Design a Community Rain Garden

Middle School Guam STEM Design Challenge

Anchor Question: In areas that flood on school grounds, how can we get rainwater to soak in rather than run off or create big puddles?

Overview

Guam Connection

In the rainy season so much rain falls that it has no place to go since the ground becomes saturated very quickly. The result is that big puddles or flooding happen, roads can become impassable, and soils can even be picked up by the water and lead to erosion. This is more of an issue in some parts of the island than in others. The southern part of Guam is lower and has this problem regularly.

Engineering Design Challenge

In places where this is a regular problem, rain gardens are specifically designed to soak up rainwater. Rain gardens look like regular flower gardens, but they are so much more. When it rains, the moisture slowly filters into the ground rather than running off across the ground, sidewalks, road, or into the storm drains. Design and create a school-site rain garden using native plants where soil and other sediments allow more water to drain to reduce flooding or erosion.

NGSS Performance Expectation

MS-LS2-5. Evaluate competing design solutions for maintaining biodiversity and ecosystem services.
[Clarification Statement: Examples of ecosystem services could include water purification, nutrient recycling, and prevention of soil erosion. Examples of design solution constraints could include scientific, economic, and social considerations.]

STEM Concepts (NGSS Disciplinary Core Ideas)

LS2.C: Ecosystem Dynamics, Functioning, and Resilience: Biodiversity describes the variety of species found in Earth's terrestrial and oceanic ecosystems. The completeness or integrity of an ecosystem's biodiversity is often used as a measure of its health.

LS4.D: Biodiversity and Humans: Changes in biodiversity can influence humans' resources, as well as ecosystem services that humans rely on—for example, water purification and recycling.

ETS1.B: Developing Possible Solutions

There are systematic processes for evaluating solutions with respect to how well they meet the criteria and constraints of a problem.

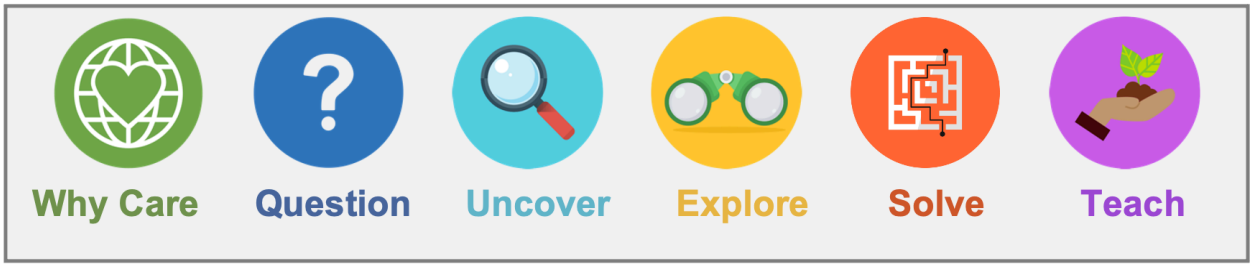
Time: Estimated Number of Classes

3-5 classes (45-minute class)

Materials for the Design Challenge

See Does Media Matter? Infiltration Rates and Storage Capacities materials list
https://www.teachengineering.org/activities/view/usf_stormwater_lesson02_activity2

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:** In areas that flood on school grounds, how can we get rainwater to soak in rather than run off or create big puddles?
2. **Read, describe, and post the design challenge:** In the rainy season so much rain falls that it has no place to go and can create big puddles or flooding, leading to erosion. Rain gardens look like regular flower gardens, but they are so much more. When it rains, the moisture slowly filters into the ground rather than running off across the ground, sidewalks, road, or into the storm drains. Design and create a school-site rain garden using native plants where soil and other sediments allow more water to drain to reduce flooding or erosion.
3. **Share and talk about the Driving Question for why we should care:** Why should I care about the flooding and erosion that regularly occurs across Guam during the rainy season. Discuss this with students and share stories about what is happening in their community and near their school.
4. **Do this:**

a. Survey your school lot to determine where the runoff rainwater moves through the school grounds and surfaces.
b. Guam TV news report of heavy rain and flooding: Local drivers cautioned…
c. Guam Design Notebook: Write or draw your "why I care" and why others on Guam care.

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 flooding, erosion and rain gardens?
    b. What do we **NEED TO KNOW** to design an effective rain garden? Have you ever thought about how water moves once it goes into the ground?
    c. What ideas **DO** we already have for what we could DO to design a rain garden?
        i. Ways to capture the rainwater?
        ii. Ways to divert it somewhere else?
        iii. Learn by looking for places that don't flood to figure it out?
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.
3. **Discuss how these lists will be helpful.** These organizational charts help create a map for what we will learn and do on the Quest. We already know some things about or have had experiences related to the challenge. Using these and additional questions, we need to uncover answers to the KND questions if we are to understand the problem in the challenge and to design a project to solve the problem. We already have some ideas about possible projects, and we need more information before deciding what we should do.

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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.

Teacher Prep

1. Remember that students will need an understanding of the main science ideas surrounding erosion and the conditions that affect the rates, what is meant by percolation and the conditions that affect the rates, the ecosystems around the school along with their health and the cycling of water through the air and land.

