Mass STEM Week 2023

About the 2023 Design Challenge

Schedule

The design challenge consists of three 45-minute lessons that guide students through the Engineering Design Process.

Lesson	Description	Objective: Students will be able to
1	Ask—What's the problem?	Identify materials they could use to improve the base package, so it better meets the needs of a plant.
2	Imagine, Plan, and Create	Imagine several ways to design a plant package that meets the criteria. Collaborate to plan and create a plant package design that meets the criteria.
3	Test, Improve, and Consider Impacts	Improve a plant package design based on data collected while testing. Discuss the impacts of packaging design and how it can help reduce food waste.

An Engineering Design Challenge for Grades 3–5

The 2023 EiE® Engineering Design Challenge focuses on packaging, and how package design can help preserve and protect food and plants. This focus was inspired by the Sustainable Development Goals (SDGs) developed by the United Nations Foundation and adopted by 193 countries in 2015. The goals seek to end extreme poverty, reduce inequality, and protect the planet by the year 2030. The following goal inspired the challenge for Mass STEM Week 2023:

- SDG 12: Sustainable Consumption and Production Patterns

This Sustainable Development Goal encourages people to consider solutions to reduce food waste that occurs during harvest, transportation, storage, and processing.

Learn more about the Sustainable Development Goals.

The 2023 design challenge is intended for students in grades 3–5 with tips for how to age the content up or down accordingly. Learners are introduced to the problem through a short story told across the three lessons—two siblings are gifting a tomato plant to their cousin, who is moving far away, and need to design a plant package to keep the plant safe and healthy during the trip. They consider the strengths and weaknesses of two existing package designs before exploring materials that they can use to improve the designs. Then, learners work in groups to imagine, plan, and create a plant package design before testing it and making improvements.

The design challenge also aligns to the three goals of the MA STEM Advisory Council:

1. Building foundational STEM skills for all through applied learning: The Museum of Science has decades of experience supporting students' understanding of STEM disciplines through its programs, curricula, and exhibits.

2. Developing guided pathways to college, careers, and lifelong learning: The Museum of Science and EiE® believe students find content interesting and engaging when it is relevant to their lives. Our curricula, programs, and exhibits provide this relevance for students and help them understand the work of STEM professionals.

3. Ensuring alignment to economic & workforce development through employer partnerships: The Museum of Science ensures alignment to economic and workforce development through its strong corporate, higher education, and nonprofit partnerships with the STEM workforce throughout Massachusetts. Our programs, exhibits, and curricula reflect and expand upon the knowledge we gain through these partnerships.

About the Massachusetts STEM Advisory Council:

The STEM (Science, Technology, Engineering, Mathematics) Advisory Council is established by M.G.L. Chapter 6, Section 218 in order to expand access to high-quality STEM education for students across the Commonwealth. Members of the Council include individuals from academia, business, government, and non-profits who believe in the necessity of a STEM-literate and skilled citizenry ready to meet the needs of a 21st Century workforce.

Learn more about the Massachusetts STEM Advisory Council.

Teacher Guide

What Is Engineering?

Engineering is the process of using creativity and an understanding of materials, tools, mathematics, and science to design things that solve problems.

In this design challenge, learners think like engineers!

The Engineering Design Process

Engineers follow a flexible process called the Engineering Design Process (EDP). Through their work with the Engineering Design Process, students gain insights into the nature of problem-solving:

The Engineering Design Process is not linear.
Engineers often start in the middle or end of the process, and they may repeat steps as they design a technology. In this design challenge, learners start by considering improvements to an existing package.

Failure is part of the process.
Learning from failure is an integral part of making successful engineering designs. The design challenge models how to learn from failure to inform improvements through the accompanying short story.

To recognize success, first define it.
To evaluate the success of a solution, engineers first define what a design must do (criteria). Learners then test their designs against the criteria. They analyze results to identify which criteria and design components could be improved.

Solutions involve tradeoffs.
Every solution has costs and benefits. Choosing a solution involves deciding which benefits are most important and which costs are acceptable.

For these design challenges, the EDP consists of five steps that guide students as they think about their engineering work and discuss their ideas with others.

Ask

- Ask questions to better understand the problem and criteria.
- Consider materials and their properties to determine which could be in the design.

Imagine

- Use your creativity to think of lots of ideas that could work.
- Evaluate the pros and cons of each idea.

- Pick one idea that is a good starting point.

