EDUCATOR GUIDE

Dear Educator:

Environmental challenges are accelerating in the 21st century.

By 2050, the global population is expected to reach 9.5 billion people. At the same time, climate change and increasing urbanization are putting pressure on the environment and existing infrastructure. Despite progress, pollution problems persist around the globe, and billions suffer from inadequate access to clean water, food, sanitation, and energy.

Environmental engineers design systems and solutions at the intersection of humans and the environment. Over many decades, the field has improved countless lives through innovative systems for delivering water, treating waste, and preventing and remediating pollution in air, water, and soil. The dramatic growth and change in this century, however, will require new and innovative ways to approach problems.

In 2018, the National Academies of Sciences, Engineering, and Medicine issued a report to explore how the field of environmental engineering might need to evolve. Authored by 18 thought leaders, *Environmental Engineering for the 21st Century* identifies five major challenges that environmental engineering is uniquely poised to help address over the next several decades.

We are excited to offer to you this set of teaching resources based on the report. They are designed to help students understand the challenges and inspire them to work to develop solutions. Students are encouraged to use information from the report, which provides an excellent overview of both the challenges and the many solutions being considered. Students also can explore more than 300 primary references listed in the book.

We hope that you will take advantage of these free resources from the nation's science advisors. We welcome your input on your experiences in using them. Please use the feedback form on the website to send us your comments.

Sincerely,

National Academies of Sciences, Engineering, and Medicine

EDUCATOR GUIDE

Target Audience

These projects and lessons are designed for students in middle school and high school grades.

Program Objectives

- To introduce students to *Environmental Engineering in the 21st Century* and the global challenges they will help to solve.
- To challenge students to research and develop their own solutions to the challenges based on what they learn.
- To introduce students to the roles the environmental engineer can play in collaboration with other stakeholders in the process of creating solutions.

Components

This program is set up as a toolkit to encourage students to explore the present and future challenges in the world with the educator's guidance.

The program includes:

- An Educator Guide for implementation guidelines, including tips for virtual learning.
- Two project-based challenges with accompanying lessons outlined in downloadable documents on the website.
- An additional stand-alone section focused on environmental justice, which complements both project-based challenges.
- The report, *Environmental Engineering for the 21st Century*, broken down into "Grand Challenges" available for download in the Resource Section.
- Additional resources for students and educators for further research.

Standards

This program aligns to Next Generation Science Standards.

EDUCATOR GUIDE

How to Use this Program

The program can be adapted for your specific location, class size, and time allotment. There are two project-based learning assignments and each one has two to three lessons that will encourage students to explore the topics in the study and apply what they learn to creating their own solutions.

There is an additional section with four lessons for students to explore environmental justice. This lesson complements the two project-based assignments.

The projects with lessons are available on the website and broken down so they can be completed over a few class periods. The lessons can be extended or they can be utilized independently.

Some suggested implementations:
- Set up time to complete the lessons, during class time and assign the project as an afterschool/ homework assignment.
- Encourage students to keep notes as they progress through the lessons to assist with the development of their culminating projects.
- Allow time at the end of the program for students to present their projects to the class.
- Utilize the lessons and the accompanying projects as a supplement to existing curriculum to reinforce concepts.
- Use specific lessons that align with current curriculum.

REMOTE LEARNING SUGGESTIONS

With the COVID-19 pandemic, educators are navigating new ways of teaching remotely. Although the guide and lessons were originally designed for classroom work, they can easily be adapted to remote learning. We have included suggestions of how to do so in blue boxes throughout the teaching material.

We have created a series of worksheets to help students do independent work to support their remote learning. These worksheets are best used together with teacher-led instruction, class discussions, and group work.

You may decide to have your students do both projects or divide the class in two and have each group work on a project. There is opportunity for students to share the results of their projects encouraging peer to peer instruction.

EDUCATOR GUIDE

Project 1: Designing a City of the Future

OVERVIEW

In this project-based learning assignment, students will design a city of the future.

▶ **Their city design should address the following aspects:**

- **Providing sustainable water, energy, and food supplies**
- **Intervention and adaptation of climate change**
- **Disaster Resilience**

Students will explore these concepts in three lessons. The lessons have been developed to encourage both partner and group exploration. The level is geared toward high school but can be used in middle school with the addition of organizational aides for the material. Also, the open-ended nature of the assignments and project allow for a range of depth and sophistication of the resulting work.