Uncover Key Ideas

1. **Share the Driving Question:** How do soil mechanics and properties of soil media determine infiltration rate and storage volume?
    a. Introduce students to the definition of media. In the context of this activity and the unit as a whole, media is defined as a combination of organic and/or inorganic earth materials. Describe the properties of inorganic vs. organic materials. Have students record the definition of media on the worksheet. If possible, gather samples and have students classify them. They can bring samples from home and use soil media from the school environment.
2. **Share the Driving Question:** How do you measure the storage capacity and infiltration rate of different types of media and media combinations?
    a. Ask students if they know where water goes once it enters the ground and if they can define the terms used to describe the movement of water. Direct them to record their answers after the worksheet question: "What do we call the movement of water INTO media layers and define percolation?" Using the soil samples already gathered place the same amount of soil in 100 ml graduated cylinders. Add 50 ml of water and measure the infiltration rate of each sample. Summarize your findings and record your information.
3. **Share the Driving Question:** What is a Rain Garden?
    a. Watch the videos and have students draw and describe a rain garden.
        i. Constructing a rain garden
        ii. Rain Garden 101
4. **Share the Driving Question:** How can media layers promote infiltration, maximizes below-ground water storage, and provide an environment for healthy plants and microbial communities? How does the size of soil media material affect infiltration rate?
    a. Based on their previous observations and information learned about the different soil properties, have students discuss and record additional information on their worksheets using the terms for the following properties: permeability, capillary action, porosity, percolation, storage capacity and field capacity. If needed, return to these properties and conduct additional observations and share their findings with one another.

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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:

LS2.C: Ecosystem Dynamics, Functioning, and Resilience: Biodiversity describes the variety of species found in Earth's terrestrial and oceanic ecosystems. The completeness or integrity of an ecosystem's biodiversity is often used as a measure of its health.

LS4.D: Biodiversity and Humans: Changes in biodiversity can influence humans' resources, as well as ecosystem services that humans rely on—for example, water purification and recycling.

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 understand the problem in our community and to come up with project ideas to help solve the problem?
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 your 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:** In areas that flood on school grounds, how can we get rainwater to soak in rather than run off or create big puddles?
4. **Read and talk about the design challenge:** In places where this is a regular problem, rain gardens are specifically designed to soak up rainwater. Rain gardens look like regular flower gardens, but they are so much more. When it rains, the moisture slowly filters into the ground rather than running off across the ground, sidewalks, road, or into the storm drains. Design and create a school-site rain garden using native plants where soil and other sediments allow more water to drain to reduce flooding or erosion.
5. **Being preparing for the design challenge.** Have students follow the steps of the Engineering design process (Poster).
    a. Returning to what we learned about rain gardens, complete additional tests on the materials chosen for the rain gardens. As a class working in small groups, answer the following questions. How can we determine the storage capacity [of water] of each of these materials: Playground sand, soil compost, limestone or pea gravel, and harvested hardwood mulch? See the instructions below and prepare to DO the explorations: Predict and then investigate how different ratios of materials affects the infiltration rate and how it changes the original material alone? Have different teams select at least two different ratios to test. Once the investigations are complete have the teams prepare a C-E-R chart (Claims, Evidence, and Reasoning). Each team should share their chart and get feedback from the class. Some groups may want to retest or revise their charts with the data shared by other groups.
    b. Complete steps 1-7 in Procedure and the section on with students. After completing the initial investigations, feel free to revise the soil medium ratios tested to determine infiltration rates.

Depending on the number of teams and the additional tests students would like to do, gather additional data.

c. Calculate the storage capacity of each of the media within the prepared 5-gallon buckets by pouring water into the media layer until the water level reaches the top surface of the material.

d. Keep track of the volume of water being poured into each bucket by first accounting for the water with a measuring cup or volumetric cylinder.

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)

Students will understand these NGSS Disciplinary Core Ideas:

ETS1.B: Developing Possible Solutions: There are systematic processes for evaluating solutions with respect to how well they meet the criteria and constraints of a problem.

Solve

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

Driving Question: How can I create and test a design that is most effective at getting rainwater to soak in rather than run off or create big puddles?

Design Your Project

1. Continue following the steps of the Engineering design process (Poster). Complete steps 9-11 in the Rain Garden Design Challenge procedure and section on investigations with students: Does Media Matter? Infiltration Rates and Storage Capacities (Teach Engineering)
    a. Create a media layer that promotes infiltration, maximizes below-ground water storage and provides an environment for healthy plants and microbial communities.
    b. Determine the criteria for your soil medium and the constraints (limitations) of your recommended soil medium. Take into account relevant scientific ideas and potential impacts on people and the natural environment that may limit possible solutions.
    c. To determine the initial effectiveness of your solution you can go to the procedure provided in the Rain Garden Design Challenge.

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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:** In areas that flood on school grounds, how can we get rainwater to soak in rather than run off or create big puddles?
2. **Prepare and creatively share your project and how it helped solve the problem.**
    a. Build your presentation around the anchor question. In areas that flood on school grounds, how can we rainwater to soak in rather than run off or create big puddles?
    b. Who's your audience? Who will benefit from hearing about and seeing your project?
    c. How will you share this information?
    d. What do you want them to know and understand about the problem and your proposed solution?
    e. When and where will you share? You can practice sharing with other groups in your class.
3. **Student reflection:** Students can reflect on their experience with this design challenge while preparing their presentation or afterwards. Here is one reflection idea: 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 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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