CLEAN ENERGY BRIGHT FUTURES
A Program of BEF

Solar Mobile Design Challenge

Lesson 6: Solar Mobile Design Challenge - Construction

AUTHOR
Kristy Schneider

CONTACT
Teacher Contact: kristy.schneider@lacenterschools.org

CE Editor Contact: CEbrightfutures@b-e-f.org, 503-553-3950

DESCRIPTION
This is the culminating hands-on project for the Solar Mobile Design Challenge Lessons, with construction aligned to an engineering design process. Students start by **Restating the Design Problem** that was introduced to them in the beginning of the Unit. Next, they **Brainstorm** ideas and **Plan** out the construction of the mobile. Students research an aircraft to draw (if this was not accomplished in the Center of Gravity lesson) and move on to the building phase. The exciting part is pulling all the parts together to **Build**, **Test**, **Evaluate**, and go through this loop multiple times making improvements along the way. The final assessment will be students demonstrating how their Solar Mobile works and justifying why their mobile should be chosen for the Children's Technology Museum.

GRADE LEVEL(S)
6, 7, 8

SUBJECT AREA(S)
Engineering design process, Solar design, Circuit design

ACTIVITY LENGTH
5-6 class periods (~55 minute class period) depending how involved students are in redesigning and optimizing the solar aircraft.

LEARNING GOAL(S)
1. Students brainstorm ideas and share with their group.

2. Students draw and label Solar Mobile designs in Engineering Notebooks.
3. Students research an aircraft to trace (if this was not accomplished in the Center of Gravity lesson) and trace the aircraft outline onto foam board.
4. Students construct a solar circuit to power motors and propellers on a foam board aircraft and test multiple times before adding to the solar mobile stand.
5. Students construct solar mobile stand and add their aircraft to a dowel attached to the central hub.
6. Students work with a partner to balance each aircraft onto the mobile.
7. Students test the mobile speed outside (depending on weather) and compare to speed under indoor light stands.
8. After initial testing, students redesign circuits or mobile construction to optimize design.
9. Students use hand-held devices to film their moving Mobiles to judge the machine's speed.
10. Students demonstrate how their Solar Mobile works and justify in writing why their mobile should be chosen for the Children's Technology Museum.

CONTENT BACKGROUND

STUDENT BACKGROUND

Students follow the Engineering Design Process for this project. If they are not familiar with the steps the instructor will need to focus on each step. Teach Engineering is an excellent resource for outlining each phase of the process for both students and teachers: https://www.teachengineering.org/k12engineering/designprocess .

EDUCATOR BACKGROUND

Instructors should be familiar with the steps of the Engineering Design Process: Restating the problem/defining the constraints, Researching the problem, Brainstorming: Developing possible solutions, Planning, Building a prototype, Testing and evaluating, Redesigning (as needed) and Analyzing.

Instructors will need to read the "Teacher Tips" for some modifications that need to be made to some of the materials.

MATERIALS NEEDED

HANDOUTS/ PAPER MATRIALS

- Student Engineering Notebooks and/or,
- Lesson 6: Solar Mobile Design Challenge -Construction

CLASSROOM SUPPLIES

- Exacto knives for cutting the foam board
- Safety goggles for use while cutting
- Wire cutters/strippers
- Needle nose pliers
- PVC pipe cutter(s)-used with teacher supervision or teacher only
- Multimeter
- Hot glue gun/glue
- Clear tape, masking tape, or blue painter's tape for temporary placement of motors
- Laptops or computers for students (for airplane design research)

ACTIVITY SUPPLIES (PER 2 STUDENTS)

This activity is designed to be a kit for 2 students to work on as a partner group.

- 2-6 Solar Modules of varying sizes (0.5V, 1V, 1.5V, and 2V work best for this application)
- 2 sheets of lightweight foam craft board for aircraft- 1per aircraft (in this project cheaper is better and easier to cut)-1 sheet/student
- 2-small DC motors (3-6V) per aircraft
- 2-small hobby propellers/aircraft

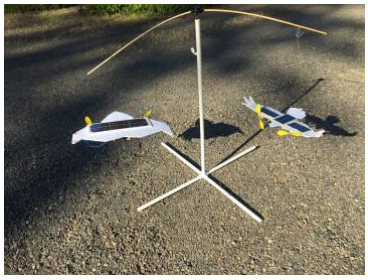
- 1-5 mm (1/4”) O ring-(1 per student), for attaching the aircraft fishing line guide wires to the dowel
- 1 to 2 meters of fishing line for suspending the foam aircraft from a central large paperclip
- 2- Large paperclips- (2-3/student)
- 1-KidWind hub (from Vernier) drilled (see Teacher Tips)
- 1-10’ section of ½” PVC pipe (to be cut into sections- 4 @ 1.5’ for the bottom support, 1 @ 4’ for the central pole)
- 1-five way 1/2” PVC connector
- 2-wooden dowels ¼” in diameter, cut to 2 feet in length each
- 1-Arrow (30” fiberglass with steel point)
- Lamp stand(s) with various bulbs for testing

LESSON PROGRESSION

PLANNING AND PREP

TEACHER TIPS

Final Solar Mobile should be similar to the set up displayed below:



