ONE STEP™

A 2-FOR-1 POLLUTION SOLUTION

LESSON PLAN | GRADES 9-12

#stompoutcarbon for a better tomorrow!

The city of Douala, Cameroon has a major issue. It is a city that thrives mainly on fishing, but the water in the rivers are so polluted with plastic bottles that it is difficult for fish to survive, *and* for fishermen to catch enough fish to support themselves. Decreased fish yields mean less profit for fishermen, which exacerbates the problem of fishermen investing in expensive wooden boats.

C1E1 (7 mins)

Ecoboats: The Solution that Floats

Learn how one person solved two different problems at the same time! Could you solve a pollution crisis and a food shortage at the same time? That's what Ismael Essome is doing in Cameroon, Africa!

Thanks to the resourceful engineers at Madiba & Nature, this problem has a very unique solution: use the plastic bottles to make boats! These inventions, known as Ecoboats, cleans the pollution and provides the local inhabitants with affordable boats for fishing. In this lesson and video, students will see how one young entrepreneur solves two problems with one solution, all while diverting tons of plastic waste. Ingenuity, creativity, and innovation are at the heart of this man's passion for the environment and the people of his city.

OBJECTIVES

Lesson Time: 2 hr 55 mins+

Lesson Description: In this lesson, students will learn about the problem of plastic pollution, especially plastic bottle pollution, and how this problem is being managed in different parts of the world. Working primarily in small groups, students will collect and analyze data to understand the scope of the plastic waste problem in their own school community, then use the engineering process to design and create an invention that solves a local community problem and upcycles plastic materials from their school. Finally, students will design an elevator pitch to explain and "sell" their product to people.

Students will:

- Students will learn about the value of engineers and the engineering process in solving problem.
- Students will discuss and analyze the scope of plastic waste problems in their school community.
- Students will use the engineering process to create a design that solves multiple community problems.
- Students will analyze the success of their design and reflect on ways to improve their design.
- Students will create a concise and compelling "pitch" to explain the value of their invention to a larger audience.

Prior Knowledge:

- Students should have some familiarity and experience with the engineering design process.

TO PREPARE

This lesson requires students to engineer a project by upcycling waste materials, and will require collection time before completing the lesson. Students will first collect data about plastic waste in their school community, then use the data to inform the materials they use for their engineering project. Collect these materials yourself, set up a bin in the teacher's lounge requesting supplies from faculty, or send home a letter requesting supplies from families.

- **common plastic waste materials:** straws, bottles, bottle caps, bags, plastic-lined milk cartons, ziploc bags, plastic packaging materials, etc
- **other helpful engineering materials to collect:** paper towel/toilet paper rolls, cardboard, egg cartons, aluminum foil, etc.
- **common classroom materials:** scissors, glue/tape/other binding materials

Vocabulary Words

Use the Vocabulary Slides to review these words and concepts as needed.

biodiversity: the variety of life in the world or in a particular ecosystem

economy: the way in which goods and services are made, sold, and used in a country or area

ecotourism: tourism directed toward natural environments intended to support conservation efforts

engineer: a scientist that solves problems by creating products or inventions

engineering process: a series of steps that engineers use to solve problems by creating products or inventions

innovation: a new idea, device, or method

upcycle: the reuse of an object or material that creates a product of higher quality or value than the original

Cross Curricular Lesson Suggestions

Math: Organize students into investigative teams to further explore and catalog the prevalence of plastic pollution in their school community or another location. Give each group a camera and handheld GPS device, and consider asking them to record a picture, picture ID, geographic coordinates, written description, and measurements for each piece of plastic trash found. Students can analyze data to determine trends, record data on an aerial view of the site, and could even use the data to create a GIS layer on a map.

Social Studies: Research teenage inventors around the globe. Lead a discussion about which examples are most inspiring, and why. Consider incorporating some videos about US-specific inventions from the US Patent and Trademark Office.

ELA: Read about the Plastiki catamaran, created by environmentalist David de Rothschild. Discuss similarities and differences between Ecoboats and Plastiki, including the goal of each project.

Art: Organize a trash cleanup in your community for students. Encourage students to carefully collect trash (always wearing gloves) and design their own work of art with the materials to encourage others to reduce waste.

Music/ELA: Distribute copies of the lyrics to "Plastic Beach" by the Gorillaz. Lead a discussion about the meaning of the lyrics and what they're referring to. Students can also research the inspiration behind the album, as well as album art, to better inform them about the work.