Plan

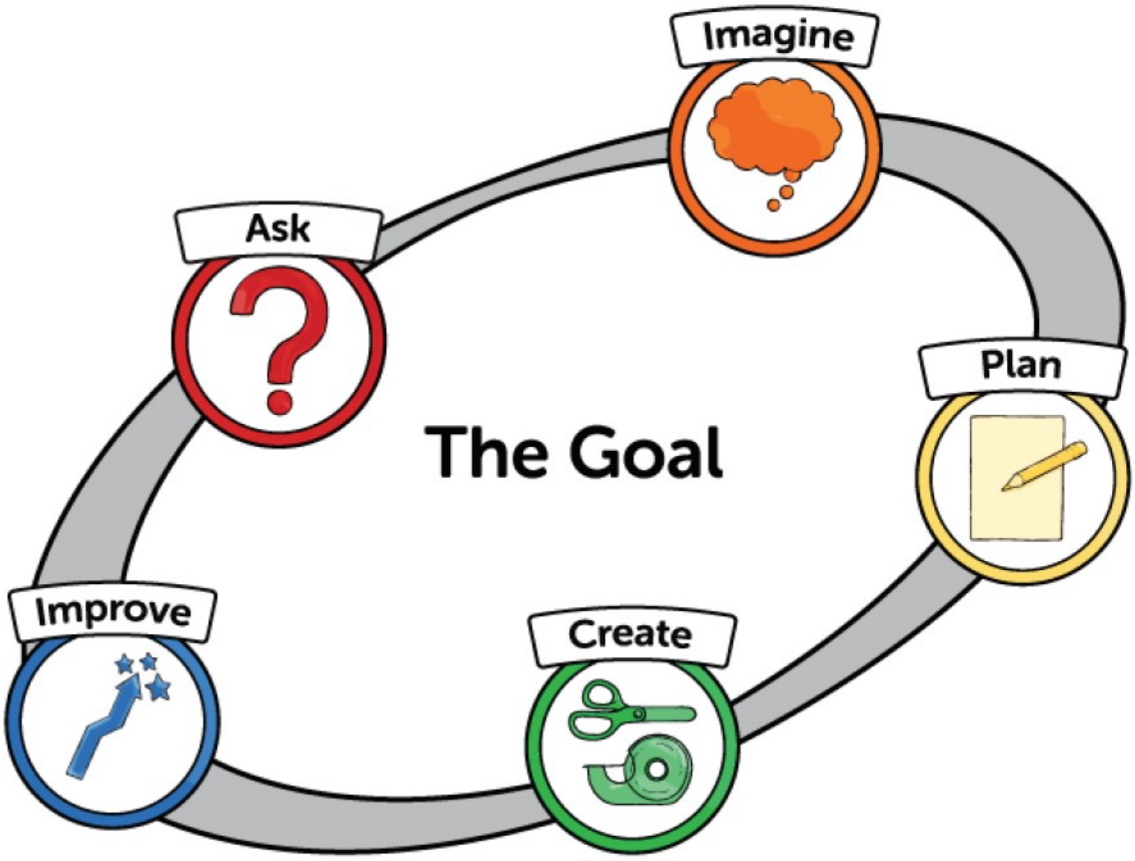
- Discuss how the design will work.
- Draw diagrams and list materials.

Create

- Follow your plan to build your design.

Improve

- Test your design and analyze the results.
- Decide what to change.
- Record your ideas for improvement.
- Build your improved design and test again.



Challenge Overview: Designing Plant Packages

Challenge Context

In this challenge, learners explore how package design can help to keep a plant healthy and safe during a trip. They consider materials properties as they work in groups to improve and existing package.

Engineering Design Challenge: Design a plant package that can keep a plant healthy and safe during transport.

Criteria

Design solutions must

- Keep the plant healthy by providing access to
    - Sunlight
    - Air
    - Water
- Protect the plant

Structure

The challenge consists of three lessons that guide students through the Engineering Design Process.

Lesson	Description	Objective: Students will be able to
1	Ask—What's the problem?	Identify materials they could use to improve the base package, so it better meets the needs of a plant.
2	Imagine, Plan, and Create	Imagine several ways to design a plant package that meets the criteria. Collaborate to plan and create a plant package design that meets the criteria.
3	Test, Improve, and Consider Impacts	Improve a plant package design based on data collected while testing. Discuss the impacts of packaging design and how it can help reduce food waste.

Note: This challenge is a modified version of the EiE unit Thinking Inside the Box: Designing Plant Packages.

Adapting the Context

You can adapt the context of this engineering design challenge and provide additional resources relevant to your local community. For example, learners may observe food in the

cafeteria or a local grocery store and consider how the food is transported and stored. Students may also observe or work in school or local gardens to consider the needs of plants. Ask questions to get learners thinking about the package design and how it helps to reduce food waste.

Resources

For the Design Challenge

These videos are linked in the unit.

