Build Buoys and Interpret Data from Drift Buoys in the Pacific Ocean

High School Guam STEM Design Challenge

Anchor Question: What are ocean buoys telling us about water in the Pacific Ocean near Guam? How can we build a buoy to mark a location or to collect data about an island water source?

Overview

Guam Connection

The Pacific Ocean and Philippine Sea surround the island of Guam and greatly influence weather, climate, movement of all things to and from Guam on water currents, activities of residents and tourists. NOAA has placed buoys in ocean locations to gather data about ocean and air. The patterns the data shown over time can be used by Guam scientists, weather reporters, students, and citizens.

Engineering Design Challenge

A buoy is a floating structure that is either anchored to the water floor and marks a location or drifts with the currents while collecting data.

- Build a marker and/or a drifting buoy that you could launch in an island water source (river, lake, ocean close to shore) to collect data or mark a location. Build A Buoy (BAB) with PVC and/or Build a marker buoy with plastic bottles
- Analyze data from buoys monitored by NOAA's National Data Buoy Center
- If this program is still running: Adopt and track a NOAA Drifter (buoy) deployed near Guam, analyzing data collected. https://adp.noaa.gov/students/adoptadrifter/

NGSS Performance Expectation

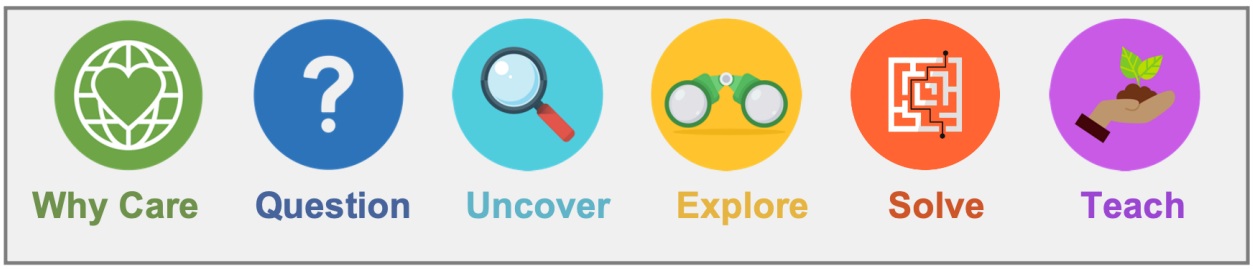
HS-ESS2-2: Analyze tools and technologies in order to make valid and reliable scientific claims.
HS-ESS2-5: Plan and conduct an investigation of the properties of water and its effects on Earth's materials.
HS-ESS3-6: Use computational representations of phenomena to support claims or explanations.
HS-PS4-2: Evaluate questions about the advantages of using digital transmission and storage of information.

STEM Concepts (NGSS Disciplinary Core Ideas)

ESS2.C The Roles of Water in Earth's Processes. The planet's dynamics are greatly influenced by water's unique chemical and physical properties.
ESS2.D Weather & Climate. The role of radiation from the sun and its interactions with the atmosphere, ocean, and land are the foundation for the global climate system. Global climate models are used to predict future changes, including changes influenced by human behavior and natural factors.
ESS3.D Global Climate Change. Global climate models used to predict changes continue to be improved, although discoveries about the global climate system are ongoing and continually needed.
PS4.C Information Technologies and Instrumentation. Large amounts of information can be stored and shipped around as a result of being digitized.

Time: Estimated Number of Classes	***Materials for the Design Challenge***
3-6 classes (45-minute class)	See list on the last page

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:** What are ocean buoys telling us about water in the Pacific Ocean near Guam? How can we build a buoy to mark a location or to collect data about an island water source?
2. **Read, describe, and post the design challenge:**
    a. Build a marker and/or a drifting buoy that you could launch in an island water source (river, lake, ocean close to shore) to collect data or mark a location. Build A Buoy (BAB) with PVC and/or Build a marker buoy with plastic bottles
    b. Analyze data from buoys monitored by NOAA's National Data Buoy Center
    c. If this program is still running: Adopt and track a NOAA Drifter (buoy) deployed near Guam, analyzing data collected.
3. **Share and talk about the Driving Question for why we should care:** Why should I care about ocean or river buoys and the data they collect?
4. **Do this:**

a. Show Science on Sphere Buoy data video and ask what all the dot represent. Why are there so many buoys? Who do you think put them there and what are they doing? https://sos.noaa.gov/catalog/datasets/buoy-and-float-locations/.