ENGAGE

30–60+ minutes* (depending on data collection method chosen)

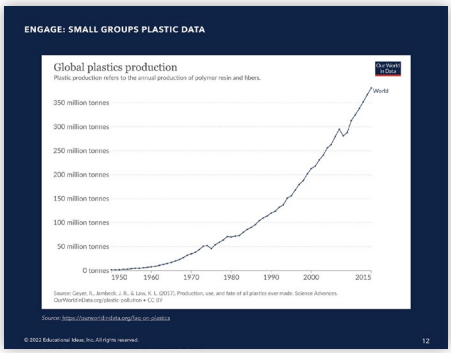
Ancillary Materials: Small Groups Plastic Data

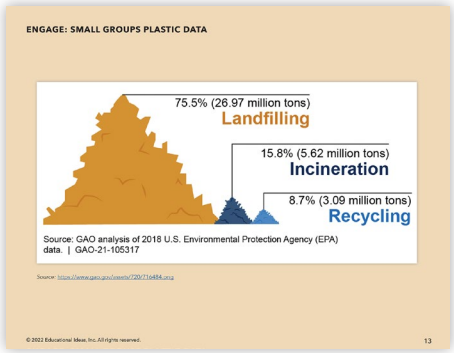
Supplies: disposable gloves (if needed), notebook

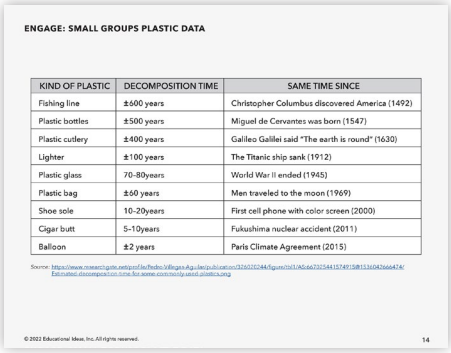
Optional Materials: Engineering Notebook

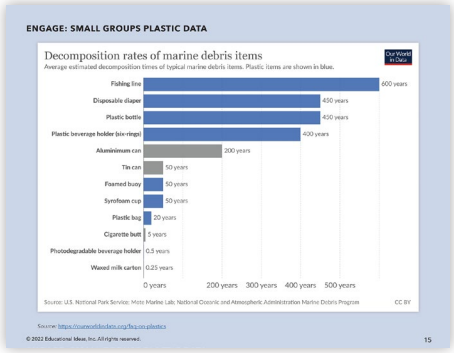
Divide students into small groups and distribute a copy of Small Groups Plastic Data to each group. Ask students to discuss the following prompts in small groups, then share with the whole group:

- Describe how global plastic production has changed over time—why are these trends concerning?
- Where does plastic go after it's used? Do you think recycling rates are adequate?
- Analyze all pieces of data. What is most concerning to you?
- Discuss ways engineers could help improve the concerning trends that you noticed.*







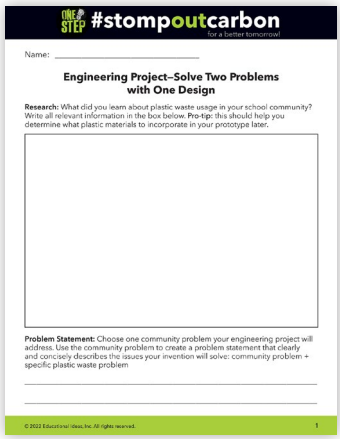


***Note:** This lesson plan is written with the assumption that students have some experience with the engineering process. Consider showing NASA Kids' Intro to Engineering video if students are unfamiliar with the engineering process, or using the 6–8 lesson plan for Ecoboats in its entirety.*

Explain to students that they will act as engineers to design and create a product that addresses plastic waste in their community. Before they create the product, they will collect data about plastic waste in order to better understand the problem. Choose one of the following suggested procedures for students (or more, depending on timing and the needs of your students):

- **School data collection "field trip":** Distribute gloves to students and conduct a brief (15–20 minutes) field trip around the school campus. Discuss important types of data to collect before beginning the field trip (plastic litter around campus, number of recycling bins and how much they are used, amount of recyclable plastic waste found in trash bins, etc.). Encourage students to explore different parts of campus and share data afterwards so students identify trends in plastic usage.
- **Design a plastic waste survey:** Divide students into groups and ask them to determine a specific audience and objective for their survey (determining what types of disposable materials are used most, what percentage of recyclable materials are actually recycled, etc.). Ask students to create a survey draft on a free website like Google Forms, then share with another group for feedback. After surveys are finalized and distributed, groups should analyze data and share trends with the whole group. *(**Note:** If you choose to use Google Forms, it will automatically organize data by question for easy analysis.)*
- **Plastic journal:** Ask students to track their plastic usage at school for 1–5 days. Students should share their results and compare data in order to identify trends in plastic usage.