- Packaging Engineers | Curious About Careers https://www.pbs.org/video/packaging-engineer-curious-about-careers-oxbplt/

- Territorial Seed Company | Brawny Packages for Perfect Plant Shipping https://youtu.be/X7BogO7GKQE?t=295

About Plants and Their Needs

- For Younger Learners:
    - PBS Learning Media: Plant Structure | Think Garden https://mass.pbslearningmedia.org/resource/5dea21b4-6c92-46ff-982c-8650f9429c01/think-garden-plant-structure/

- For Older Learners:
    - MOS Kahoot: Who Needs Dirt? https://create.kahoot.it/share/who-needs-dirt/74094741-baa1-4b7d-8072-c92a3534a9f0

More about Food Waste

- For Older Learners:
    - Food Waste: The Hidden Cost of the Food We Throw Out | ClimateScience #9 https://youtu.be/ishA6kry8nc?si=MwVT9HoFaKXj7JxI

Goals

By the end of this challenge, engineers will

- **Ask** and answer questions about the problem, materials and their properties, and potential solutions.
- **Imagine** multiple plant package designs and discuss as a group to select one.
- **Plan** and **create** a plant package design in a small group.
- **Improve** their plant package design based on test results.

Materials: for a group of 30 learners

For the Educator:

Quantity	**Material**
1 sheet	*Chart paper*
1	Marker
1	Utility knife
1	Device to play video, with sound (Lesson 3)
1	Stapler
1	Storybook slide deck: *A Gift from Fadil* (shortened; may also be printed)
1	straw
5	Sheets of scrap paper
6	Pipe cleaners (green if possible)
12	Cups, 8-ounce or smaller
Video	Packaging Engineer | Curious About Careers
Optional Video	Brawny Boxes for Perfect Plant Shipping
Optional	A few packaged foods (Lesson 3)

Consumable Materials:

For the Whole Group

Quantity	**Material**
Access to	Masking Tape – enough rolls to share
2	Rolls of paper towel (at least 30 towels total)
30	Transparency sheets
30	Manila folders
30	Wax paper pieces, approx. 6” x 6” (about 8 sq. ft.)
200	Cotton balls

For Each Learner

Quantity	**Material**
1	Writing utensil
1	straw

For 10 Groups of Three (adjust as needed)

Quantity	Material
10	Empty plastic bottle, 2-liter
10	Empty cardboard juice carton, half-gallon
2 cans	Play dough, enough for each group to have an ~1” ball
Access to	Water

Non-Consumable Materials:

Quantity	Material
10	scissors
10	Pipettes or eye droppers
Access to	A safe light source—daylight, lamps, flashlights, etc.
Optional	3-6 single hole punches
Optional	3-6 staplers

Printed Materials:

For the Whole Group

Quantity	Material
1	*Engineering Design Process* poster

For Each Learner

Quantity	Material
1	*Imagine Plant Packages*

For Each Group of Three

Quantity	Material
1	*Ask: Materials Testing*
1	*Plan a Plant Package*
1	*Testing a Plant Package*

Timing

3 Lessons
45 minutes each
~3 hours total

Vocabulary

General Engineering

- Criteria [what a successful design needs to do or have]
- Engineer [a person who designs things to solve problems]
- Failure [something that does not work or is not successful]

- Food Waste [food that could have been eaten, but is thrown out or goes bad instead]
- Healthy [well; in good condition]
- Package [a covering or container]
- Protect [to keep safe from harm]

Standards Alignment

This challenge is aligned with the following MA curriculum standards:

Grade 3

3.3-5-ETS1-1. Define a simple design problem that reflects a need or a want. Include criteria for success and constraints on materials, time, or cost that a potential solution must meet.

3.3-5-ETS1-2. Generate several possible solutions to a given design problem. Compare each solution based on how well each is likely to meet the criteria and constraints of the design problem.

3.3-5-ETS1-4. Gather information using various informational resources on possible solutions to a design problem. Present different representations of a design solution.

Grade 4

4.3-5-ETS1-3. Plan and carry out tests of one or more design features of a given model or prototype in which variables are controlled and failure points are considered to identify which features need to be improved. Apply the results of tests to redesign a model or prototype.

4.3-5-ETS1-5(MA). Evaluate relevant design features that must be considered in building a model or prototype of a solution to a given design problem.

Grade 5

5.3-5-ETS3-1(MA). Use informational text to provide examples of improvements to existing technologies (innovations) and the development of new technologies (inventions). Recognize that technology is any modification of the natural or designed world done to fulfill human needs or wants.

5.3-5-ETS3-2(MA). Use sketches or drawings to show how each part of a product or device relates to other parts in the product or device.

Lesson 1: Ask—What's the Problem?

45 minutes

Summary

In this lesson, students will

- read Part 1 of the story, *A Gift from Fadil.*
- discuss the problem and its implications.
- observe and explain how the base packages do or do not meet the needs of a plant.
- explore materials to determine which could be used to help keep a plant healthy while inside a package.

Objectives

Students will be able to

- identify materials they could use to improve the base package, so it better meets the needs of a plant.

