Design Technology Powered by Solar Energy

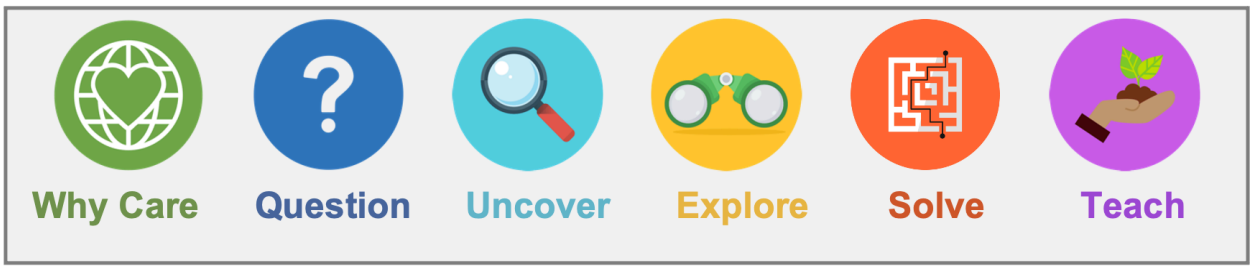
High School Physical Science Guam STEM Design Challenge

Anchor Question: How can we use the energy of the sun to power devices that are important to our everyday lives?

Overview

Guam Connection   Guam is an island that is over 200 square miles. Not every portion of the island has electrical power to use and charge mobile devices such as cell phones and small reading lights.
Engineering Design Challenge   Design a solar battery charger that will allow people to power and charge everyday devices that are portable, durable, and efficient.
NGSS Performance Expectation   HS-PS3-3. Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy.   HS-PS4-5. Photoelectric materials emit electrons when they absorb light of a high-enough frequency.   HS-ETS1-2. 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.
STEM Concepts (NGSS Disciplinary Core Ideas)   To understand the problem and complete the engineering design, students need to understand: ● Solar cells are human-made devices that likewise capture the sun's energy and produce electrical energy.
Time: Estimated Number of Classes   3-6 classes (45-minute class)
Materials for the Design Challenge   Alligator clips and wire, potentiometer, multimeters, mini-PV panels, 100-watt bulbs or sunlight, cardboard, protractor, string

The Q-U-E-S-T Experience



Why Care?	What is the problem, anchor question, and design challenge? How is this relevant and interesting to us and where we live?
Question	Begin by asking QUESTIONS about the problem and ways to solve it. Figure out what you already know, and brainstorm what you could do.
Uncover	Learn the science ideas needed to understand the problem and design a project to solve the problem.
Explore	Apply what you've learned in Uncover to EXPLORE the problem in your community and consider project ideas to solve the problem.
Solve	Use the engineering design process to design and do a project that helps SOLVE the problem.
Teach	Share your project with others to help others understand the problem and how your project helped solve it.

Why Care?

What is the problem, anchor question, and design challenge? How is this relevant and interesting to us and where we live?

Introduce the Quest

1. **Post and read the anchor question:** How can we use the energy of the sun to power devices that are important to our everyday lives?
2. **Talk about:** Super Typhoon Mawar has hit the US territory of Guam with damaging winds, heavy rain, and power outages for most of the island. "It is going to be scary," a meteorologist with the National Weather Service (NWS) in Guam said. "There is no electricity," the forecaster told a news briefing. As of Wednesday afternoon, local time after the May 2023 storm, only 1,000 out of 52,000 customers on the island had power, the Guam Power Authority said. The utility worked to restore electricity as soon as winds decreased to safe levels. The eye of the category four storm brought 145 mph winds, making it one of the strongest typhoons to hit Guam in years. While there were no reports of severe injuries or deaths, the storm brought a life-threatening storm surge and up to 20in of rain to the island before moving northwest towards the Philippines. President Biden declared an emergency to mobilize federal agencies for relief efforts, and the US Federal Emergency Management Agency coordinated the response

to the storm. Creating sustainable portable solar chargers could help ease the need for electricity to power essential and portable devices.