***Note:** Depending on the needs of your students, you may choose to ask students to record all information in their notebooks, or you may provide an Engineering Notebook as a scaffold.*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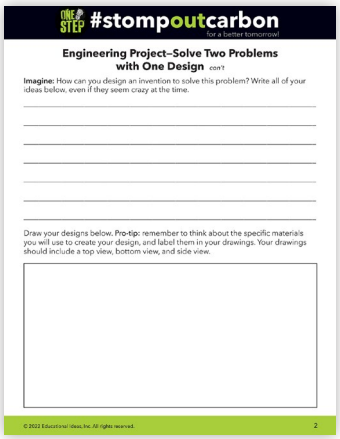
Name: _____

Engineering Project–Solve Two Problems with One Design

Research: What did you learn about plastic waste usage in your school community? Write all relevant information in the box below. **Pro-tip:** this should help you determine what plastic materials to incorporate in your prototype later.

Problem Statement: Choose one community problem your engineering project will address. Use the community problem to create a problem statement that clearly and concisely describes the issues your invention will solve: community problem + specific plastic waste problem

 1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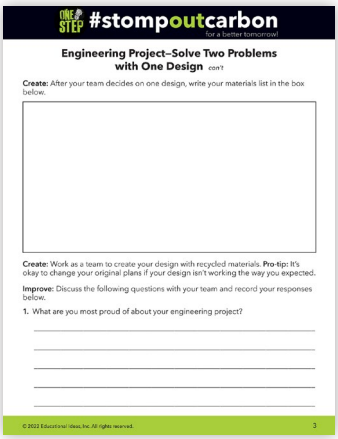
Engineering Project–Solve Two Problems with One Design *con't*

Imagine: How can you design an invention to solve this problem? Write all of your ideas below, even if they seem crazy at the time.

Draw your designs below. **Pro-tip:** remember to think about the specific materials you will use to create your design, and label them in your drawings. Your drawings should include a top view, bottom view, and side view.

 2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Engineering Project–Solve Two Problems with One Design *con't*

Create: After your team decides on one design, write your materials list in the box below.

Create: Work as a team to create your design with recycled materials. **Pro-tip:** It's okay to change your original plans if your design isn't working the way you expected.

Improve: Discuss the following questions with your team and record your responses below.

1. What are you most proud of about your engineering project?

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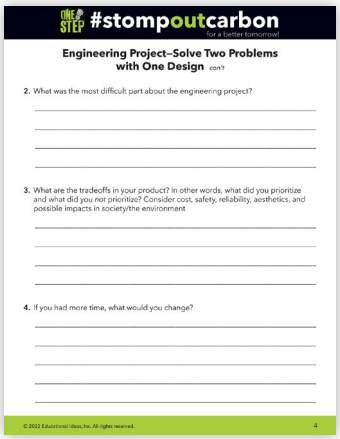
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Engineering Project–Solve Two Problems with One Design *con't*

2. What was the most difficult part about the engineering project?

3. What are the tradeoffs in your product? In other words, what did you prioritize and what did you not prioritize? Consider cost, safety, reliability, aesthetics, and possible impacts in society/the environment

4. If you had more time, what would you change?

 4

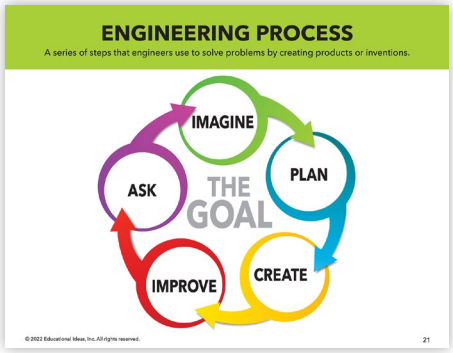
EXPLORE

45 mins

Ancillary Materials: Engineering Notebook

Tell students that before you reveal the details of their engineering project, they will watch a video about another engineer for inspiration. Watch the video "Ecoboats" and engage students in a whole group discussion with the following prompts:

- How might plastic pollution affect plants and animals in the environment?
- How does reducing pollution affect biodiversity? Why does that matter?
- How might a decrease in biodiversity affect ecosystems? *(**Note:** A decrease in biodiversity will always impact an ecosystem in some way; for example, a decrease in insects means there is less food for animals that eat insects. A decrease in predators could mean an increase in prey animals, like mice, and a decrease in the populations of their food source. Push students to answer with specificity by giving them specific prompts, if needed. The Climate Talk video and lesson "Animals" will address ecosystems in detail.)*
- What are the two problems that Ecoboats help solve?
- How could you use this story as inspiration to solve multiple problems in your community?



Explain to students that they will go through the engineering process in order to design and build a prototype that solves a community problem and incorporates common plastic waste materials in the school community, like the engineers at Madiba & Nature did with Ecoboats. Engage students in a whole group discussion with the following prompts:

- What are some problems that people in our community face? One way to generate ideas is to think of the issue of "safety" for all people in our community throughout the year. *(Write down ideas for students to refer to later.)*
- Which of these problems could be addressed with an invention that incorporates plastic waste materials? Why do you think that?