The lessons are designed for a single 50-minute class but with discussion and or additional writing assignments they can be extended into more class time.

- Utilize the lessons and the accompanying projects as a supplement to existing curriculum to reinforce concepts.

- Use specific lessons that align with the current curriculum.

TIMELINE

DAY 1
Sustainability

DAY 2
Climate Change

DAY 3
**City Structure Issues/
Introduce Project**

DAYS 4 - 10
Project Based Work

EDUCATOR GUIDE

Project 1: Designing a City of the Future

Lesson 1

Sustainably Supply Food, Water, and Energy

Lesson 1 focuses on the sustainable supply of food, water, and energy. Students will understand the concept of sustainability and explore the impact of population growth, climate change and increased living standards on our supply of these essential life components. The concluding exercise, which explores solutions to these issues will be used for their work on the city design project.

Lesson 2

Curb Climate Change and Adapt to Its Impacts

Lesson 2 focuses on climate change. Students will understand the impacts and consequences of climate change and analyze solutions based on both adaptation and mitigation. The concluding exercise, which explores solutions to these issues will be used for their work on the city design project.

Lesson 3

Create Efficient, Healthy, Resilient Cities

Lesson 3 focuses on issues in our current cities. Students will understand that the future is becoming increasingly urban and they will identify the challenges of urban growth. In the concluding exercise, students will develop the characteristics of healthy cities and incorporate these into their city-design project.

The Design a City of the Future project incorporates three major focuses:

1. **Providing sustainable water, energy, and food supplies**

2. **Intervention and adaptation of climate change**

3. **Disaster resilience**

4. **Addressing environmental justice in solutions and designs for equity throughout the city**

Each student group will develop a presentation (the format is at the discretion of the educator – suggestions would be PowerPoint, video, graphs, documents, etc.) depicting their City of the Future design. We suggest providing the students with 2 to 3 class periods to do research and 3 to 4 class periods to work on the design. This can also be assigned as an out-of-class time project for teams to work on.

EDUCATOR GUIDE

Project 2: Creation of a Public Campaign on Environmental Impact of Smartphones
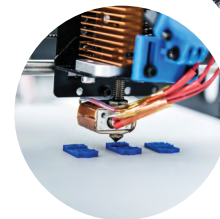
OVERVIEW

In this project-based learning assignment students will analyze the environmental impacts of smartphones and have an opportunity to create a public campaign. Their campaigns will be designed as Public Service Announcements (PSA) to raise awareness of the problem and change public attitudes and behavior.

▶ **This campaign will:**

- **Include at least two out of four elements of policy solutions**
- **Propose ways to incorporate a circular model of production and use for smartphones**

Students will explore these concepts in two lessons. The lessons have been developed to encourage both partner and group exploration. The level is geared toward high school but can be used in middle school with the addition of organizational aides for the material. Also, the open-ended nature of the assignments and project allow for a range of depth and sophistication of the resulting work.

The lessons are designed for a single 50-minute class but with discussion and/or additional writing assignments they can be extended into more class time.

TIMELINE

DAY 1
Fostering Informed Decisions

DAY 2
Designing a Future Without Waste

DAYS 3 - 9
Project Based Work

The National
Academies of | SCIENCES
ENGINEERING
MEDICINE

EduNetwork
PARTNERS

EDUCATOR GUIDE

Project 2: Creation of a Public Campaign on Environmental Impact of Smartphones

Lesson 1
Fostering Informed Decisions

Lesson 1 focuses on fostering informed decisions.
Students will understand how to analyze the problem, understand who needs to be involved in decision making and implementing a given solution. The concluding exercises, which explore different stakeholders and how they will influence change will be used in their work on their campaigns.

Lesson 2
Designing a Future Without Polution or Waste

Lesson 2 focuses on designing a future without pollution or waste.
Students will understand the impacts of waste in nature and the linear model of "Take-Make-Dispose". They will learn about current recycling programs and their challenges and the need for a circular model to reduce waste. The concluding exercise, which explores solutions to these issues will be used for their work on their campaigns.

The Creation of a Public Campaign on Environmental Impact of Smartphones incorporates two major focuses:

1. **Incorporating a circular model of production and use of smartphones**
2. **Considering the four elements of policy solutions**

Each student group will develop a Public Service Campaign (the format is left to the educator – we recommend video or some type of visual presentation) to raise awareness of the issue and with a goal to impact behavior. We suggest providing the students with 2 to 3 class periods to do research and 3 to 4 class periods to work on the campaign. This can also be assigned as an out-of-class time project for teams to work on.

