

**MIDDLE SCHOOL**

**Green Chemistry**

**Lesson Two: Using Engineering Design to Make a Prototype**

**Background:** When making a new product or process, engineers use the *engineering design process* to methodically create and test prototypes to determine the best option. There are many ways to represent this method, including the cycle below.

This method is typically highly iterative. As the engineers test their prototypes, they often discover properties or features of their design that need to be improved. They will then update and reevaluate their prototype until it meets their requirements. Throughout the process, engineers are challenged to think critically and creatively as they collect and analyze data and draw conclusions.

In this lesson, students will be tasked with designing a biodegradable cell phone case made with mycelium material by Ecovative Design. They will explore how Ecovative is combating the global problem of plastics by using Styrofoam-alternative materials grown from mycelium, which are the parts of a fungi analogous to the roots of a plant. They will then be introduced to the engineering design process, which they will use to design, construct, and evaluate a prototype for their cell phone case.

**Additional Resources:** *The Fungus Files: An Educator’s Guide to Fungi K–6* <http://www.thicketofdiversity.org/static/media/uploads/TOD%20Files/Resources/thefungusfiles.pdf>

**Objectives:** Students will…

* Determine design requirements for a cell phone case
* Use the engineering design process to identify and solve a problem
* Design and test prototypes for the cell phone case
* Communicate results from testing of prototypes
* Construct iterations of their cell phone case design

**Key terms**: engineering design process, prototype, functional and aesthetic properties

**Materials:**

* Cell phone cases (optional; students will bring in)
* Copies of Cell Phone Case Prototype Requirements Rubric (one per group)
* Copies of two Student Sheets
* Paper, cardstock, and cardboard
* Tape
* Scissors

**Time Required:** 45–60 minute (1 or 2 class periods)

**Standards Met:**

**MS-ETS1-1.** Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.

**MS-ETS1-2.** Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.

**MS-ETS1-3.** Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.

**MS-ETS1-4.** Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved.

**Keys to Success:**

* Some students may see the engineering design process strips as linear, but many will recognize that the process is more cyclical. There are many ways to lay out the strips, especially when students attempt to represent them as a cycle. Encourage students to justify their layout.
* Students can work in groups of 2 to 4 to make their cell phone cases, (depending on how much mycelium material you plan to use during Lesson 4).
* Every class will have different cell phone case properties that they will want to test. Some of these properties are easier to test than others. Some examples of properties and how to test them are:
  + Impact resistance: Test by using a drop test.
  + Strength: Test by measuring the weight the case can hold.
  + Size: Test by determining whether the case will fit in a pocket or a purse.

**Teacher Preparation:** At least one day prior to the lesson,

* Ask students to bring in cell phone cases to analyze product features.

Cut out strips for engineering design process activity.

**Procedure:**

5E Procedure:

*Engage:*Introduce Ecovative mushroom material tostudents with the TED talk “Are mushrooms the new plastic?” by Eben Bayer as a prompt for creating their own biodegradable cell phone case.

* Hand out Lesson 2 Student Sheet: *Are Mushrooms the New Plastic?* and have students answer questions 1–3 prior to starting the video.
* Play the TED Talk and instruct students to answer questions 4–7 while watching the video. Video is found here: <https://www.ted.com/talks/eben_bayer_are_mushrooms_the_new_plastic>
* Once the video is finished, have students complete question 8.
* Tell students that they will be designing and growing their own cell phone case using mycelium material.
* Ask the class to brainstorm the important steps in creating new products, then write their ideas on the board.
* Without telling them what the strips represent, pass out the engineering design process strips. Instruct students to work either in partners or in groups to put the strips in the order in which a new product is made.
* Ask a few groups to share how they laid out their strips and explain their reasoning.
* Debrief by explaining to the students that they just put together the engineering design process, the methodical series of steps that are used by engineers to create new products and processes. Refer back to the students’ ideas captured on the board and validate the steps they could identify. Emphasize that this process is typically iterative—that often, some of the steps must be repeated by the engineer in order to move on to the next steps.

*Explore:*In small groups, have students brainstorm to define the problem of replacing plastic with mycelium materials and determine the constraints of their cell phone case in terms of style, function, and sustainability.

* Tell the students that they will work in groups to create a cell phone case using mycelium material. Each group will use the engineering design process, guided by the student sheet.

Divide the class into groups of 2–4 and hand out Lesson 2 Student Sheet: Using Engineering Design to Make a Prototypealong with the rubric.

* Have student groups fill out each step of the process on their sheet with any necessary information and plans, up through determining how they will test their case.

