Marine Engineering Project

Lesson Title: Attack of the Toxic Algae
Author: Lily Rutledge-Ellison
Topic: Environmental Conservation and Engineering
Targeted Grade Level: 4th grade, but it could be adapted for 3-5
Time Needed: 2-3 days
Subject Integration: Science, Engineering, Social Studies-Colorado

Teacher Background Info:
Toxic algae or harmful algae blooms are made up of what many people call blue-green algae. Technically, these organisms are a special type of bacteria called cyanobacteria or cyanoHABs. Although these organisms naturally occur in Colorado waters, they become a problem when they multiply rapidly, resulting in a dense cyanobacteria concentration or “bloom.” The blooms become harmful when the cyanobacteria produce toxins.
Some (but not all) water bodies in Colorado are monitored and tested for toxic algae to protect the health and safety of water users. Always look for caution or warning signs before allowing children, pets, or yourself to come into contact with water.

What causes blue-green algae?
Blue-green algae thrive in warm, nutrient rich water. Water nutrients such as nitrogen and phosphorus help algae grow and support fish and other aquatic life. But too much nitrogen and phosphorus in the water allows blue-green algae to grow quickly and form blooms and scums. Blooms can occur anytime but are most common during hot, sunny weather and in slow-moving water bodies such as lakes.

Potentially dangerous blooms have recently been observed at Wonderland Lake in North Boulder. According to city officials, nitrogen and phosphorus running-off into bodies of water from fertilized lawns and other sources can facilitate the growth of these blooms.
Signage notifying visitors of the harmful blooms at Wonderland Lake were to be posted in the area on Friday afternoon. Swimming, wading, and boating are prohibited in the lake. Dogs should also be kept out of the water.

Blue-green algal blooms are often described as thick pea soup or spilled bluish-green paint on the water's surface. Blooms, which thrive in shallow, warm, and still bodies of water, can contain toxin-producing cyanobacteria. If ingested, these toxins can be deadly to dogs.

When farm and lawn fertilizers run into the water system, they can affect local water sources, but can also build up down stream becoming worse and worse. This problem of nitrogen and phosphorus runoff affects multiple marine environments.

Students will define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.

Students will generate and compare multiple solutions to reduce the impacts of human activity on aquatic life in our state and beyond.

Science and Engineering Practices

Asking Questions and Defining Problems
Asking questions and defining problems in 3–5 builds on grades K–2 experiences and progresses to specifying qualitative relationships.

- Define a simple design problem that can be solved through the development of an object, tool, process, or system and includes several criteria for success and constraints on materials, time, or cost.

Disciplinary Core Ideas

ETS1.A: Defining and Delimiting Engineering Problems

- Possible solutions to a problem are limited by available materials and resources (constraints). The success of a designed solution is determined by considering the desired features of a solution (criteria). Different proposals for solutions can be compared on the basis of how well each one meets the specified criteria for success or how well each takes the constraints into account.

Crosscutting Concepts

Influence of Science, Engineering, and Technology on Society and the **Natural World**

- People's needs and wants change over time, as do their demands for new and improved technologies

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Cause and Effect

- Cause and effect relationships are routinely identified, tested, and used to explain change.

Video of Experiment: *https://youtu.be/XXOLaA1iN-k*

Engage: Students should inquire and hypothesize about what is seen in these Colorado Waterways

https://cdphe.colorado.gov/toxic-algae

Explore: An expert should speak with the students virtually or in person. Experts could include: Conservation Colorado, Colorado Storm water Council, Colorado Parks and Wildlife (CPW), or a representative from the Colorado Ute Mountain Tribe, or Southern Ute Tribe.
Students should prepare questions that will allow them to "Identify the Problem"

Explain: Students should engage in a structured discussion to clarify the problem. Student's are encouraged to challenge each other's thinking, and add on with evidence from the interview.

Elaborate: Students may now apply their thinking to the design process.

- Brainstorm
- Design
- Build
- Test
- Redesign

Evaluate: Students will be assessed on how they applied knowledge of Colorado's water ecosystems to a solution

Exceeded standard-

- Design Process followed and communicated in writing
- Solution is based on deep knowledge of Colorado's water ecosystems
- Presentation of Solution is inspiring and educational

Met standard-

- Design Process followed and communicated
- Solution is informed by science
- Presentation of Solution is educational

Approaching standard-

- Parts of the process were followed
- Solution is creative
- Solution is presented to an audience