Materials (for a group of 30 learners)

Educator:

- *Engineering Design Process* poster
- Chart paper
- Markers
- Slide deck: *A Gift from Fadil* story
- 1 empty plastic bottle, 2-liter
- 1 empty cardboard juice carton, half-gallon

Tip
You will need 10 cartons and 10 plastic bottles for Lesson 2. If you are unable to collect 10 of each, instead collect enough so each group of 3 learners has 1 base package to start from. Groups would not have a choice, but would still be able to engage in the design challenge.

- 1 utility knife
- 1 roll of tape
- 1 pipe cleaner
- 1 piece of scrap paper
- 1 pair of scissors (for cutting pipe cleaner/paper)
- 1 stapler
- 1 straw
- 2 small cups, 8-ounce or smaller
- Play dough
- Access to water
- *Ask: Materials Testing* page
- Access to a safe light source—daylight, lamps, flashlights

Learners: per group of 3

- writing utensil
- *Ask: Materials Testing* page

Tip
Groups can work on 1 *Ask: Materials Testing* page collaboratively or you can print enough so that each learner has their own page.

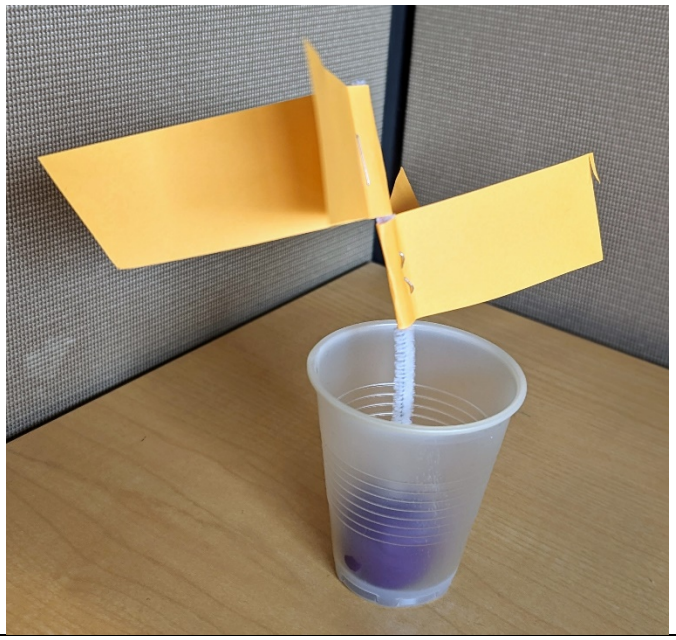
- 1 pipette or eye dropper
- 1 cup of water
- 1 sheet of transparency
- 1 manila folder
- 1 piece of wax paper, approx. 6” × 6”
- 2 sheets of paper towel
- 3 straws
- 6 cotton balls
- Access to a safe light source—daylight, lamps, flashlights

Preparation

- Use the utility knife to cut each plastic bottle and carton in half —the top half (with the cap) and the bottom. Keep the caps on.

Tip
Cut and clean the remaining bottles and cartons now to save time in later lessons.

- After cutting, rinse the inside of both halves of the bottles and cartons thoroughly with warm water and soap. Allow them to dry before use.
- Make 2 model plants:
    - Cut the pipe cleaner in half.
    - Cut strips of scrap paper, about 1” wide
    - Fold a strip around one piece of pipe cleaner and staple it in place on the pipe cleaner.
        - Repeat with 1 or 2 additional strips to create model leaves.
    - Place each model plant into a small ball of play dough.
    - Stick the play dough with the model plant into each cup.



Tip
Each small group will use a model plant when testing their plant package design in Lesson 3. Consider making all plants now or having learners help make the plants.

- Organize the testing materials for easy distribution:
  - Make sets of the following materials for each group. Consider placing the materials in bags or bins:
    - 1 pipette or eye dropper
    - 1 sheet of transparency
    - 1 manila folder
    - 1 piece of wax paper, approx. 6″ × 6″
    - 2 sheets of paper towel
    - 3 straws
    - 6 cotton balls
  - For each group, fill a cup about halfway with water.

Tips
Groups receive 2 sheets of each testing material in case a material gets wet and cannot easily be used for another test.

Cut additional small 2″ × 2″ squares of each of these materials to use during the Reflection.

- Create the *Plant Packages Criteria* chart by copying the chart below onto chart paper. Leave space below as this chart will be added to in Lesson 2:

Plant Package Criteria
The plant package needs to…

- Keep the plant healthy by providing access to
  - Sunlight
  - Air
  - Water

- Display the *Engineering Design Process* poster and *Plant Packages Criteria* chart.
- Divide learners into small groups of 3. Learners will work in these small groups throughout the unit.
- If reading the story digitally, be prepared to project it for the group.