***Note:** Depending on timing and your students' experience with the engineering design process, you may choose to scaffold this project by choosing a community problem generated by students for all groups to address, or by listing 2–3 community*

problems and asking each student group to choose one to address with their project. This project will be more meaningful if your students center it around the students' local community/school community. If you choose to generate a list for students to choose from, consider common community problems, such as: drought/flooding issues; a decrease in a specific organism problem, or other local ecosystem issues; or dangers around extreme temperatures.

Ask groups to create a problem statement, which should clearly and concisely describe the issues their invention will solve (community problem + specific plastic waste problem in school community). If needed, guide groups through this process by modeling how to create a problem statement, and/or work together to improve groups' problem statement drafts as a class.

Explain the importance of researching existing solutions to groups, and give them ample time to research existing inventions that solve similar problems (both to ensure that they don't duplicate an existing solution, and for inspiration). One valuable place for students to research is the U.S. Patent Office's search index.

Encourage students to be as creative as possible during the brainstorming process. The most creative ideas can create the most innovative solutions! Go over brainstorming guidelines with students as needed:

- Use your imagination when brainstorming.
- No negativity or disrespectful comments.
- Write down all ideas, even if they seem crazy at the time.
- Consider the materials you have to build with as you brainstorm—what's the function of each material? How could you use that material to help solve the community problem?
- Think about ways to build on each other's ideas, or combine ideas to come

As students are brainstorming, circulate and support as needed. *(**Note:** It is highly suggested to give students some silent brainstorming time before they share with their teammates.)* After students finish brainstorming, they should consider each member's design and choose a final design. Remind students that the final design choice can be one student's design or a combination of several student designs.

***Note:** Depending on the needs of your students, you may choose to ask students to record all engineering project information in their notebooks, or you may provide an Engineering Notebook as a scaffold.*

EXPLAIN

30 mins

Supplies: Common plastic waste materials (to be determined by student data collection; common materials include straws, bottles, bottle caps, bags, plastic-lined milk cartons, ziploc bags, plastic packaging materials, etc.); other engineering materials (paper towel/toilet paper rolls, cardboard, egg cartons, aluminum foil, etc.), scissors, glue/tape/other binding materials

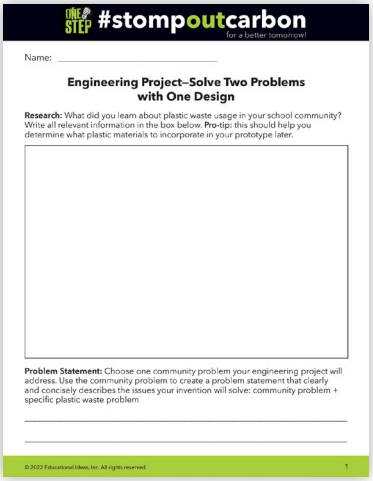
Optional Materials: Engineering Notebook

Remind students that their goal is to create an invention that solves a community problem and contributes to the school community's plastic waste problem. Go over the relevant parts of the rubric and answer any student questions before beginning. Distribute requested materials to each group along with tape, scissors, and glue. After students complete their model, ask them to discuss and record their reflections on the following prompts in their notebooks (***Note:*** *The same prompts are found in the Engineering Notebook if you choose to use this document as a scaffold)*:

- What are you most proud of about your engineering project?
- What was the most difficult part about the engineering project?
- What are the tradeoffs in your product? In other words, what did you prioritize and what did you not prioritize? Consider cost, safety, reliability, aesthetics, and possible impacts in society/the environment.
- If you had more time, what would you change?

Note: *Depending on timing and the needs of your students, it may be beneficial to allow students to briefly present their ideas to the group and gather feedback from their peers. This can be accomplished verbally or through a gallery walk format with written student feedback cards. Students can then use their reflection and peer feedback to improve their prototype.*

Depending on the needs of your students, you may choose to ask students to record all engineering project information in their notebooks, or you may provide an Engineering Notebook as a scaffold.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Name: _____

Engineering Project–Solve Two Problems with One Design

Research: What did you learn about plastic waste usage in your school community? Write all relevant information in the box below. **Pro-tip:** this should help you determine what plastic materials to incorporate in your prototype later.

Problem Statement: Choose one community problem your engineering project will address. Use the community problem to create a problem statement that clearly and concisely describes the issues your invention will solve: community problem + specific plastic waste problem

ELABORATE

30–40 mins

Supplies: notebooks

Engage students in a brief whole group discussion with the following prompt:

- How do you think engineers/inventors move from the prototype stage, which we're in, to actually creating something usable for people?

