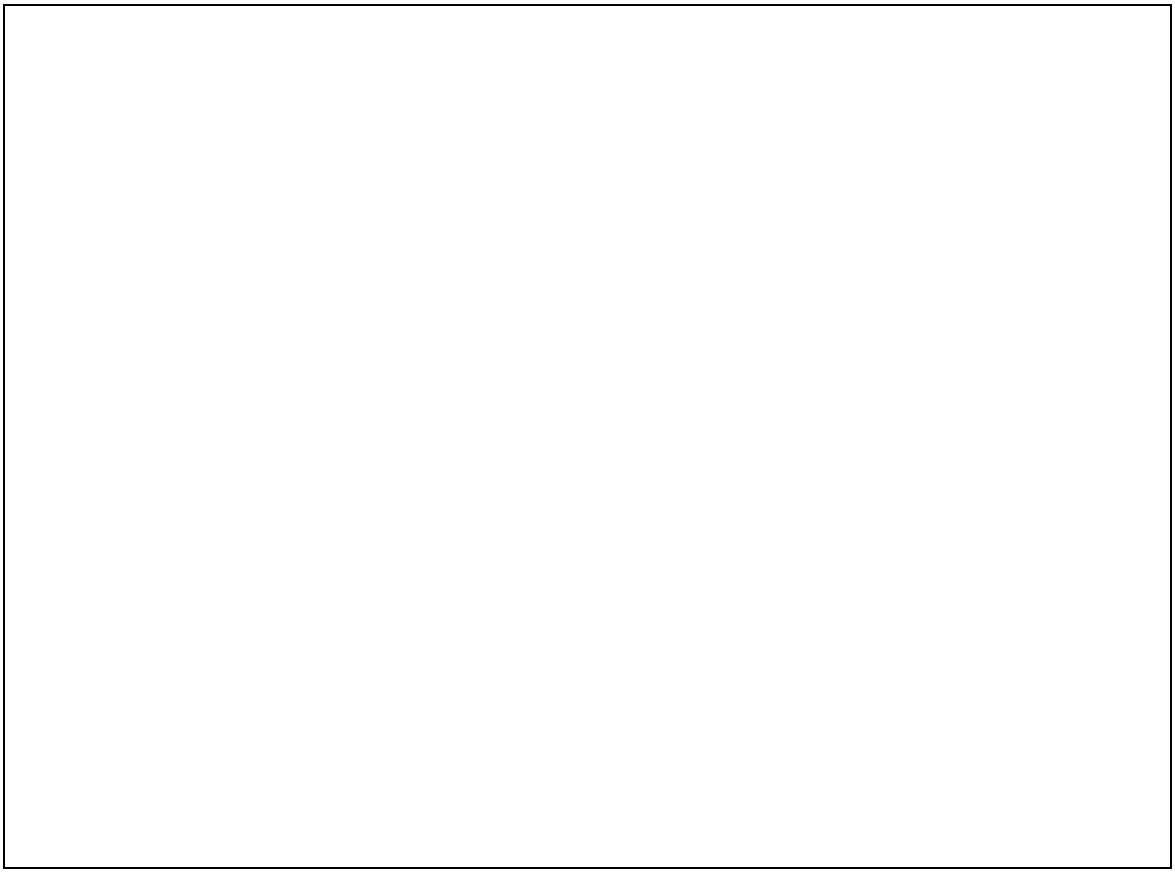


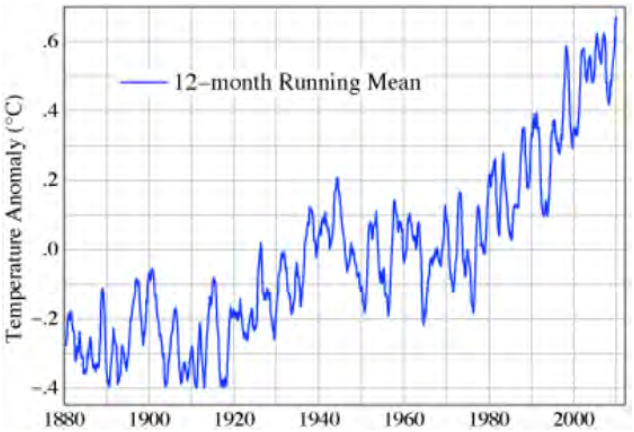
- What amount is given on the axis X on graphic?
- Which colour of line refers to temperature in time?
- What is the reading for mean temperature variation for 2000 (in °C)?