Protecting Colorado

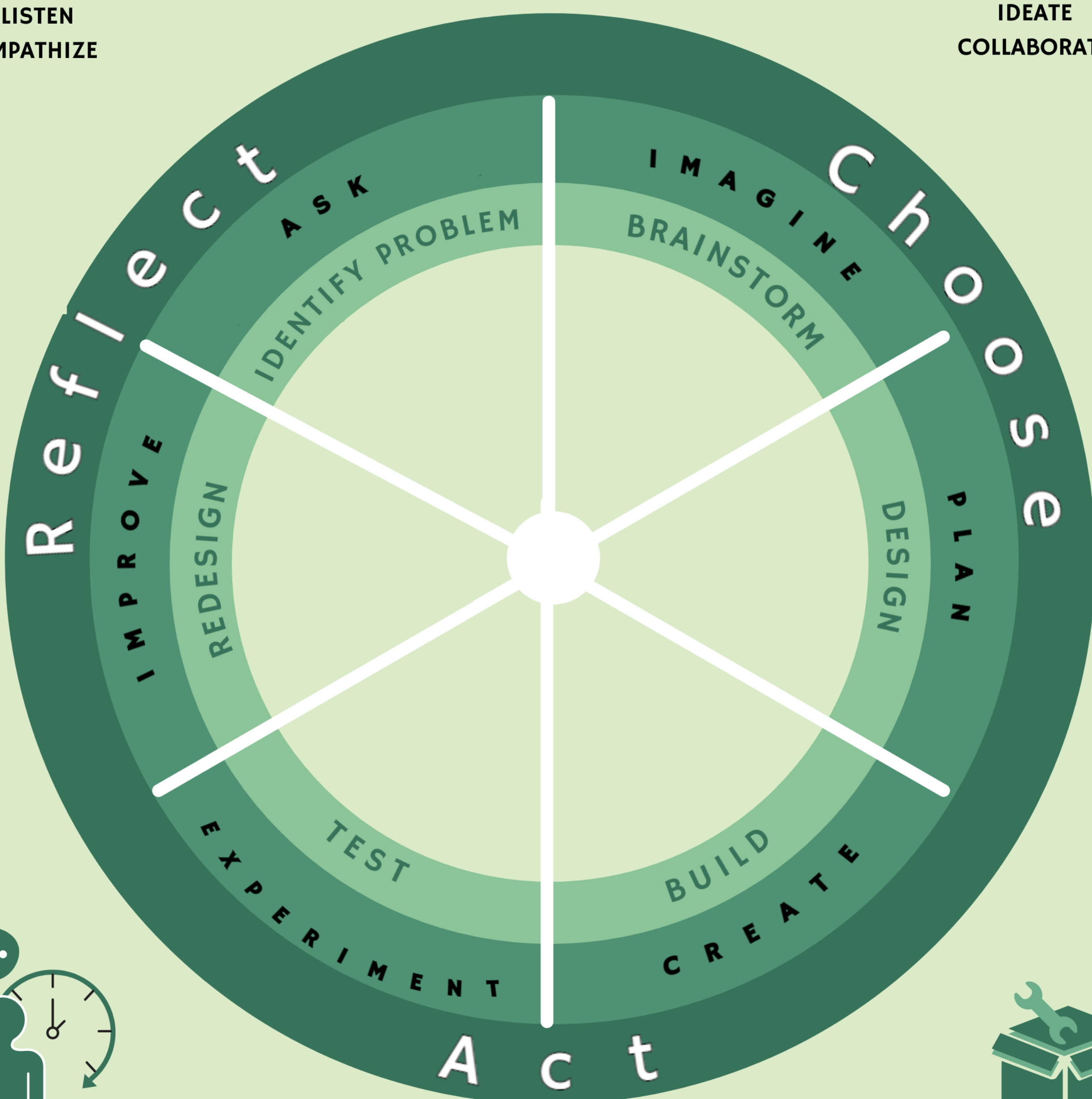
Name of engineer:

CONSERVATION

COLORADO'S WATER AND WILDLIFE

LOOK
LISTEN
EMPATHIZE

NAVIGATE IDEAS
IDEATE
COLLABORATE



FAIL EARLY
DISCOVER GLITCHES
LAUNCH
AUTHENTIC FEEDBACK

PROTOTYPE
DRAFT
REBUILD

IDENTIFY THE PROBLEM

We need to prevent algae blooms from poisoning Colorado's fish and other wildlife. We need to create something that lowers the amount of fertilizer runoff.

The model has to cut down the Nitrogen levels in the water that flows downstream. Then that same design could be implemented on a larger scale.

