RESET | Biodegradable Plastic

AN AEOP EFFORT aeop

5E Lesson Plan

TEACHER

Linda Crossno
Vera Pape
Jennylou Riel
Renae Lawing

SUBJECT/GRADE LEVEL

Subject

Life Science

Extension: Robotics

Grade Level: High School

Materials

- Lab handouts
- Household materials for lab
  - Corn or Potato starch
  - Cooking oil or Glycerol
  - Water
  - Vinegar (Potato plastic only)
  - Measuring cups/spoons
  - Pipette
  - Stir rod
  - Beakers
  - Hot Plate
  - Oven or microwave oven

Extension: (Technology integration)

- Robotics kits (whichever is available/ teacher prefers)
- Desktop Computer/ Laptop
- 3D Printer (optional)

COMMON CORE STANDARDS

Next Generation Science Standards

- HS-LS2-3: Construct and revise an explanation based on evidence for the cycling of matter and flow of energy in aerobic and anaerobic conditions.
- HS-LS2-7: Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity.
- HS-ESS3-2 Evaluate competing design solutions for developing, managing, and utilizing energy and mineral resources based on cost-benefit ratios.
- HS.ESS3-4: Evaluate or refine a technological solution that reduces impacts of human activities on natural systems.
- HS-ETS1-2: -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 trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics as well as possible social, cultural, and environmental impacts.

Connections to environmental principles and concepts:

- Principle I: The continuation and health of individual human lives and of human communities and societies depend on the health of the natural systems that provide essential goods and ecosystem services.
- Principle II: The long-term functioning and health of terrestrial, freshwater, coastal and marine ecosystems are influenced by their relationships with human society
- Principle IIII: Natural systems proceed through cycles that humans depend on, benefit from, and can alter.
- Principle IV: Decisions affecting resources and natural systems are based on a wide range of considerations and decision-making processes.

English Language Arts Standards | Common Core State

- ELA/Literacy - WHST.6-8.7 Conduct short research projects to answer a question (including a self-generated question), drawing on several sources and generating additional related, focused questions that allow for multiple avenues of exploration. (MS-ESS3-3)

Mathematics Standards | Common Core State Standards

- Mathematics - 6.RP.A.1 Understand the concept of a ratio and use ratio language to describe a ratio relationship between two quantities. (MS-ESS3-3) 7.RP.A.2 Recognize and represent proportional relationships between quantities. (MS-ESS3-3)

LESSON OBJECTIVE

Students will identify the criteria and constraints of their biodegradable plastic production and investigate the rate of decomposition between biodegradable and non-biodegradable plastic in different environments in order to study the environmental impact of petroleum-based plastic.

CAREER STATEMENT

Linda Crossno worked with Kathryn Guy at the ERDC CERL Army Research Lab in Champaign, Illinois. Their work led to the creation of this lesson plan. This lesson will lead students to material sciences/chemistry, environmental sciences, and environmental policies.

ENGAGEMENT

TEACHER

Create a circle map on the board. Have students think of ways they interact with plastic in their daily lives. As homework prior to discussing, have students make a list of encounters with plastics.

Links to articles and videos:
The Majestic Plastic Bag- 4 minutes mockumentary on the life of a plastic bag (Full video- 19 min)
Addressing the Sustainable Development Goals through Packaging: SDG 12, Sustainable Production & Consumption | GreenBlue
Issues and Concerns – Page 6

Plastic and Albatross- Dissecting Albatross Bolus
Background video: Albatross Barfing Plastic - Lesson 4 Winged Ambassadors on Vimeo
Order here or do the virtual dissection

Plastic and Human
After discussing the effect of plastic on albatross, have students discuss the effect on humans directly and indirectly.

STUDENTS

Before starting the unit, have students download an app on their phone "My Little Plastic Footprint" to determine how much plastic students are using. Students will list the ways in which they interact with plastics for at least 24 hours. Students will then share out in class (as the teacher fills out a circle map). Discuss what students know about plastics (good or bad).

Watch the mockumentary. Ask students what happens to the plastic in the Great Pacific Garbage Patch. If available, do the Albatross' bolus dissection at this time. If unavailable, show or have students complete a virtual dissection. Discuss how this indirectly affects humans.

EXPLORATION Potato/Corn Plastic Lab

TEACHER

The objective of this section is to have students make plastic using potato starch (or cornstarch) with varying amounts of plasticizers (corn oil or glycerol). The teacher will model the procedures of the lab for students. Students will then make the biodegradable plastic using different amounts of plasticizers. While the plastic is curing overnight, students will begin researching the "explanation" portion of this lesson plan.