EDP Steps

Lesson

Introduction

10 minutes

1. Introduce the story, *A Gift from Fadil.*
   - **In this story, Fadil and his sister Bashira are sad because their cousin is moving away. They decide to give their cousin a special gift.**
2. Read Part 1 of the story aloud.
3. Lead a whole group discussion:
   - **What is Fadil and Bashira's problem?** *They want to give a plant from the garden to their cousin, but they are afraid it will break or die during the trip.*
   - **How could you solve this problem?** *Accept all responses.*
   - **What do plants need to stay alive?** *Learners may identify some plant needs, such as sunlight and water, but not all. Accept incomplete responses at this time.*
4. Explain that they will be helping Fadil and Bashira by engineering a plant package to keep the plant healthy during the trip.
5. Display the *Plant Package Criteria* chart and review the first criterion.

Tip
To modify this unit for older learners in Grades 6–8, include the additional criteria of providing nutrients through the soil and invite learners to help you devise a test and generate a list of potential materials that could be used in the unit.

6. Explain that today they will ask and answer—does the existing package allow the plant to stay healthy?

Optional
If learners have not used an Engineering Design Process before, display the poster and talk through each step before moving on to the Activity.

Activity

25 minutes

Ask: How can we keep the plant healthy?

1. Refer to the Ask step on the *Engineering Design Process* poster.
2. Explain that, just like Fadil and Bashira, they will start with some existing packages, or base packages, to ask questions and think of ways to improve it.
3. Display the two base packages, the plastic bottle and cardboard carton, and the model plants. Explain that the play dough is acting as soil for the model plant.
4. Place a model plant inside each base package and ask:
    - **Can the plant get sunlight? How?** *The plastic bottle is clear, so it lets in sunlight. But the cardboard carton won't let sunlight through.*
    - **Can the plant get air? How?** *Both have gaps from where they're cut in half which could let air in. You could take off the caps on both.*
    - **Will the soil stay wet? How?** *Probably not, because there is nothing to keep it wet inside. It might dry out during the trip.*
    - **What would you do to improve one of these packages? What types of materials would you use?**
5. Tell students that they will work in groups to improve the existing packages using other materials. To do this, they will test each material to determine whether it could be used to meet a need of the plant. Introduce the available materials: transparency, manila folder, cotton balls, paper towel, and wax paper.

Tip
To modify this unit for older learners in Grades 6–8, have learners generate a materials list to test and potentially create with throughout the unit.

6. Tell learners that they should use the following roles in their small groups:
    - Tester: this person will do the test.
    - Observer: this person will observe or feel the results of the test.
    - Recorder: this person will record the test results for each material on *Ask: Materials Testing.*
7. Explain and demonstrate the testing procedures using 1 piece of manila folder. Invite two learners to help you demonstrate. Model how to record the test results on *Ask: Materials Testing*.
    - One person will hold a material up to the light source. Another will look at the other side. Ask:
        - **Can sunlight get through?**

- One person will use a straw to blow onto the material. Another will place their hand on the other side of the materials to feel for air. Ask:
    - **Can air get through?**

Tip
There are 3 straws so that each group member can have their own. Consider having three distinct colors. This ensures health and safety when using the straws during testing.

- One person will use the pipette or eye dropper to place 5 drops of water onto the material. Another will observe and feel the material. Ask:
    - **Can this material absorb, or soak up, water to keep the soil wet?**

Tip
This criterion and test has intentionally been simplified to fit within the 3-lesson structure. In reality, many factors can impact how a plant gets water when inside of a package—absorption, release, evaporation, etc. For a deeper investigation into this concept, see the larger EiE Plant Packages unit.

- Repeat the tests for each material and record the results on *Ask: Materials Testing.* Encourage groups to circulate through roles as they test each material.

8. Tell students to follow the order on *Ask: Materials Testing*: test for sunlight and air first, followed by water.
9. Distribute *Ask: Materials Testing*, the test materials, and cups of water to each group.
10. Circulate as learners test to ensure they are switching roles and to provide support. Ask:
    - **Which materials will allow sunlight/air/water to get to the plant? How do you know?**
    - **Which materials might you use to improve the base packages. Why?**

Reflection

10 minutes

1. Lead a whole group discussion to reflect on test results. As the class identifies useful materials, tape small pieces of these materials onto the *Plant Packages Criteria* chart beside the criterion. Ask:
    - **Which materials could help keep the plant healthy by providing access to…**
        - **Sunlight?** *Transparency, wax paper, paper towel*
        - **Air?** *Paper towel; Could cut holes/windows into transparency, wax paper, cardstock*
        - **Water?** *Cotton balls, paper towel*

Tip
If learners do not introduce the idea of cutting holes or windows, suggest it to them and discuss how it could help.

2. Tell learners that they will imagine, plan, and create a plant package in the next lesson.
3. Have learners make predictions about whether any of these materials could be used to stop the plant from breaking. Ask:
    - **Could any of these materials also be used to keep the plant from breaking during the trip? Why or why not?** *Accept all responses at this time.*
4. Save any materials you can to reuse in Lessons 2 and 3.