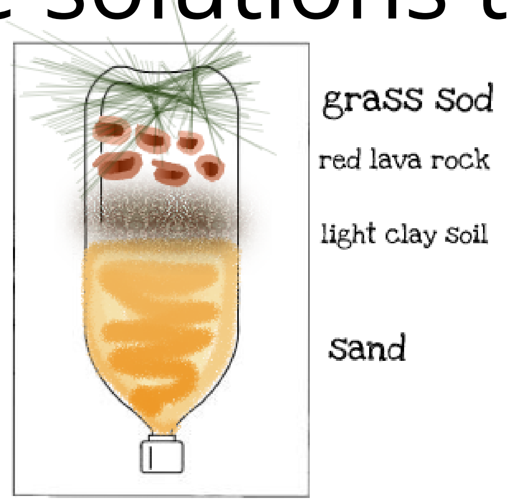
Constraints: **time** - 2 hours
materials- aggregates (sand, gravel, or crushed stone), dirt, woodchips, ash, measuring cup, clear bottle for model, water
cost- less than 5 dollars
classroom constraint- the design must fit in a 2 liter bottle, and water will need to move through it

Specifications: -2 liter soda bottle- clear plastic
-liquid measuring cup that measures in ml and oz
-smaller and larger aggregates that can fit in a soda bottle

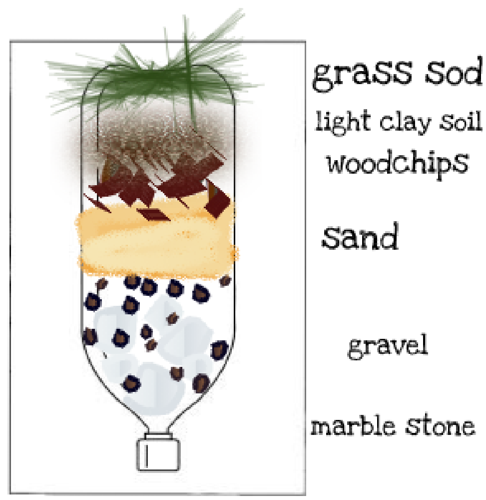
BRAINSTORMING

Some solutions that may work:

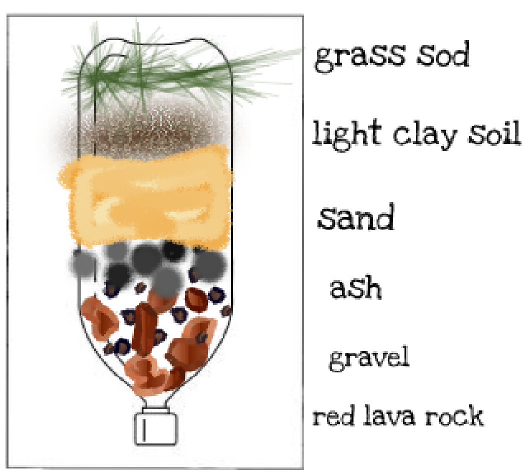
Design 1:



Design 2:

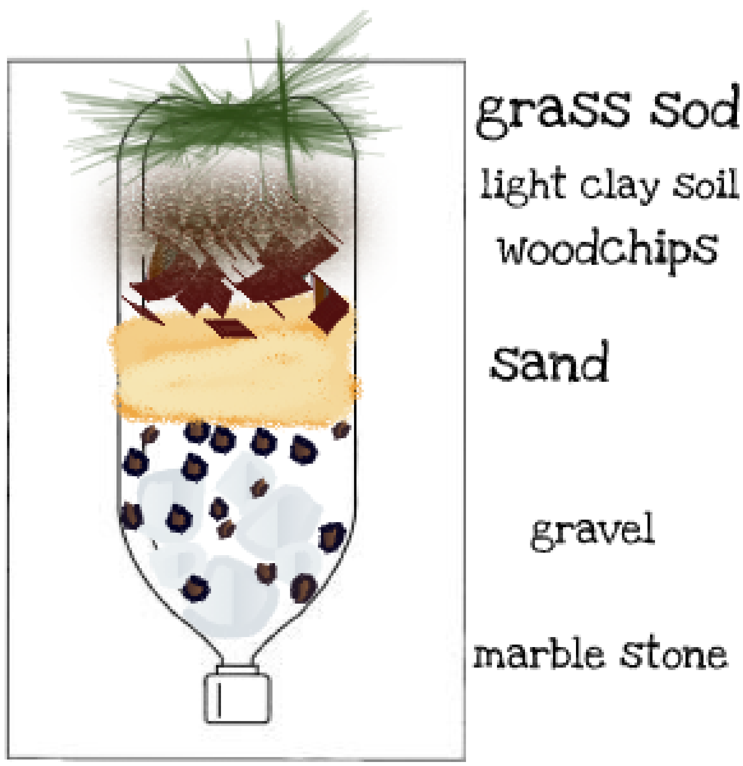


Design 3:



DESIGN

After working with the materials, we believe this is the best design.



BUILD

Procedure needed:

<u>Step 1</u>
Carefully cut the bottom of a 2 litter bottle off.
You may need a serrated knife.

Be careful with the materials, wash your hands afterwards.

<u>Step 2</u>
Measure how much of each layer you are adding in.
If using the 8 oz scoops, a good rule is to add no more than 8 scoops total (64 oz/67 oz)

Make sure the cap is still on!