Supplement the discussion as needed. By the end of the conversation, students should recognize that engineers/inventors have to "pitch" their design, or explain its usefulness, in order to get funding support from investors or the government.

Explain to students that they will create their own 1-minute "elevator pitch" of their prototype to help "sell" their idea to anyone. Students should record ideas for their pitch in their notebooks. Display and discuss the pitch requirements; suggest requirements include:

- The pitch must clearly explain the who, what, when, where, why, and how of the issues and solution.
- The pitch must be designed in a way that would convince anyone (investor, government official, potential customer) that your product solves two problems with one solution.
- The pitch should include one slide (poster paper or digital) that enhances the message of the pitch.
- The pitch should include a brief demonstration with the prototype so that people understand how it works.
- The entire pitch shouldn't last longer than 1 minute.

Based on timing and the needs of your students, you may choose to ask groups to present their pitches to the whole class or to create a video of their pitch for you to view later.

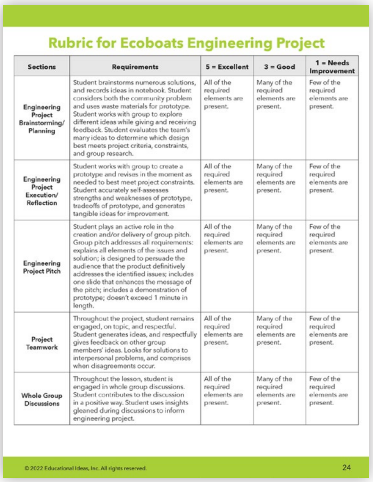
Optional Extension Project: Challenge students to turn their pitch into a social media campaign for their invention and run their campaign on a school social media account, if possible.

EVALUATION

Ancillary Materials: Ecoboats Rubric

Evaluate students' efforts throughout the lesson by using the provided rubric.

Note: *The goal of this rubric is to provide a holistic grade of students' efforts throughout the engineering project, including teamwork within small groups, creating design prototype and product pitch. The rubric also includes a section for whole group discussions throughout the lesson. Please feel free to alter the categories and/or points values based on the needs of your students.*



Rubric for Ecoboats Engineering Project

Sections	Requirements	5 = Excellent	3 = Good	1 = Needs Improvement
Engineering Project Brainstorming/ Planning	Student brainstorms numerous solutions, and records ideas in notebook. Student considers both the community problem and uses waste materials for prototype. Student works with group to explore different ideas while giving and receiving feedback. Student evaluates the team's many ideas to determine which design best means project criteria, constraints, and group research.	All of the required elements are present.	Many of the required elements are present.	Few of the required elements are present.
Engineering Project Execution/ Reflection	Student works with group to create a prototype and revises in the moment as needed to best meet project constraints. Student accurately self-assesses strengths and weaknesses of prototype, tradeoffs of prototype, and generates tangible ideas for improvement.	All of the required elements are present.	Many of the required elements are present.	Few of the required elements are present.
Engineering Project Pitch	Student plays an active role in the creation and/or delivery of group pitch. Group pitch addresses all requirements: explains all elements of the issues and solution; is designed to persuade the audience that the product definitively addresses the identified issues; includes one slide that enhances the message of the pitch; includes a demonstration of prototype; doesn't exceed 1 minute in length.	All of the required elements are present.	Many of the required elements are present.	Few of the required elements are present.
Project Teamwork	Throughout the project, student remains engaged, on topic, and respectful. Student generates ideas, and respectfully gives feedback on other group members' ideas. Looks for solutions to interpersonal problems, and comprises when disagreements occur.	All of the required elements are present.	Many of the required elements are present.	Few of the required elements are present.
Whole Group Discussions	Throughout the lesson, student is engaged in whole group discussions. Student contributes to the discussion in a positive way. Student uses insights gleaned during discussions to inform engineering project.	All of the required elements are present.	Many of the required elements are present.	Few of the required elements are present.