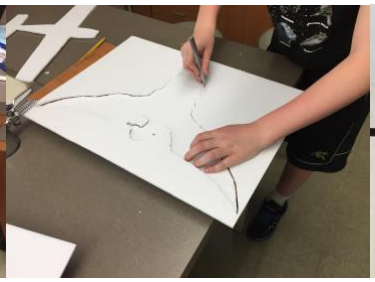
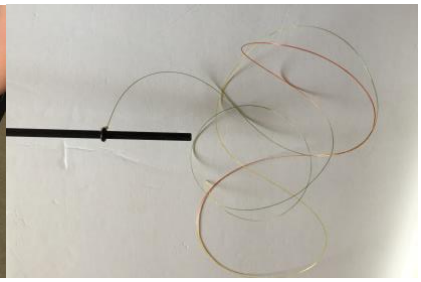
Outside using the sun Inside using 2 halogen light stands

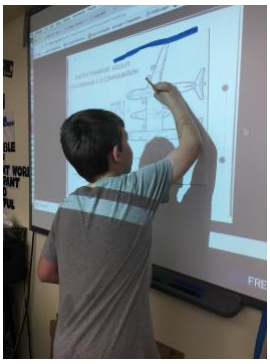
If using the KidWind Hubs from Vernier (https://www.vernier.com/products/kidwind/wind-energy/kw-wth3/), instructors need to use a 15/64 “ drill bit and drill out an additional 5mm into two opposing hub holes. A drill press works great if you have one. Explaining the circumference of the hole gives dowels more stability and allows the hub to have a better grip on the dowels.

Teachers also need to widen the central hole of the hub by drilling a small amount (3 to 5mm, depending on your arrow tip) using a 3/16” bit drilled into the existing center hole. This will give the hub a more stable resting point on the arrow. Depending on your arrow tip size, you will need to drill approximately ¼” into the hole.

-  

For this project, wooden dowls are suggested. Original prototypes used to develop this curricula, included fiberglass rods for more flexibility. However, potential fiberglass shards in student fingers is not a good idea and wooden dowels are safer, albeit can crack with too much weight placed on them.



LESSON SEQUENCE

PART 1 – REVIST THE ENGINEERING DESIGN CHALLENGE

1. **(5 min)** Go over the initial Scenario and Design Challenge of designing at mobile for a Children's Technology Museum.

   Scenario

   "A small Children's Technology Museum needs to attract more visitors with sustainability ideas. They asked our class to help them by creating a special display as part of a Renewable Energy exhibit. They want an interactive solar mobile that will be in the center of the exhibit to attract kids. Specifically, they want visiting kids to like it so much that they want rebuild it themselves!

   The Museum's Board of Directors knows that kids like the challenge of things moving fast, so the objective of this Solar Mobile design challenge is create the fastest spinning machine!"

   Design Challenge

   "As a team, design and build a fun, fast and attractive solar mobile that will draw visitors into the Museum's Renewable Energy Center. Your team needs to build a stand, balance multiple airborne objects and make it spin as fast as possible without falling or breaking!"

2. **(5-10 min)** Discuss the engineering design criteria as listed on the Lesson 6: Solar Mobile Design Challenge –Construction and the constraints.

   CRITERIA:

   All designs must:

   - use a PVC stand, be self-supporting (stand on its own)
   - balance on a central point (black hub),
   - use at least one solar panel per aircraft (or other airborne object) in order to power the mobile
   - design a solar circuit in order to provide power to two motors with propellers
   - include LED lights to attract attention
   - be as creative as possible with a theme to attract kids-colorful and interesting
     Extra bonus: include reflected light as a boost for extra power to the aircraft

   CONSTRAINTS:

   - Team must use only the materials provided or get approval of any additional materials.

PART 2 – FOLLOWING THE ENGINEERING DESIGN CHALLENGE

The following will take from a number of days, depending how many times students revise designs, to weeks. Students will follow the engineering design process recording information in their science journals.

Students should:

- Brainstorm ideas about which circuits they want to use for their aircraft and share with their group.
- Draw and label solar mobile construction designs in an Engineering Notebook during all parts of the design and revision stages.
- Research an aircraft to trace (if this was not accomplished in the Center of Gravity lesson) and trace the aircraft outline onto foam board.
- Students will cut out the aircraft using an Exacto knife.
- Students will construct a solar circuit to power motors and propellers on a foam board aircraft and test multiple times before adding to the solar mobile stand.
- Students will attach their aircraft to a large paperclip using fishing line.
- Students will add an O-ring to the large paperclip so that they can adjust the suspended aircraft along the wooden dowel. Adjusting the weight on the mobile.
- Students will work with their partner to construct solar mobile stand out of the cut PVC pipe and add their aircraft to a dowel attached to the central hub.
- Students will work with partner to balance each aircraft onto the mobile changing the weight by changing solar panels, motor placement, wiring, and/or moving the O-ring to another location.
- Students will test the mobile speed outside (depending on the weather) and using indoor light stands.
- After initial testing, students will redesign circuits or mobile construction to optimize design.
- Students will video the moving mobile to judge the speed of the mobile.

ASSESSMENT AND EXTENSIONS

FORMATIVE ASSESMENT

- Students record drawings and findings in their engineering notebook or on the Lesson 6: Solar Mobile Design Challenge –Construction worksheet.
- Observe how students are following the engineering design process of testing and redesigning and retesting after the initial design.

SUMMATIVE ASSESSMENT

- For a short summative assessment, students will demonstrate how their Solar Mobile works and justify in writing why their mobile should be chosen for the Children's Technology Museum's Renewable Energy display.

- Use the rubric in the attached materials to score students on their entire process, using their notes and sketches when necessary