LESSON 1 Design Like an Eco-Engineer

OBJECTIVE

Students deepen their understanding of the engineering design process using a real-world case study, and apply the process in an eco-engineering challenge.

MATERIALS

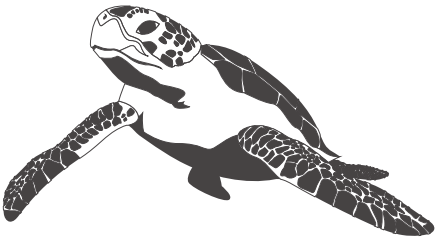
"Tackling the Plastic Disaster" reading passage, Internet access, paper, tape, scissors, other modeling materials found readily in the classroom

TIME

75 minutes

CONTEST PREP

Review the contest entry form before completing this lesson; students will use the engineering design process to develop a manufacturing a solution to a real-world problem.



CLASS DISCUSSION

Write or project the steps of the engineering design process on the board. Ask students how they think the steps are related. Discuss some of the points below. If students don't bring it up, tell them these are stages of the engineering design process. Explain that this process isn't always orderly. In practice, innovators may jump back and forth between steps or visit steps out of order. If you wish, show and discuss these videos about the process from NASA: bit.ly/1LeJa5P and go.nasa.gov/2PnkzFv.

ENGINEERING DESIGN PROCESS STEPS
Define the problem. What is inside and outside the scope of the problem?
Collect research. What is already known? What remains unknown? Use empathy: Who or what does the problem affect?
Specify requirements for your solution. What will a successful solution accomplish and not accomplish?
Brainstorm, evaluate, and choose a solution. Think of ideas. Compare and assess them. Decide which ideas you'd like to test further.
Develop and prototype a solution. Create a sample or test model.
Test your solution. Simulate realistic conditions. Does the prototype meet your requirements?
Communicate your results. Share your learnings. Solicit peer feedback. Gather funding.
Revisit any part of the process. Respond to failure. Do more research, iterate your prototype, brainstorm new ideas, or specify new requirements.

CASE STUDY

Distribute "Tackling the Plastic Disaster." Ask students to look for the steps of the Engineering Design Process as they read. Students should use context and inference (or do research) to sketch diagrams and answer the questions at the end of the article. Have them share a few of their answers with the class.

ACTIVITY

Ask students to work in pairs or small groups to apply the Engineering Design Process to one of the eco problem statements below. Challenge them to use as many stages of the process as they can in the allotted time. Have students share their work with the class.

PROBLEM STATEMENTS

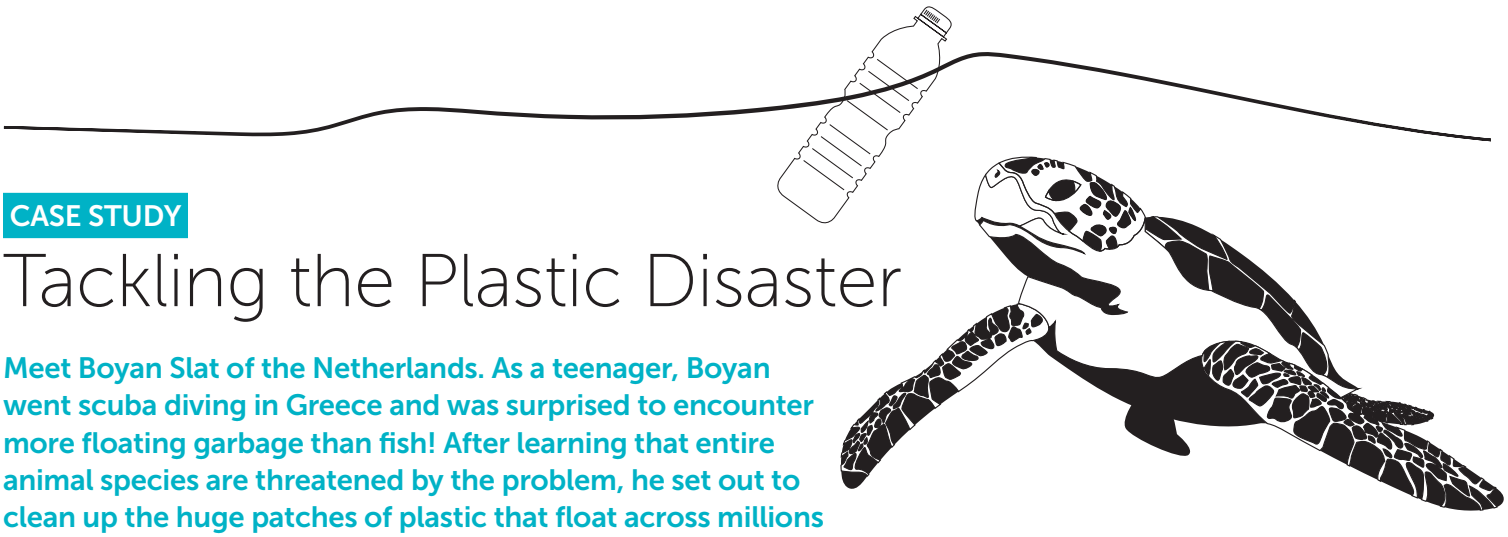
- Transportation (cars, trucking, air travel) continues to be one of the most significant contributors of pollution.
- Population growth creates an increase in home-energy consumption.
- The manufacture of single-use materials (packaging, plastic bags, straws) is detrimental to the environment.
- The food supply chain is a significant draw on our water sources, aquatic life, and more.