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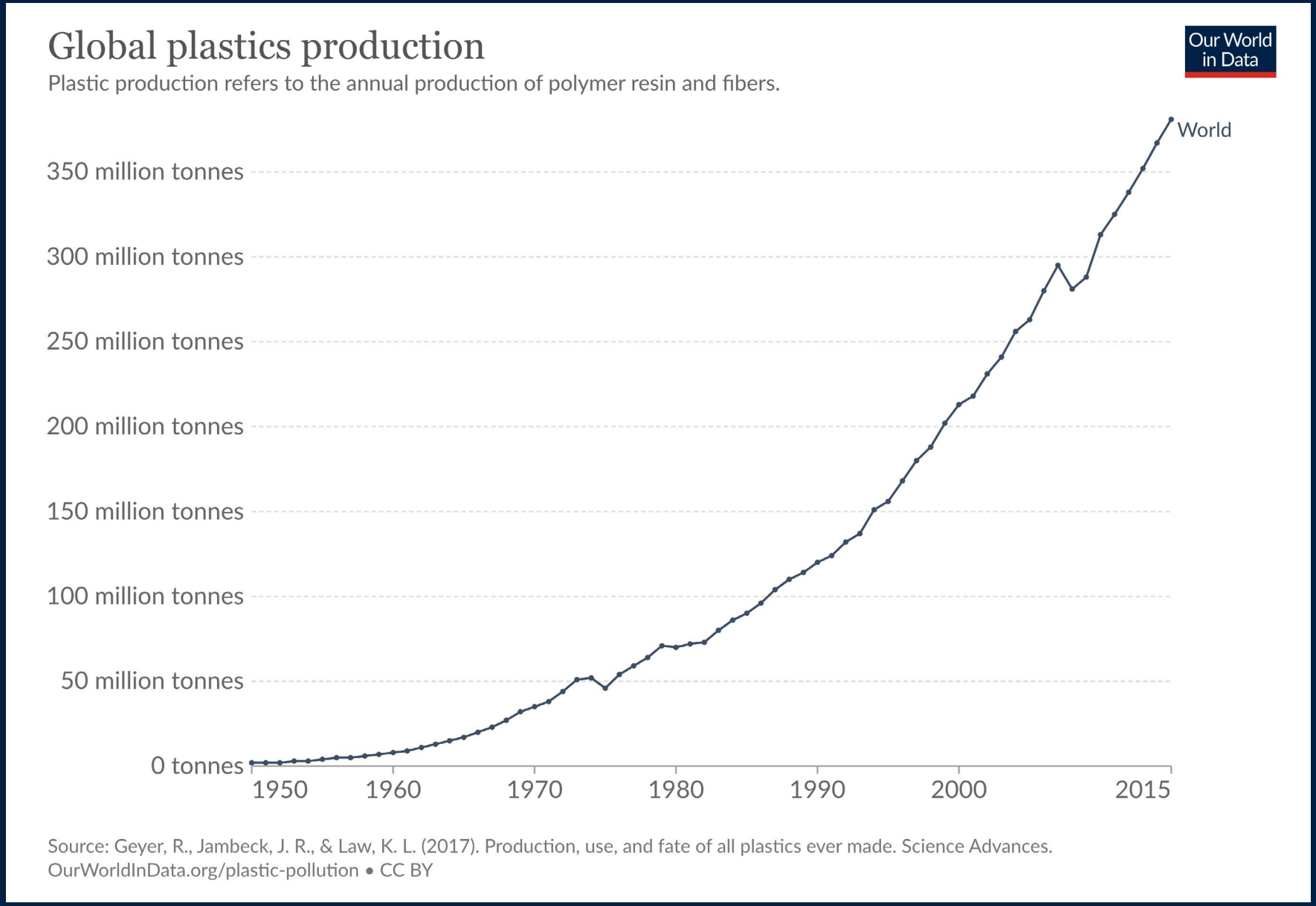