*Explain:*Each group will consider the different features and properties of cell phone cases that make them desirable to consumers, then integrate these features into their prototype design.

* Once groups have reached this point, bring the class back together and create a list of features and properties that they believe their phone case should have. These properties can include both functional and aesthetic properties.
* As a class, vote on which two properties are most important to the class as a whole. Discuss how they might test the performance of the case related to each of those features.
* Have the students continue working in their groups to sketch a prototype that includes clear labeling of the cell phone case’s features.
* Using cardstock, paper, and tape, have groups construct their prototypes.

*Elaborate:*Each group will plan and carry out tests to evaluate their prototype.

* Instruct groups to write in their notebooks a procedure for each of the tests they will perform on their prototype. Additionally, have students create any data tables they will need to capture the data from each test.
* Have students perform the tests and capture their results.
* Once tests have been completed, instruct students to complete their engineering design process sheet with the observations and conclusions from their tests.

*Evaluate:*Students share their results and decide on changes they wish to make in their product design.

* Ask students to share their successes and failures with the class. Encourage students to use the feedback from other groups to improve their design.
* Have groups review and analyze the prototype design and decide on any adjustments they wish to make for the final mycelium cell phone case.
* Collect the student sheets and rubrics for evaluation.

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**Extension Option:**

* If time allows, encourage students to make changes to their prototype and evaluate again before deciding on the final design to be made with the mycelium material.

**Using Engineering Design to Make a Prototype: Student Worksheet**

**Name\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Date \_\_\_\_\_\_\_\_\_\_\_\_\_\_**

**Lesson 2 Student Sheet: *Are Mushrooms the New Plastic?***

Answer the following questions *before* watching the TED Talk video about Mycelium:

1. Describe the benefits of plastic cell phone cases for the consumer.
2. What are the environmental impacts of a plastic cell phone case?
3. What materials would you use to make a cell phone case that was better for the environment?

Answer the following questions *while* watching the video:

1. Approximately what percentage of the volume in United States landfills is occupied by Styrofoam?
2. What are the three principles we can use to guide the creation of better materials?
3. What is mycelium?
4. Describe the benefits that mycelium materials provide for the consumer.

Answer the following question *after* watching the video:

1. What would be the environmental impacts of a cell phone case made of mycelium material?

**Name\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Date \_\_\_\_\_\_\_\_\_\_\_\_\_\_**

**Lesson 2 Student Sheet: Using Engineering Design to Make a Prototype**

**The Engineering Design Process**

**Directions:** Fill out each of the engineering design process steps below with the relevant information about your mycelium materials cell phone case. Include brainstorms, observations, and any conclusions you draw as you go through the process.

Identify the problem:

Research the problem and brainstorm a solution to the problem:

Imagine, develop, explore, and create a solution (plan):

Create a prototype and test it for its strengths and weaknesses:

Communicate results from testing:

Redesign based on feedback from other teams and resume investigation:

Cell Phone Case Prototype Requirements Rubric

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Criteria**  **Student will be able to:** | **Needs improvement (0)** | **Apprentice (1)** | **Proficient (2)** | **Mastery (3)** |
| **Identify the problem** | Student does not identify the problem. | Student incorrectly identifies the problem. | Student identifies part of the problem. | Student identifies problem completely. |
| **Brainstorm a solution(plan)** | Student does not brainstorm. | Student generates one solution. | Student provides 2 solutions. | Student provides 3 or more solutions. |
| **Develop a solution (plan)** | Student does not select or present a solution. | Student presents a solution that is incomplete and/or missing details. | Student selects a solution but does not consider all constraints. | Student selects a solution and considers all constraints. |
| **Create a prototype** | Student does not directly contribute to the creation of a prototype. | Student’s prototype does not meet the problem requirements and constraints. | Student’s prototype meets most problem requirements and constraints. | Student’s prototype meets all problem requirements and constraints. |
| **Test a prototype** | Student does not contribute to the testing of the prototype. | Student conducts tests that are poorly developed. | Student carefully conducts tests and considers 1 to 2 strengths and weaknesses of prototype. | Student carefully conducts tests and considers 3 or more strengths and weaknesses of prototype. |
| **Communicate results from testing** | Student does not communicate results. | Student shares random results. | Student shares organized results but they are incomplete. | Student shares detailed, organized results with class. |
| **Redesign based on feedback from other teams** | Student does not contribute to the redesign. | Student does not improve the design or address concerns. | Student addresses 1 concern to improve the design. | Student addresses 2 or more concerns to improve the design. |

<http://static.nsta.org/connections/elementaryschool/201301Rubric.pdf>