EDUCATOR GUIDE

Environmental Justice Lessons

OVERVIEW

The U.S. Environmental Protection Agency defines environmental justice as "the fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income with respect to the development, implementation, and enforcement of environmental laws, regulations and policies. EPA states, "this goal will be achieved when everyone enjoys:

- The same degree of protection from environmental and health hazards, and

- Equal access to the decision-making process to have a healthy environment in which to live, learn, and work."[1]

When learning about the future of environmental engineering and the challenges encountered, it is important to have students explore the topic of environmental justice. The lessons are developed to encourage group research and discussion.

This section has 4 lessons and includes a subject matter expert video interview to assist your students with understanding the concepts in environmental justice and explore solutions.

The lessons are designed for a single 50 minute class but with discussion and/or additional writing assignments that can be extended into more class time.

[1] See www.epa.gov/environmentaljustice.

TIMELINE

DAY 1
Introduction - What is Environmental Justice?

DAY 2
Exploration of Environmental Justice Issues

DAY 3
Impact of Environmental Justice

DAY 4

Challenges and Solutions

EDUCATOR GUIDE

Environmental Justice Lessons

Lesson 1
What Is Environmental Justice

Lesson 1 focuses on the definition of Environmental Justice. Using a video interview by a high school student with Professor David Pellow, Dehlsen Chair and Professor of Environmental Studies and Director of the Global Environmental Justice Project at the University of California, Santa Barbara along with a case study, students will develop an understanding of the concept.

Lesson 2
Exploration of Environmental Justice Issues

Lesson 2 focuses on the issues people face in our society concerning environmental justice? Students will be given specific issues to research and discuss.

Lesson 3
Impact of Environmental Justice

Lesson 3 will have students discussing and drawing conclusions of how environmental justice impacts their community, the government, and is influenced by status and locality.

Lesson 4
Challenges and Solutions

Lesson 4 focuses on a specific challenge in one location in the U.S. and challenges students to develop solutions. They will work in groups to take on specific roles in the development of solutions. At the end of this lesson, there is a video with Professor David Pellow describing the actual issue and the solutions that were developed.

The National
Academies of | SCIENCES
ENGINEERING
MEDICINE

EduNetwork
PARTNERS

EDUCATOR GUIDE

REMOTE LEARNING SUGGESTIONS

1 **Student Introduction:**
Introduce the projects by sending the students to the **Student Page** on the website. There they can read the overview of the project and some starter questions before embarking on the lessons for their project.

2 **Lesson Implementation:**
The lessons were designed to encourage brainstorming and discussion. Utilizing the tools available to you through your district, you might:

a. Create a quick video for each lesson where you introduce the content and give them instructions utilizing the information in the lesson PDFs on the **Educator Page**. You can also do this part in a live video meeting with the class or project group. The video will allow students to access and watch independently.

b. Develop a timeline for each lesson that best fits your online class instruction model and includes:
   i. Independent research time for students to read the assigned sections of the report as outlined in the lesson plans
   ii. Online group brainstorming sessions either through live video discussions or collaborative group documents
   iii. Sharing time for groups to share what they have learned utilizing a discussion board, live video discussion and/or through short student video presentations that are shared with the rest of the class

3 **Project-Based Learning Projects:**
Upon the completion of the lessons - engage your students in the projects. Student should work in teams independent from the teacher utilizing tools that facilitate teamwork and collaboration.

Each project team will need:

a. Clear expectations of what the end product (presentation) should be – video, PowerPoint, or maybe it is open to them to determine
b. Clear timeline for completion of the project
c. A space where they can collect information as a team to use to develop their presentations (Google Classroom, Dropbox folder etc.)
d. Ability to brainstorm with their teammates as they build their solution-based presentation
e. Access to the teacher for assistance along with periodic check-ins along the way
f. A schedule for final presentations either accessible online or through a live video chat

Your school district may have specific tools that you are encouraged (or required) to use for remote learning. These tools may include interactive/collaborative work environments like Google Classroom and Google Docs along with video chat environments like Zoom. There are many wonderful tools to encourage group learning and team collaboration which will assist with the implementation of this program.