- How do you see the future climate on the planet?
- How warm will it get?
- How fast does the planet get warm? What will be the future climates like?



(https://www.youtube.com/watch?v=NnjTnUm9t-0). What do the colours tell us about the average temperature variation from 1884 to 2012? Where is the maximum temperature variation seen for the last 50 years?





Temperature variation from 1880 to 2010 according to the reference pointer of 1950-1980

And then the teacher asks students to complete the average temperature variations from 1880 to 2010 by using the graphic next to here.

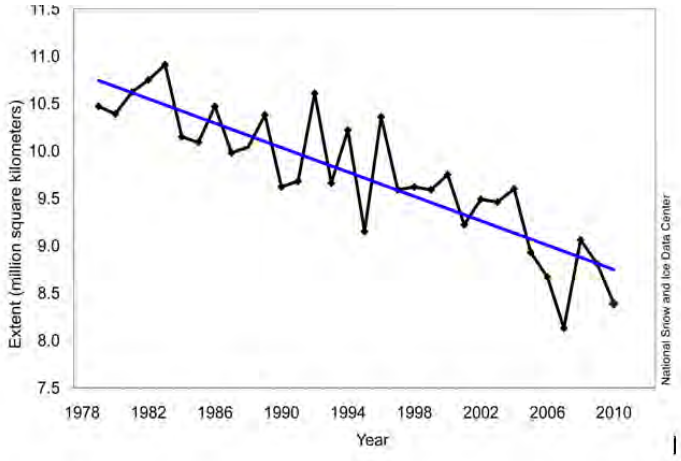
- Do the past data help you project the future?
- How can we expand this graphic to cover the temperature for the next 100 years?

http://has.concord.org/air-pollution.html & http://has.concord.org/global-climate.html according to simulators;

What are the reasons for the increase in carbon dioxide in the last 50 years? How does carbon dioxide in the last years? How does carbon dioxide in the atmosphere affect global temperature? What happens if you remove all carbon dioxide from the atmosphere?

What kind of things can reduce Earth's temperature? How can light surfaces such as snow, ice and some clouds have a cooling effect on Earth's temperature?

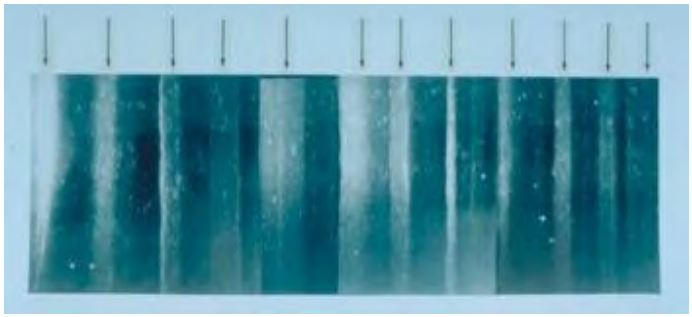
The photographs show the Bear Glacier in Alaska. The first one was taken in 1909, and the second in 2005. The Bear Glacier seems to have retracted over 96 years of time, over passing the meadows shown in the photograph below. Which photograph shows that the land not less reflects the incoming sun rays?



Temperature variation measured from dissolved gases in the Vostok ice-core by years.

How do you think the curve shown on the graphic is likely to affect the earth's temperature by 2100? This question is addressed to students, asking for their projections for the future.

So, if scientists want to know the temperature of Earth before people start collecting data, how can they proceed?