Lesson 2: Imagine, Plan, and Create

45 minutes

Summary

In this lesson, students will

- read Part 2 of the story, *A Gift from Fadil.*
- imagine some plant package ideas independently.
- work in their small groups to plan and create one plant package design.

Objectives

Students will be able to

- Imagine several ways to design a plant package that meets the criteria.
- Collaborate to plan and create a plant package design that meets the criteria.

Materials (for a group of 30 learners)

Educator:

- *Engineering Design Process* poster
- *Plant Packages Criteria* chart (from Lesson 1)
- Story: *A Gift from Fadil*
- 1 model plant (from Lesson 1)
- 1 marker
- 1 stapler

Learners: for each learner

- *Imagine Plant Packages* page
- writing utensil

Learners: per group of 3

- 1 sheet of transparency
- 1 manila folder
- 1 piece of wax paper, approx. 6” × 6”
- 1 sheet of paper towel
- 1 cotton ball
- writing utensil
- *Plan a Plant Package* page

Tip
This lesson is written so that groups create one plan together. If preferred, learners can each record their own plan.

- 1 pair of scissors
- Access to tape
- 1 model plant:
  - 1 cup, 8-ounce or smaller
  - 1 pipe cleaner, half length

- Scrap paper
- Play dough

Materials Table:

- 10 sheets of transparency
- 10 manila folders
- 10 pieces of wax paper, approx. 6″ × 6″
- 2 rolls of paper towel
- 200 cotton balls
- Optional: 3–6 single-hole punches, 3–6 staplers
- 20 Base packages (1 of each type for each group):
  - 10 cardboard cartons, half-gallon
  - 10 plastic bottles, 2-liter
  - 1 utility knife

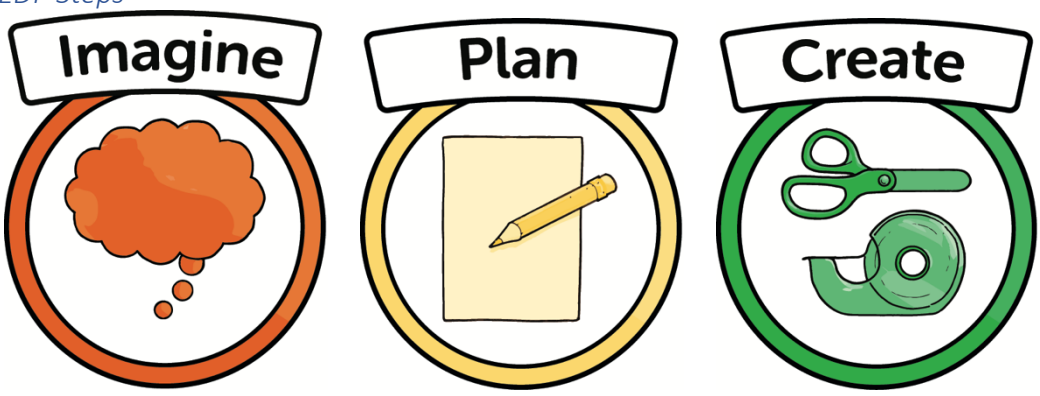
Preparation

- Prepare 1 plastic bottle base package and 1 cardboard carton base package per group. See Activity 1 for further instructions.
- Prepare 1 model plant for each group. See Activity 1 for further instructions.

Tip
Create a few extra model plants to use in Activity 3 in case the model plants get severely damaged during testing.

- Organize the Materials Table by laying out all of the materials that learners can use in an accessible location.
- Display the Engineering Design Process poster and Plant Packages Criteria chart.
- If reading the story digitally, be prepared to project it for the group.

EDP Steps



Lesson

Introduction

5 minutes

1. As needed, review the previous part of the story, *A Gift from Fadil.*
   - **Last time, Fadil and Bashira decided to engineer a plant package to keep a special plant healthy as it travels to its new home with their cousin.**
2. Read Part 2 of the story aloud.
3. Lead a whole group discussion:
   - **Fadil and Bashira need to keep the plant healthy. What else does the package need to do?** *It needs to protect the plant so that it won't get crushed or broken during the trip.*
4. Add this criterion to the *Plant Package Criteria* chart: *protect the plant.*

Activity

35 minutes

Ask: How can we protect the plant?

1. Demonstrate how to test whether a package protects the plant using a base package and model plant. Invite a learner to help you demonstrate:
   - Place the model plant inside the bottom half of the base package. Close the package by placing the top half over the plant and taping the two halves together.

   - Shake the package:
     - Invite a volunteer to shake the plant package 5 times.
   - Drop the package:
     - Place the plant package on a table.
     - Invite a volunteer to gently push the package off the table and onto the floor.
   - Open the package to observe what happened. Make sure learners can see inside.