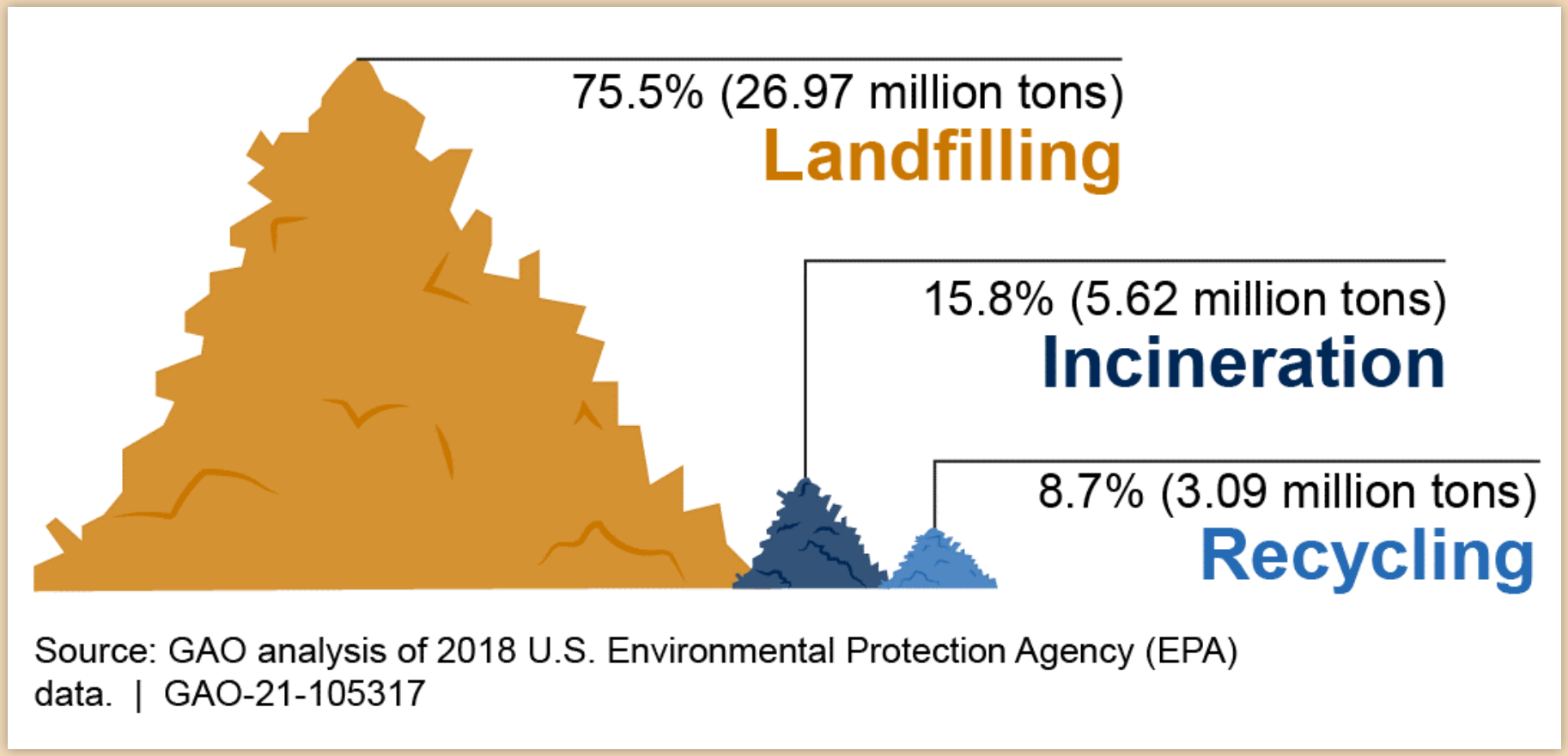
ENGAGE: SMALL GROUPS PLASTIC DATA



