Driving Question:
Can we prototype our design?

Overview
In this lesson, students will first explore what steps they have already taken in the engineering design cycle. Then, the class will review norms for building and working together as groups. Finally, they will build their prototypes.

Lesson Standards

| 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-ETS1-4: Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design is achieved |

Objective
Students will prototype their designs while utilizing feedback from others.

I Can Statement
I can prototype my designs utilizing feedback from others and my STEM expertise.

Materials
- Handcrank
- Piezo pads
- Small solar panels
- Copper tape
- Wires
- Simple motors
- Various led lights
- Common classroom and school
- Items that can be altered, but not destroyed
- Cardstock
- Cardboard
- Construction paper
- Scotch Tape
- Masking Tape
- Electrical tape
- Glue sticks
- Markers
- Craft Sticks
- Washi Tape
- Duct tape
- Pipe Cleaners

Equipment
- Wire cutters
- Scissors
- Voltmeter
Background for Teachers
A prototype is a representation of the final product. Prototypes vary in how realistic they are. For example, engineers build smaller prototypes of skyscrapers that can fit in an office while others create working appliance prototypes to test them before designing full-scale manufacturing processes.

They should make them as functional as possible. This will vary from group to group. If students’ designs stayed within the constraints of using only hand-cranks, solar panels or piezoelectric pads to light up something or make noises, students should be able to work in groups independently.

These pictures show students practicing the "Hands on, eyes on" approach. "Hands on, eyes on" is a practice that expects youth makers to maintain both, hands and eyes on the task they are doing while working on their prototypes.

In addition to promote overall classroom safety, this practice promotes students’ agency.
Lesson Sequence

I. Group Discussion

A. Group discussion

- As a class, look at the engineering design cycle. Have the students review the steps that they have taken so far and remind them that they will have to go back through the cycle as they experience challenges of prototyping.
- Review material constraints with your class:
  i) Each group gets one energy source
  ii) Each group gets the materials listed on their material list
  iii) They put all of the materials in their groups' work area
  iv) If they need more, they must discuss it with their teacher
  v) While they can use cardboard, it is better for the students to find a sturdier source on which to build their circuit. For example, they can put the copper tape directly on the wall or bulletin board instead of putting it on cardboard first.

TIP

- By actually building their own ideas, students are actually engineering. They are making their own engineering design.

- Review your class’ norms for project work. Here are some tips you may find handy:
  i) Hands on, eyes on: if you are ever using materials and equipment your eyes are concentrated on those not others.
  ii) Groups are Gold: Stay with your group, and only leave them with the purpose of helping your group.
  iii) Three then me: Ask for help from three students before you ask the teacher.
  iv) Everyone matters! Each group member contributes and is cared for in their group.

II. Creating Prototype Plan

A. As a class go over the example of the prototype plan.

B. Have each group fill in their own prototype plan.

C. Once they are completed, have students share their plan with you. Have them add any critical steps missing. Once you think their plan will lead them to success, have them get their materials and move onto the prototyping step.

TIP

- Students are positioned with more agency by creating their own prototype plan. They are creating a way for themselves to find engineering success and strategies to follow when they face challenges.
Prototyping Designs

III. Prototyping/Building

A. Have students prototype their work in groups following your class’ project norms.

B. As students complete each step of their design, they should check it off on their design rubric.

C. Once the design is working, the students should move onto the early finisher steps listed below this step. This will help ensure that the designs do not break from overuse.

TIP

• By rotating who is the lead student in charge of each step, every student will be positioned as an expert.

• Have each group share their materials in a labeled box. This helps for easy clean up and quick starts for prototyping.

IV. User Guide/Directions

A. Have groups create a set of directions/a user guide to be displayed with the engineering design. The directions/user guide should include who and how the engineering design should be used.

B. User guide/directions community feedback: have students share their user guide/directions with another group of students, the teacher and someone representing whoever else will be using the engineering design. Have the students get feedback and revise their user guide/directions.

C. As a class community have use the engineering design according to the user guide/directions.

Early Finishers

A. During this stage of the unit, groups will work at different speeds. Be clear with students about how much time they will have for prototyping. 2-3 class periods should be sufficient. If groups seem like they will not finish in time, provide alternatives times for them to finish if possible.