Tip
You can demonstrate one base package or both. Demonstrating both may help learners decide which base package to use in their design.

2. Have learners turn and talk:
   - **What happened to the plant?**
   - **What happened to the soil (playdough)?**

- **How might you improve this base package design to protect the plant and hold the soil in place?**

3. Have learners gather in their groups. Distribute a set of materials to each group. Give groups 5 minutes to manipulate the materials and discuss:
   - **Could this material be used to help protect the plant or hold the soil in place? Why or why not?**
4. Invite a few learners to share their ideas with the whole group about how to protect the plant.
5. Refer to the Imagine, Plan, and Create steps on the *Engineering Design Process* poster. Ask:
   - **How did Fadil and Bashira decide which materials to use for their plant package?** *They imagined some ideas and then made a plan. They decided to use materials that would keep the plant healthy and protect it.*

Imagine a Plant Package

6. Explain that last time they Asked and answered questions about the problem and materials. Now, just like Bashira and Fadil, they will start by imagining some ideas before working together to make a plan and then create a plant package design.
7. Review the criteria on the *Plant Package Criteria* chart.
8. Let learners know that they can touch and manipulate materials from the Materials Table to help them imagine some ideas.
9. Give learners 5 minutes to independently imagine 2 or more designs for a plant package and record their ideas on *Imagine Plant Packages.*

Tip
If learners need help imagining two different designs, consider having them imagine one design for each base package.

Plan a Plant Package Design

10. Explain that now they will share their imagined ideas and work together to select one idea and record it on *Plan a Plant Package.*

Tip
To modify this page for younger learners in Grades 1–2, consider having groups place the materials they will use into a bag or bin rather than writing a list on the page.

11. Give groups 5 minutes to discuss and record a plan.
12. Circulate to support groups as they discuss and plan. Support learners in using the following sentence stems to support collaboration:
    - **One idea I have is _____.**
    - **I think we should try _____.**
    - **I agree because _____.**
    - **I disagree because _____.**
    - **Maybe we could combine _____ and _____.**
13. Have groups check in with you upon completing their plan.

Tip
Groups should include a way to keep the plant wet. Decide whether to allow access to water as groups create. If you do allow water, groups should add water to the material they have selected that will help keep the plant wet.

Create a Plant Package Design

14. Dismiss groups to use their plans to select the materials they need from the Materials Table. Learners can revisit the Materials Table as needed throughout the create time.

Tip

To modify this unit for older learners in Grades 6–8, consider incorporating some constraints by limiting the amount of each materials groups can use or by attaching a budget to the design challenge and assigning prices to each material.

Reflection

5 minutes

1. Lead a group discussion to reflect on the planning and creating process:
   - **How did your group work together to decide on and record a plan?**
   - **What was challenging about planning? What was easy?**
   - **How did your group work together to create a plant package design?**
   - **What was challenging about creating your plant package? What was easy?**
   - **Why do you think engineers plan and create in teams?**
2. Have groups store their plant package designs (with model plants inside) in a safe location.
3. Tell learners that in the next lesson they will test and improve their plant package designs.
4. Collect the plant package designs and *Plan a Plant Package* pages from each group to use in Lesson 3.
5. Save any materials you can for use in Lesson 3.

Lesson 3: Test, Improve, and Consider Impacts

45 minutes

Summary

In this lesson, students will

- read Part 3 of the story, *A Gift from Fadil.*
- test their initial plant package design to assess how well it meets the criteria.
- improve their plant package design based on evidence from testing.
- consider why food packaging is important and how packaging can help reduce food waste.

Objectives

Students will be able to

- Improve a plant package design based on data collected while testing.
- Discuss the impacts of packaging design and how it can help reduce food waste.

Materials (for a group of 30 learners)

Educator:

- *Engineering Design Process* poster
- *Plant Packages Criteria* chart
- Story: *A Gift from Fadil*
- *Testing a Plant Package* page
- 1 base package
- 1 model plant (from Lessons 1 and 2)
- 1 straw
- Video: Packaging Engineer | Curious About Careers
- A device to play the video, with sound, for your group
- Optional: gather a few packaged foods to use in the Reflection discussion

Learners: per group of 3

- Plant Package design created in Lesson 2 with model plant inside

Tip
Each group's model plant will be inside of the package making these ready to test!

- Colored writing utensil
- *Testing a Plant Package* page
- *Plan a Plant Package* page, from Lesson 2
- Access to a light source
- 3 straws
- 1 pair of scissors
- Access to tape

Materials Table: organize materials in an accessible location

- Remaining materials from the Materials Table in Lesson 2
- Optional: 3–6 single hole punches, 3–6 staplers

Preparation

- Organize the Materials Table by laying out the remaining materials learners can use to improve their designs.
- Display the Engineering Design Process poster and Plant Packages Criteria chart.
- If reading the story digitally, be prepared to project it for the group.
- Prepare for group testing:
    - Ensure groups have access to a light source like a flashlight, lamp, classroom light, or sunny window.
- Be prepared to play a video with sound to the whole group.