Source: https://ourworldindata.org/faq-on-plastics

ENGAGE: SMALL GROUPS PLASTIC DATA



Source: https://www.gao.gov/assets/720/716484.png

ENGAGE: SMALL GROUPS PLASTIC DATA

KIND OF PLASTIC	DECOMPOSITION TIME	SAME TIME SINCE
Fishing line	±600 years	Christopher Columbus discovered America (1492)
Plastic bottles	±500 years	Miguel de Cervantes was born (1547)
Plastic cutlery	±400 years	Galileo Galilei said "The earth is round" (1630)
Lighter	±100 years	The Titanic ship sank (1912)
Plastic glass	70–80years	World War II ended (1945)
Plastic bag	±60 years	Men traveled to the moon (1969)
Shoe sole	10–20years	First cell phone with color screen (2000)
Cigar butt	5–10years	Fukushima nuclear accident (2011)
Balloon	±2 years	Paris Climate Agreement (2015)

Source: https://www.researchgate.net/profile/Pedro-Villegas-Aguilar/publication/326020244/figure/tbl1/AS:667025441574915@1536042666474/Estimated-decomposition-time-for-some-commonly-used-plastics.png

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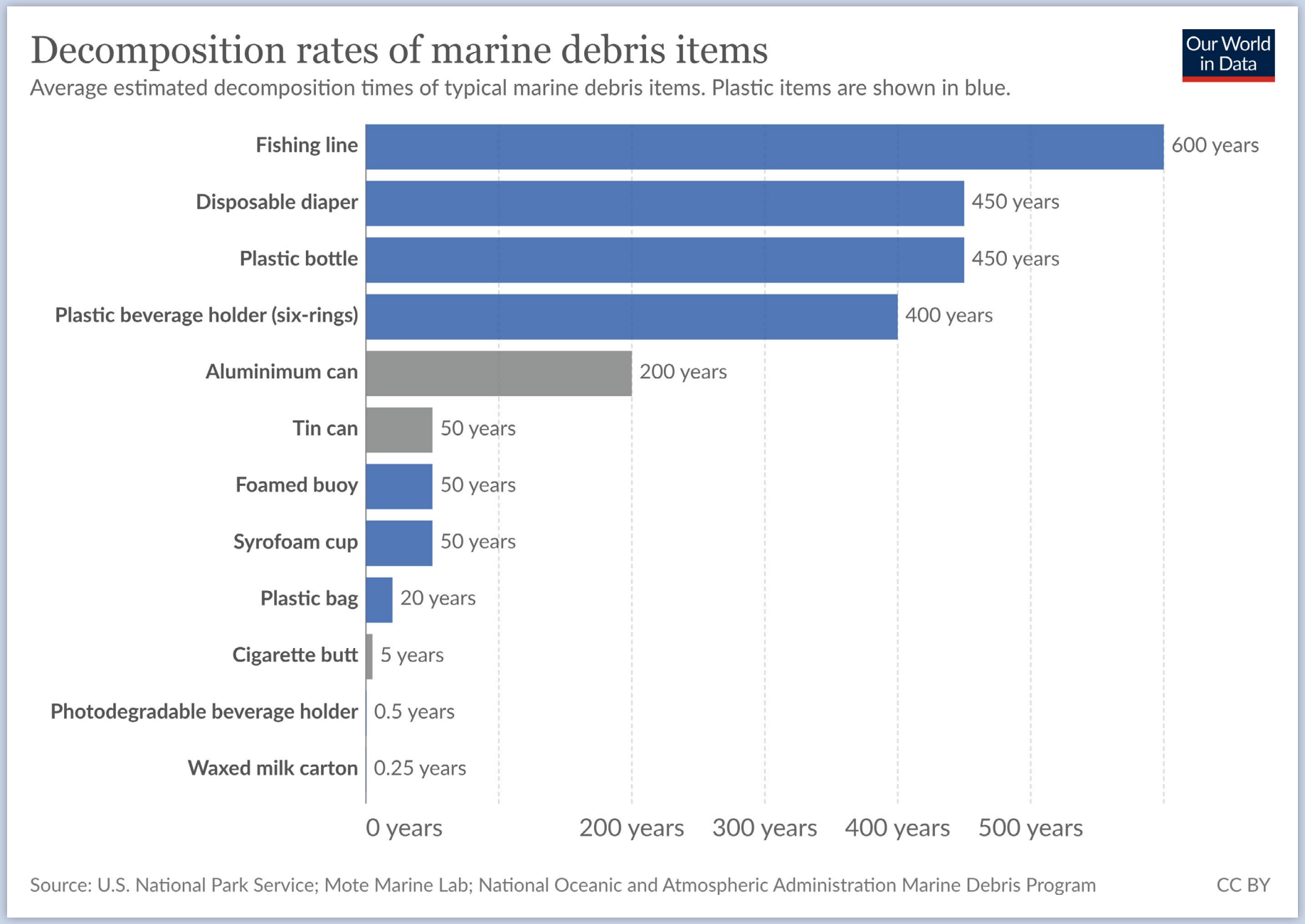

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Vocabulary

BIODIVERSITY

The variety of life in the world or in a particular ecosystem.

ECONOMY

The way in which goods and services are made, sold, and used in a country or area.

ECOTOURISM

Tourism directed toward natural environments intended to support conservation efforts.

ENGINEER

A scientist that solves problems by creating products or inventions.

ENGINEERING PROCESS

A series of steps that engineers use to solve problems by creating products or inventions.

INNOVATION

A new idea, device, or method.

UPCYCLE

The reuse of an object or material that creates a product of higher quality or value than the original.

Rubric for Ecoboats Engineering Project

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HS-ESS3–4: Evaluate or refine a technological solution that reduces impacts of human activities on natural systems.

HS-ETS1–1: Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants.

HS-ETS1–2: Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.

HS-ETS1–3: Evaluate a solution to a complex real-world problem based on prioritized criteria and tradeoffs that account for a range of constraints, including cost, safety, reliability, and aesthetics as well as possible social, cultural, and environmental impacts.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Constructing Explanations and Designing Solutions Asking Questions and Defining Problems	**ESS3.C:** Human Impacts on Earth Systems **ETS1.A:** Defining and Delimiting Engineering Problems **ETS1.B:** Developing Possible Solutions **ETS1.C:** Optimizing the Design Solution	Stability and Change **Connections to Engineering, Technology, and Applications of Science** Influence of Science, Engineering, and Technology on Society and the Natural World

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Student Materials

Name: _____

Engineering Project—Solve Two Problems with One Design

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_____

_____

Engineering Project—Solve Two Problems with One Design *con't*

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Engineering Project—Solve Two Problems with One Design *con't*

Create: After your team decides on one design, write your materials list in the box below.

Create: Work as a team to create your design with recycled materials. **Pro-tip:** It's okay to change your original plans if your design isn't working the way you expected.

Improve: Discuss the following questions with your team and record your responses below.

1. What are you most proud of about your engineering project?

Engineering Project—Solve Two Problems with One Design *con't*

2. What was the most difficult part about the engineering project?

3. What are the tradeoffs in your product? In other words, what did you prioritize and what did you *not* prioritize? Consider cost, safety, reliability, aesthetics, and possible impacts in society/the environment

4. If you had more time, what would you change?