3. **Read, describe, and post the design challenge:** Design a solar battery charger that will allow people to power and charge everyday devices that are portable, durable, and efficient.
4. **Share and talk about the Driving Question for why we should care:** Why should we care about being able to use the sun's energy to power everyday devices when other energy sources are not available?
5. **Do this:**
    a. Read and discuss the following articles:
        i. Rolling Power Outages Possible across Guam (The Guam Daily Post)
        ii. STEM Students Create Solar Phone Chargers.
    b. For each article, identify the claim (C) being made, indicate the evidence (E) provided and provide the reasoning (R) and justification for the claim. Each team should share their C-E-Rs with another team and come to consensus before discussing as a whole team.

Guam-STEM Design Notebook for students (FOLDER with pdf and editable pages)

Write or draw your "why I care" and why others on Guam care.

Question

Begin by asking QUESTIONS about the problem and ways to solve it. Figure out what you already know, and brainstorm what you could do.

Ask Questions

1. **Create a KND Chart (Know, Need to know, Do)** with the three driving questions below. Save the questions and responses to look at during the QUEST; writing them on chart paper, butcher paper, in student design notebooks, or use a digital organization chart, like Jamboard. KND Questions:
    a. What do we **KNOW** already about brownouts, blackouts and the use of solar energy on Guam?
    b. What do we **NEED TO KNOW** to understand Guam's current ability to replace traditional carbon-based generators with solar energy (solar cells or passive solar) for use by homes and businesses and other devices?
    c. What could we **DO** to learn about how solar energy works and the benefits as well as the limitations to passive and active solar energy applications.
2. **Gather responses from students.** Have students think and write responses: First, silently and individually. Then, in small groups. And finally, with the full class. The end result is a class KND chart to refer to, add to, and reorganize throughout the QUEST. Students could sort the responses that are similar. This information will help guide the UNCOVER and EXPLORE.

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Write KND lists. Organize the questions (Need to Know) from class. Record the categories, or themes, of the questions and ones you are most interested in.

Uncover

Learn the science ideas needed to understand the problem and design a project to solve the problem.

Uncover Key Ideas

1. **Share the Driving Question:** What are the different types of solar energy systems?
    a. Go through the following Slide Deck: Types of Solar Systems (WeShareSolar.com)
    b. How does the angle of the sun impact the amount of energy that can be harnessed from the sun?
2. **Share the Driving Question:** How can Engineers design solar panels to be more effective and efficient? The next set of lessons originated from the Unit on Solar Energy Efficiency. https://www.teachengineering.org/curricularunits/view/cub_pveff_curricularunit
    a. Work through the following lessons from Teach Engineering:
        i. Solar Angles and Tracking Systems. There is an article embedded within this site.
        ii. Introduce the hands-on activity: New Angle on Photovoltaic Solar Panel Efficiency.
3. **Share the Driving Question:** How can we determine the optimal power of a specific solar cell? Work through the following lesson from Teach Engineering:
    a. What are the different variables that determine the power of a solar cell? Maximum Power Point. There is an article embedded within this site.
    b. Introduce the hands-on activity regarding determining the power of a solar cell: Pointing at Maximum Power for PV.
4. **Share the Driving Question:** How can we concentrate the sun's energy to make a solar cell more efficient? Work through the following lesson from Teach Engineering: Let the Sun Shine. There is an article embedded within this site.
5. **Share the Driving question:** How can we increase the output of a solar panel through the science and engineering process? Discuss some ideas about how we can use the energy of the sun to power devices that are important to our everyday lives?

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Write the driving question and summarize what you did and learned. (blank page)

Students will understand these NGSS Disciplinary Core Ideas:

HS-PS3-3. Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy.
HS-PS4-5. Photoelectric materials emit electrons when they absorb light of a high-enough frequency.
HS-ETS1-2. 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.