B. For early finishers, you can:

• Have students add more outputs to their design and add them to the prototype. For example, encourage students to add a noisemaker to their Woot Wall Design.
• Have students become helpers for other groups.
Sample prototype: A Woot Wall. A thick poster board with a led light border. In the center of the board there is space to put students' accomplishments on the board with sticky notes. The border is a parallel circuit with 5 lights. It is powered by a hand crank generator. It will honor students accomplishments.

<table>
<thead>
<tr>
<th>Big Steps</th>
<th>Considerations: What do we need to think about this?</th>
<th>Challenges we are facing and ideas for addressing them:</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Decorate the board’s background</td>
<td>The background needs to be a good surface to attach copper tape. It should look neat, and students should like it.</td>
<td>The cardboard is bumpy, which makes it hard to attach the copper tape so we will first create a border of duct tape and put the circuit on top of that.</td>
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<tr>
<td>2. Build circuit onto the border of the board.</td>
<td>The lights should be positioned to bring attention to the board. We should limit resistance in the circuit by pressing the copper tape down tightly and putting tape on the top and bottom of LED leads.</td>
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<td>3. Attach the hand crank generator</td>
<td>The hand crank needs a place to sit when it is not being used so it doesn’t fall off of the Woot Wall.</td>
<td>The hand crank is heavy so we placed the Woot Wall on the top of a bookshelf so everyone could see it still, but the hand crank had a solid place to sit.</td>
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<tr>
<td>4. Post students’ accomplishments</td>
<td>We want to make sure a wide range of students’ accomplishments are celebrated and new accomplishments are recorded.</td>
<td>New accomplishments are not being written down. We talked to our teacher, and during bell work time students can get sticky notes to write down their peers accomplishments.</td>
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Group Members:  

Name of Prototype:  

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<thead>
<tr>
<th>Big Steps</th>
<th>Considerations: What do we need to think about this?</th>
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Prototyping | Lesson 08

Group Members: __________________________________________

Name of Prototype: _______________________________________

1. Who will use this design?

2. When will it be used?

This is how to use our engineering design: (write directions)

Commented [KS2]: User guide handout
Commented [KS3R2]: Need one in Spanish, will make if we like the English one.
**Miembros del grupo:**

**Nombre del prototipo:**

**Prototipo de muestra:** Una caja de cartón que, al levantar la tapa, hará que un hipopótamo de juguete gire encima de un motor pequeño. Es alimentado por un panel solar. Ayudará a la autoestima de la clase.

<table>
<thead>
<tr>
<th>Grandes pasos</th>
<th>Consideraciones: ¿En qué necesitamos pensar para hacer esto?</th>
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<tr>
<td>1. Caja de construcción</td>
<td>La caja debe ser lo suficientemente profunda para aguantar la caja de sonido. No queremos que sea tan grande que no quepa sobre el escritorio de un estudiante.</td>
<td>El cartón es demasiado frágil para aguantar el hipopótamo. Usamos el cartón de una caja más gruesa.</td>
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<tr>
<td>2. Construye el circuito en la caja con un motor simple.</td>
<td>El circuito debería tener las dimensiones correctas para que quepa correctamente en la caja. (¿Dónde queremos colocar la caja? Al fondo de la caja, al lado de la caja, la parte superior de la caja...)</td>
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<tr>
<td>3. Fija el hipopótamo al motor simple</td>
<td>Usaremos la pega caliente para fijar el hipopótamo. Esto es para asegurararlo a la caja.</td>
<td>El circuito se encontraba en la caja de una manera que no fijaba bien el hipopótamo. Movimos el circuito al fondo de la caja para que cupiera el hipopótamo.</td>
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<td>4. Posiciona el panel solar para que le dé la luz</td>
<td>Necesitamos colocar el panel solar en la parte superior de la caja para que le dé la luz.</td>
<td>Tuvimos que redesignar el circuito para que los cables se conectaran con el panel solar cuando estuviera fuera de la caja.</td>
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<tr>
<td>5. ¿Construyó el interruptor para que el circuito se encendiera al abrirse la caja?</td>
<td>Se necesita diseñar el interruptor para que cierre el circuito cuando se abra la caja.</td>
<td>No pudimos averiguar cómo hacer esto, así que le pedimos ayuda a otro grupo.</td>
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Crear un prototipo | Lección 08

Miembros del grupo: ____________________________________________________________

Nombre del prototipo: ________________________________________________________

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