b. Show a video of a student designing and launching a buoy: We launch a student built -- Research Buoy in the Florida Keys! : https://www.youtube.com/watch?v=q3mGnNdShYc&t=2s (Article: High school student build…)

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. You will want to 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 buoys, their purpose, and the data they collect?
   b. What do we **NEED TO KNOW** about buoys to build ones and interpret data they collect?
   c. What could we **DO** to learn about buoys and their purpose? What are some ideas of what we could DO to build and use buoys to gather data on a body of water near our school?
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 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 ocean buoys, what do they do, and what information can they give us?
   a. Watch Video: What are ocean buoys and what do they do? (Maine Mathematics)
   b. OR Video: Making drifter buoys and tracking ocean currents with NOAA satellites. Video of school making and launching NOAA Drifter.

   c. NOAA Interactive Array Map with Buoy Drifter Cards. What does the website show? What do the different colors mean? Click on buoys near Guam. What do the drift cards tell you? Click on other cards anywhere in different ocean locations around the globe. Write 3: I notice__, 2 I wonder__, 1 I'd like to know more about__ statements.
   d. Go to this site with data from drifting buoys. Choose data for them to analyze. NOAA National Data Buoy Center home page
      i. Education page– Choose data set questions that you want students to analyze.
      ii. FAQ page - Have students go to this page and read answers to 2-4 (you decide) questions that they are curious about or that you assign. Have them move into small groups (2-3) to tell others what they learned.

2. **Share the Driving Question:** Why do scientists collect data on water and air temperatures using buoys? What's the relationship between climate and ocean temperature?
   a. Global Climate Change Explorer: Oceans and water (Exploratorium). Read about this relationship. Interpret the data sets about global ocean temperatures. Take a closer look at ocean temperatures around Guam in each data set. Summarize what you now know about ocean temperatures around Guam.
3. **Share the Driving Question:** What does scientific data tell us about how our ocean systems are changing?
   a. Go to this NOAA page: Understanding Ocean & Coastal Acidification using Data in the Classroom. What lessons would you want to include to help students understand ocean systems such as El Nino, sea level, coral bleaching, water quality and ocean acidification? Buoys are gathering data on these physical and chemical changes to our oceans.
4. **Share the Design Question:** How can we build a simple model of anchored and drifting buoys to demonstrate how they are the same and different, and when they would be useful, and how to keep them stable and balanced?
   a. Materials: an empty plastic water bottle, twine, and a rock or other weight. Water, sand, or soil to fill bottles.
   b. Design two simple buoy models: Each pair or triad of students chooses one to build and test.
      i. Marker: One that holds the bottle stable at its greatest height in one location (marker),
      ii. Drifter: One that holds the bottle steady and upright at its greatest height while it drifts freely in a student-created water current.
   c. Test in a basin or sink with 1 ½ or 2 feet of water.
   d. Refine your designs as you test what happens when bottles are empty, half full, full of water.
5. **Share the driving question:** How can understanding buoyancy help us design a buoy?
   a. TeachEngineering.org lessons on buoyancy (website list of lessons)
   b. Optional: If students need to start with density as a refresher, here is a lesson to do before buoyancy: Floaters and Sinkers
   c. What floats your boat? https://www.teachengineering.org/lessons/view/duk_float_mary_less Students use modeling clay, a material that is denser than water and thus ordinarily sinks in water, to discover the principle of buoyancy. They begin by designing and building boats out of clay that will float in water, and then refine their designs so that their boats will carry as great a load (metal washers) as possible.

i. Suggestions on clay to use from other teachers: Any brand of oil-based modeling clay (plasticine) should work fine. These clays soften up when they are warmed in the hands, making them easy to shape, and become stiffer when cool. PRANG modeling clay is oilier than the Crayola plasticine (Home Depot).

d. Buoyant Boats https://www.teachengineering.org/activities/view/duk_boat_mary_act Students conduct a simple experiment to see how the water level changes in a beaker when a lump of clay sinks in the water and when the same lump of clay is shaped into a bowl that floats in the water. They notice that the floating clay displaces more water than the sinking clay does, perhaps a surprising result. Why?

e. Estimating buoyancy https://www.teachengineering.org/lessons/view/cub_balloons_lesson01 Students learn that buoyancy is responsible for making boats, hot air balloons and weather balloons float. They can calculate whether or not a boat or balloon will float, and calculate the volume needed to make a balloon or boat of a certain mass float.

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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:

ESS2.C The Roles of Water in Earth's Processes. The planet's dynamics are greatly influenced by water's unique chemical and physical properties.