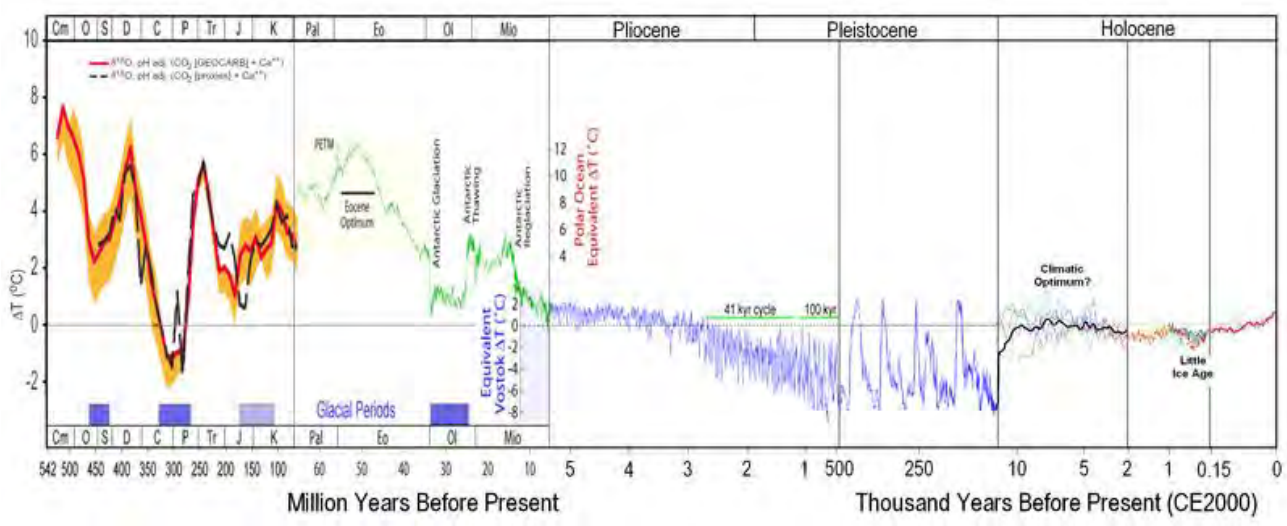


1855m long annual layer structure of GISP ice core illuminated by a 19m-long fibre optical source from beneath.

- Why do you think that the ice core in winter layers is darker than that of summer years? We want to predict the future climatic conditions but it is now sufficient to check with the temperature variations only.
- How can the scientists be sure that the earth gets warmer and warmer gradually even when they cannot be fully sure about the planet's future temperature?

Prototype Drawing

Our planet used to be much warmer as a place than it is today. The graphic below shows the temperature variation for the last 542 million years. The students are asked to examine the temperature variations for the following geological time, and write down recommendations on their engineering notebook to reduce global warming.



Temperature variations throughout the geological time

Solution Ideas:

Appendix 2

Interview Form

1) What are the parts that you liked about the activities? Explain.

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.....
.....
.....

2) What are the parts that you disliked about the activities? Explain.

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.....
.....

3) Do you think the activities have been useful for you? Explain.

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.....
.....

4) Which part of the activities was particularly useful for you?

.....
.....
.....
.....

5) Would you want to apply these activities in other courses or for other topics?

.....
.....
.....
.....

Appendix 3

Subject Area Standards

Sciences Standards:
F.5.6.2.2. Makes suggestions on an environmental issue in or around our country.
F.5.6.2.3. Draws conclusions on potential environmental issues derived from human activities.
F.5.6.2.4. Discusses pros and cons of human and environment interactions with examples.

Mathematics Standards:
M.5.3.1.1. Creates research questions that entail collection of data.
M.5.3.1.2. Collects data for research questions, and shows them on frequency table and column chart.
M.5.3.1.3. Solves problems of interpreting the data shown on the frequency table or the column chart.

Information Technologies Standards:
2.1.5.5. Defines functions of the types of sensors.
2.1.3.1. Lists the structural components of the robot.
2.1.3.2. Defines functions of structural components.
2.1.3.3. Lists the assembling components.
2.1.3.4. Defines functions of the assembling components.
2.1.6.12 Uses robot-specific structures genuinely.
2.1.5.4. Lists the types of sensors.

Engineering Standards:
1. The student makes a prototype using appropriate tools, materials and techniques.
2. The student identifies the steps needed to produce a prototype and presents the prototype appropriately.

Appendix 4

Analytic Rubric Used for the Teaching Syllabus

Features	Poor (1)	Good (2)	Excellent (3)
Generating a prototype	Incomplete Prototype	Prototype generated	Prototype generated and visuality added
Evaluating the prototype	No evaluation on the prototype generated.	Evaluation performed on the prototype generated.	Evaluation performed on the prototype generated and prototype re-designed based on the evaluations.
Introduction of the prototype and sharing the process	Poorly introduced.	Satisfactorily introduced.	Impeccably introduced.
Awareness of the link between sciences and mathematics during the process of generating a prototype and collection of data	Failed to understand the link between sciences and mathematics during the process of generating a prototype and collection of data.	Failed to understand good enough the link between sciences and mathematics during the process of generating a prototype and collection of data.	Understood the link between sciences and mathematics during the process of generating a prototype and collection of data.

Appendix 5

Group Work Evaluation Rubric

	Never (1)	Sometimes (2)	Frequently (3)	Always (4)
All student of the group contributed to the work.				
Students of the group exchanged opinions, reviewed the ideas they defended.				
Students of the group interacted for discussion, and addressed questions.				
Students of the group encouraged each other, and supported each others' opinions and efforts.				
Students of the group helped each other.				