CONTEST | $1,000 CLASSROOM GRANTS

Use these lessons to prepare students to enter the Innovators of Tomorrow Contest. Students will develop an invention that uses advanced manufacturing to solve a problem. Five winning students will each receive a tablet and their teachers will receive $1,000 for the classroom. Get details at **scholastic.com/arconicfoundation/contest**

NO PURCHASE NECESSARY TO ENTER OR WIN. Void where prohibited. Open only to students in grades 9–12 in a public school, an accredited private school, or a home school in the 50 United States (or the District of Columbia) which is in compliance with the laws and regulations of its state/district and who are residents of the United States. Students' teachers may also submit entries on their students' behalf both online or by mail, if the teacher is 18+ and a teacher at the student's school. To enter, an eligible student must go to scholastic.com/arconicfoundation to complete the online entry form, as well as create and upload a written description and sketch of an innovation that uses advanced manufacturing; or complete entries can be submitted through the mail. Deadline: submitted or postmarked between 12:01 a.m. ET on October 1, 2019, and 11:59 p.m. ET on December 13, 2019 (mail-in entries must be received by 12/20/20). Prize: Five (5) winning students will receive one tablet (ARV: $79.99). Each winning student's teacher will receive a $1,000 grant for classroom use (five grants in total). See Official Rules.

ARCONIC FOUNDATION



CASE STUDY

Tackling the Plastic Disaster

Meet Boyan Slat of the Netherlands. As a teenager, Boyan went scuba diving in Greece and was surprised to encounter more floating garbage than fish! After learning that entire animal species are threatened by the problem, he set out to clean up the huge patches of plastic that float across millions of square miles of our oceans.

Boyan devoted himself to learning more about the plastic littering the oceans. He read that the patches of floating plastic were so large that experts believed they could never be cleaned. Undaunted, Boyan asked himself: "Why can't we clean this up?" He dedicated a high school science project to understanding the problem, researching why a cleanup was considered impossible. Boyan discovered that the conventional idea for ocean cleanup—an **active system** involving a boat dragging a net that collects plastic and brings it back to shore—was so costly and slow-working that it could never make an impact on the problem.

Soon, he began conducting his own field research, using a boat to tow a manta trawl (a net system that resembles a manta ray) that gathered samples of the plastic floating on the water's surface. Then he expanded his field research, designing a **multi-level trawl** to figure out just how deep the problem went. During collection, Boyan's multi-level trawl snapped from the tremendous forces exerted on it. With his research cut short, Boyan learned that he'd need to come up with another approach.

After a year of researching and experimenting, Boyan came up with the idea for a **passive system:** a V-shaped boom (a boom is a floating barrier), that skims plastic with the help of ocean waves and currents). One small problem: The boom requires an anchor or it will float away, but you can't anchor things to the ocean floor. It's far too deep. Boyan kept, researching solutions before landing on the idea for a system of drifting "anchors" 600 meters below the ocean's surface.

At sea during testing, parts of the prototype came loose from the mooring. Boyan and his team made adjustments to both the design and materials, switching from a soft, inflatable boom to a rigid boom made of pipe, solving for the mooring as they went. Boyan stresses the importance of testing on a small scale and making **iterative improvements** as you go. He says, "We test not to prove ourselves right, but to find things that don't work."

Now 24, Boyan and his nonprofit The Ocean Cleanup have raised millions in funding from the public and investors who believe in both the cause and the feasibility of Boyan's solution. Following scale prototypes and system trials, the first cleanup system deployment is scheduled to begin in the Great Pacific Garbage Patch in 2018.

DIVE IN

Write your answers on a separate sheet of paper.

1. EXPLAIN THESE TERMS from context using sketches and/or rough notes: multi-level trawl, active system, passive system, iterative improvements.
2. FIND EXAMPLES of stages of the Engineering Design Process in the case study.
3. LIST THREE EXAMPLES of failure from the article. How is failing important to the Engineering Design Process?