ESS2.D Weather & Climate. The role of radiation from the sun and its interactions with the atmosphere, ocean, and land are the foundation for the global climate system. Global climate models are used to predict future changes, including changes influenced by human behavior and natural factors.

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 interpret data from drifting buoys in the Pacific Ocean and around the globe? How can we apply what we have learned to design a buoy we will build, test in an island water source, and use to collect data.
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.
3. **Return to the anchor question:** What are ocean buoys telling us about water in the Pacific Ocean near Guam? How can we build a buoy to mark a location or to collect data about a water source?
4. **Review and edit your KND lists:**
    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.

5. **Read and talk about the design challenge:**
    a. Build a marker and/or a drifting buoy that you could launch in an island water source (river, lake, ocean close to shore) to collect data or mark a location. Build A Buoy (BAB) with PVC and/or Build a marker buoy with plastic bottles
    b. Analyze data from buoys monitored by NOAA's National Data Buoy Center
    c. If this program is still running: Adopt and track a NOAA Drifter (buoy) deployed near Guam, analyzing data collected. https://adp.noaa.gov/students/adoptadrifter/
6. **Teacher decisions:** Do you want students to build with plastic water bottles or PVC pipes or both. Show students the materials they will use. Do not show them any photos of what a finished design could look like! In small engineering teams, have them brainstorm how they could use the materials to build a buoy (anchored or drifting). Have them sketch out their design or several designs. You can read the challenge as described.
    a. Build A Buoy (BAB) with PVC and test payload: How can a payload be maximized on a buoyant device? (One Watershed)
    b. Build a marker buoy with plastic bottles (Instructables)

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

- 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.

Do Your Design Project

Your steps will follow the steps of the Engineering design process (Poster).

1. Have students work in buoy engineering teams of 3-4 people.
    a. Design the criteria for the buoy to be an effective design: What does it need to have and be able to do?
    b. Let students modify their sketches and then design and test a buoy model based on the sketches.
    c. Have them refine, redesign several models and determine the best model.
    d. Give them any additional hints.
    e. After they try some of their own designs, you might choose to show them models from the digital design instructions. Have them redesign and test after integrating this new information.
2. If possible, attach thermometers, build and attach an anemometer (wind), or attach other instruments to collect data. Take the buoys to a nearby body of water. You will probably want them to be anchored to the bottom or attached to a structure on shore. If possible, you can have them collect and analyze any data. Perhaps the buoy can collect a sample of water to be tested for salinity and pH.

Analyze Data

1. Analyze your data and compare it to previous data collections from your team. Compare your data to the findings of other student teams. Answer the driving question and develop an explanation supported by evidence. Using a claims, evidence and reasoning format provided, make a claim that answers these questions,
    a. What are ocean buoys telling us about water in the Pacific Ocean near Guam
    b. How does your new understanding of buoy data about oceans in particular help us understand the impact of human activity on both weather and climate that creates changes in ocean currents and water properties?

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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.

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:** What are ocean buoys telling us about water in the Pacific Ocean near Guam? How can we build a buoy to mark a location or to collect data about an island water source?
2. **Prepare and creatively share their project** and who 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 iNaturalists, your project and its impact?
    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 of the most important things I learned doing this design challenge.
    b. THREE of the most important things I learned about myself doing this design challenge.
    c. TWO of the 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.

Materials

For BoB (Build a Buoy)	***Build a Marker buoy***
The following list includes the materials needed per team. This activity is designed to have students competing and recommends you acquire multiple sets of these materials to accommodate competition. ● PVC Pipes: ○ twelve 1⁄2" by 6" PVC pipes ○ eight 1⁄2" 3-way connectors, ○ four 1 1⁄2" by 6" PVC pipes, ○ four 1 1⁄2" 90° elbows ● 10 – 12" (30cm) Reusable Plastic Cable Ties ● plastic disc with four 1⁄2" holes ● Scissors or snips ● Golf balls ● Baby pools or other water source ● Indoor/outdoor thermometer ● A premade 'decoy buoy'	● board of wood or plastic at least 0.5 inch thick (no fiberboard) ● saw ● plastic rope ● lighter ● knife ● 16 Pan Head screws ● 16 water bottles and their caps ● Paint (the color you want) ● piece of flexible foam (1/2 inch thick and more), like a square of Play Mat (I took my little sister's) ● Teflon tape or silicone tube (optional) ● drill ● hot glue gun

For inquiry buoy designs (per 2-4 students, small groups): Empty plastic water bottle, twine or string, and a rock or other weight. Water, sand, or soil to fill bottles.

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