STUDENTS

Lab
Extra Challenge: Going from potato to plastic and lab handout

EXPLANATION Biodegradable VS Non-biodegradable

TEACHER

Bioplastics and biodegradable plastics - How do they work?
Why Doesn't Plastic Biodegrade? | Live Science

Biodegradation: Microorganisms at Work

When something is biodegradable, soil, air, or moisture decomposes it so that it becomes part of the land. Bacteria, fungi, and other decomposers break down dead organisms in a natural process that keeps dead material from covering the planet. **Are there problems with Biodegradable plastics? Do some research and present.**

Non–biodegradable fossil-based polymers The term *non-biodegradable* describes polymers that do *not* break down to a natural, environmentally safe condition over time by biological processes. **What are the problems with non-biodegradable plastics?**

STUDENTS

Students design and test their own potato plastic creation and its biodegradability

- Different soils/compost/wood chips/sawdust etc.
- Different amounts of water
- Different exposure to sunlight
- Time to biodegrade

Students research and present.

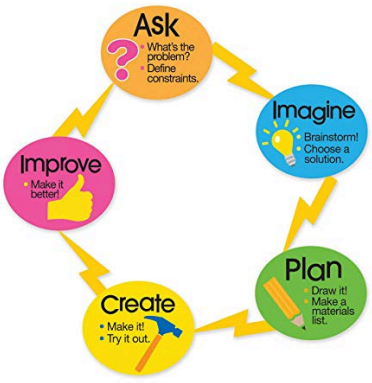
Rubric for Presentation

Assessed Item	Expectations	Points
Time	• 1-2 minutes	5
Presenting	• Every person must present(say something)	5
Content	• Discusses Independent Variable being changed • Dependent Variable responding to the IV • Hypothesis • Constants • Procedure • What data will be collected	5
Visual Aids	• Has a visual aid to demonstrate experiment, graph, etc.	5

ELABORATION Engineering Design Challenge

TEACHER

Discuss the Engineering Process and define the problem with plastics. Discuss with students ways to reduce the plastic problem. One of the solutions should be utilizing more biodegradable plastics. Give students the plastic they created in "Exploration" and explain the plastic they created is biodegradable. Present the challenge to students: create biodegradable plastic to replace non-biodegradable plastic and calculate how long it will take to totally decompose in one of three conditions: landfill, ocean, and body of freshwater. Before students may begin, have students come up with criteria and constraints (brainstorm) for their plastic and create a model (plan) before creating. All groups must have at least one re-design (improvements to the original design). Students will then test their final product based on the original criteria and investigate how long it would take to break down in one of the conditions given. It will take too long for the plastic to break down but students should be able to run a trial for at least a week and extrapolate the data.



STUDENTS

In pairs:

-brainstorm what plastic they want to create

-come up with criteria and constraints. What must their design be able to do? What are some of the challenges students will face (some out of their control)

-Have students draw (can be hand drawn or on the computer) what their product would look like, including how they plan to mold the plastic

-Have students write down the procedure for their original design and how it was created

-After students get the results, students make improvements. It can be improvements to the design, improvement to the recipe, improvement in aesthetics, or any other improvements (add food dye to the original recipe?). Be sure to have students take a picture of their original design for their presentation

-Final product: students will need to choose an environment to test how long it will take to biodegrade. Students will be required to show data, graphs, and calculations

EXTENSIONS: Engineering Design

TEACHER

The teacher will have the option to engage students in robotics. The students work collaboratively with the STEM/ MESA/ ROBOTICS clubs in the school. This will require time and effort thus the teacher must carefully plan the activities. This project can also be entered in a local or international contest to promote responsibility and time management to the student participants.

STUDENTS

Robotics application on the production of bioplastic.

Students design a working prototype of the production area. The objective is to create sheets of bioplastic that will be tested using a rubric. The goal is to have consistency in the production in terms of uniformity in the main preparation of the mixture from the actual combination of ingredients to the completion of the drying process.

Students will later test for significant differences between manual and automated production as discussed in the earlier part of this lesson.

Planned Activities:

1. Experimentation via actual experimentation the traditional way
2. Research via Inquiry-Based Approach and Collaborative Groups
3. Design Thinking Process and Engineering Design Approach via LEGO Digital Designer
4. Basic workshop on the use of robotics and software platforms
5. Prototyping and Testing.
6. Comparison of results in the product's biodegradability between automated and manual production.



EVALUATION Presentation

TEACHER

Provide a rubric to students on how they will be graded on the project. Students' grades should not be based on whether it worked or not but on the process students took and reflection on errors and areas of improvement.

A. Reference Rubric for Conducting an Experiment in the Lab:
   Guide: Commenting on and Grading Student Writing
   Rubric used to assess lab experiments. | Download Scientific Diagram

B. Scoring Rubric for Projects, Consulting-Style Reports, and Reports on Technical Topics
   Guide: Commenting on and Grading Student Writing

STUDENTS

Students will present their engineering process (building of plastic) and scientific inquiry (rate of decomposition).

APPENDIX A

Decomposition of potato plastic: https://www.jamesdysonaward.org/2018/project/potato-plastic/