EDP Steps

Lesson

Introduction

5 minutes

1. As needed, review the previous part of the story, *A Gift from Fadil.*
    - **Last time, Fadil and Bashira realized that their plant package not only needed to keep the plant healthy, but also to protect it during the trip. Then, they imagined, planned, and created an initial plant package design.**
2. Read part 3 of the story aloud.
3. Lead a whole group discussion:
    - **What happened when Fadil and Bashira tested their plant package?** *The plant broke. They needed to improve their design.*
4. Refer to the EDP poster as you tell learners that they will test their plant package designs to see how well the package meets the criteria. Then, they'll have time to improve their design and test again.

Activity

25 minutes

1. Review the *Plant Packages Criteria* chart. Ask:
    - **How will you know if your plant package design meets the criteria?** *We can shake it. We can blow air on it.*

2. Using a base package, review the testing procedure and how to record the results on *Testing a Plant Package*:
    - Keep the plant healthy:
        - Hold the plant package up to a light source. Observe: can sunlight get in?
        - Use a straw to blow onto your plant package, try at least 3 different locations. Observe: can air get in?
            - You may notice the model leaves moving from the wind you create.
        - Does the plant package include something that will keep the soil wet?
    - Protect:
        - Shake the package 5 times. Push the package off the table.
        - Open the package and observe: is the plant damaged?

Tips

You can show an example of a real plant package being tested by showing 4:55-end of this video: https://youtu.be/X7BogO7GKQE?t=295

To modify the tests and testing page for older learners in Grades 6-8, have learners create the tests as a class. Record the agreed upon tests for the class to display.

3. Remind learners of the three roles they can rotate through during testing:
    - Tester: this person will do the test.
    - Observer: this person will observe or feel the results of the test.
    - Recorder: this person will record the test results for each material on *Testing a Plant Package.*
4. Tell learners that after testing and recording the results, they should work in their groups to identify areas for improvement. Then, they can use the materials from the Materials Table to make improvements and retest.

Tips

Groups should improve using the same base package from their initial design.

If time allows, have learners go through the steps of the EDP again as they improve: ask questions, imagine improvements, record a plan, then create and test. This helps reinforce that the EDP is an ongoing process.

5. Explain that groups may need to open the package and reposition the model plant before retesting.
6. Distribute groups' plant package designs from Lesson 2 and invite them to begin testing, improving, and retesting.
7. Circulate to support collaboration using the following questions and sentence stems:
    - **What did you learn from testing?**
    - **How can you make your package design work even better?**
    - **How will your improved design preserve the plant?**
        - **How will it let in sunlight?**
        - **How will it let in air?**
        - **How will it keep the plant moist or provide it with water?**
    - **How will your design protect the plant?**

Reflection

15 minutes

1. Lead a group discussion to reflect on the successes and failures of designs:
   - **What did you learn from testing your first plant package design?**
   - **How did you use what you learned to make your package work better?**
   - **How did you work together to improve your plant package design?**
2. Guide learners to consider why packaging is an important part of our food system—the process of getting food to people. Ask:
   - **Think about one food you like to eat. How does it get to the store?** *It gets to the store on a truck or train that carries the food in large crates or boxes. It may also travel by boat or plane before being loaded onto a truck or train.*
3. Watch and discuss the following 2-minute video about package engineering: Packaging Engineers | Curious About Careers https://www.pbs.org/video/packaging-engineer-curious-about-careers-oxbplt/

Tips

To modify this discussion for learners in Grades 6–8, consider showing and discussing the video Food Waste: The Hidden Cost of the Food We Throw Out https://youtu.be/ishA6kry8nc?si=i_VSafycheIMZgYJ

To modify this discussion for learners in Grades 1–2, do not show the video. Instead, have learners discuss the various types of food packaging they know and how that packaging may or may not protect the food and keep it good to eat.

   - **What kinds of criteria are packaging engineers thinking about as they design packaging for different foods?** *They think about the size, shape, and material of the package and how to keep the food fresh (preserve it) and how it will do during transportation (protect it).*
   - **Why is food packaging important?** *Food packaging can be designed to help keep food fresh and good, so it doesn't go to waste. Packaging can also be designed using eco-friendly materials.*
4. Lead a discussion. Ask:
   - **How can packaging help limit food waste?** *A package can protect and preserve food during transportation, so it arrives fresh. When packaging plants like tomatoes, basil, and mint, packages can be designed to meet the needs of the plant so that the plant arrives healthy and can continue to be used for food.*
5. Explain to learners that they have practiced engineering as they designed a plant package. Encourage them to use their engineering skills to think about other packages they see and even design some new packages!