Explore

Apply what you've learned in Uncover to EXPLORE the problem in your community and consider project ideas to solve the problem.

Apply Your Learning

1. **Share the Driving Question with students:** How can we apply what we learned in UNCOVER to figure out how to use the energy of the sun to power devices that are important to our everyday lives?
2. **Revisit the KND lists** you wrote at the beginning of your Quest. Add and edit them to include new understandings and experiences from UNCOVER.
    a. KNOW - What have you confirmed as accurate? Correct any inaccurate information.
    b. NEED to know - Mark any questions that you have answered, and ones you still need and want to answer. Add new questions.
    c. DO - Add any new project ideas you could do to help solve the problem.
3. **Return to the anchor question:** How can we use the energy of the sun to power devices that are important to our everyday lives?
4. **Read and talk about the design challenge:** Design a solar battery charger that will allow people to power and charge everyday devices that are portable, durable, and efficient.
5. **Work through this Teach Engineering activity:** Concentrating on the Sun with Photovoltaic Solar Panels.

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- Design Challenge Map- Complete as much as you can. Then add to and edit it throughout SOLVE.
- Design Requirements and Limitations (criteria and constraints)

Solve

Use the engineering design process to design and do a project that helps SOLVE the problem.

Design Your Project

1. **Define the criteria** (what are you trying to do) **and constraints** (what are the limitations) **of a design problem** with sufficient precision to ensure a successful solution, taking into account relevant scientific ideas and potential impacts on people and the natural environment that may limit possible solutions.
    a. What kind of a charger will you be designing (to power what device)?
    b. How will it use the sun's energy?
    c. What are the limitations of your device?
    d. What already exists, and can you improve on this device? (less expensive, more durable, etc.)
    e. What part of the design and completion is most problematic?
2. **Construct a mobile solar charging devic**e from the materials used in the Uncover and Explore parts of the QUEST and using your newly acquired knowledge and skills. The outline of the process can be found in the following Teach Engineering Investigation-- Build Your Own Solar USB Charger-- which provides a sample solution to the design challenge. Have students follow the steps of the Engineering design process (Poster).

3. Be prepared to share your design features, your criteria and constraints, and your Claims, Evidence, and Reasoning (CER) justifying why your device works.

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- Edit and complete the Design Challenge Map.
- Edit and complete the Design Requirements and Limitations (criteria and constraints)
- Action Plan: List steps to complete the project, and who will do what.
- Team Self-Review: Review your project design to make sure it is focused on the design challenge, anchor question, and Guam.
- Gathering Feedback from Others: Get input from others to help strengthen your project.
- Claim-Evidence-Reasoning (CER): Give evidence for the most effective project design.

Students will understand these NGSS Disciplinary Core Ideas:

HS-ETS1-2. 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.

Teach

Share your project with others to help others understand the problem and how your project helped solve it.

Share & Reflect on What You Learned

1. **Return to the anchor question:** How can we use the energy of the sun to power devices that are important to our everyday lives?
2. **Students creatively share their project** and how it helped solve the problem.
    a. Who's your audience? Who will benefit from hearing about and seeing your project?
    b. How will you share this information?
    c. What do you want them to know and understand about the problem, how you collected data on using the sun's energy in your project and its impact when solving the problem?
    d. When and where will you share?
3. **Student reflection:** After teaching others, students can complete a reflection about their Design Challenge. Here is one option: 4-3-2-1: Looking back, planning forward. Respond to:
    a. FOUR most important things I learned doing this design challenge
    b. THREE most important things I learned about myself doing this design challenge
    c. TWO things I will do differently in my next problem-solving experience
    d. ONE thing I now want to learn more about

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- TEACH. Make a plan for sharing your project with others.
- Looking back, planning forward. Reflect on what you did and what you might do next time.

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