BUILD

Procedure needed:

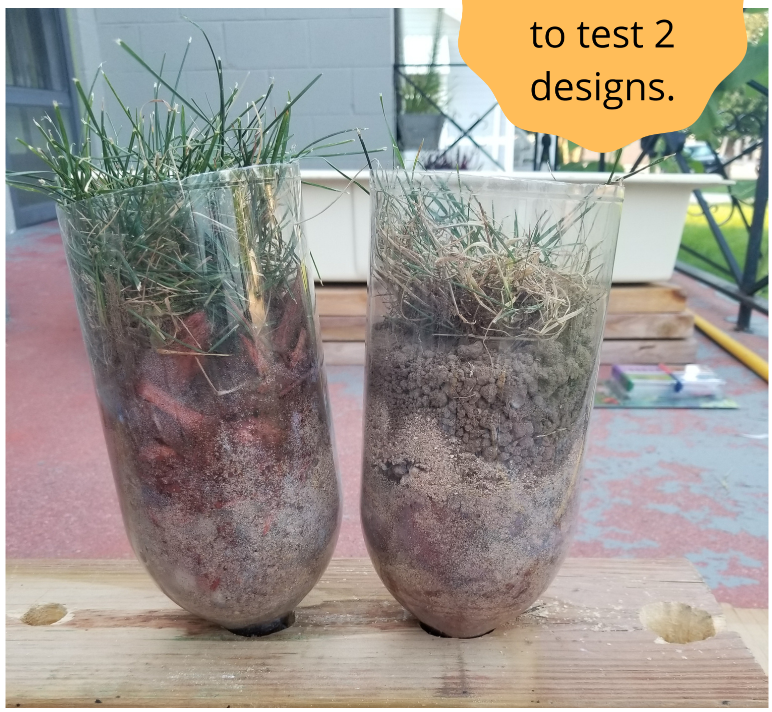
We decided to test 2 designs.

Step 3

Remove the cap

Place your system in a holder (wooden or other)

Place a collection container beneath the hole.

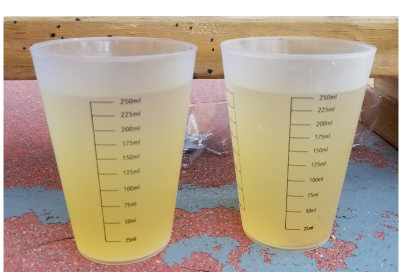


Step 4

Measure 25 ml of a nitrogen fertilizer.

Measure 250 ml of water.

Then combine.



TEST AND EVALUATE

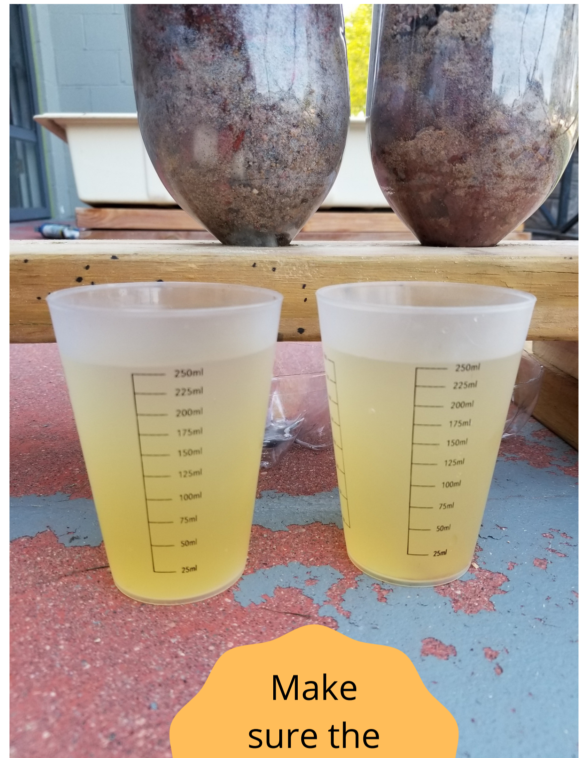
What is not working?

I immediately saw that the design on the right looked clearer, or less yellow. I was really surprised by this because I thought for sure the one on the left would work better. I also noticed they both smelled fishy.

They both seemed to let some fertilizer through.

What is working?

The system on the right seemed to hold more of the liquid. Perhaps this would give it more time to break up the Nitrogen.



Make sure the cap is off when you pour!

Upon nitrogen testing both samples, it turned out that the system on the left was actually better at removing nitrogen from "runoff."
We hypothesized that the sample on the right looked clearer because less solution made it through the system. This solution was probably absorbed by the pumice (red lava rock). If the lava rock had already been wet, it may not have worked.

REDESIGN

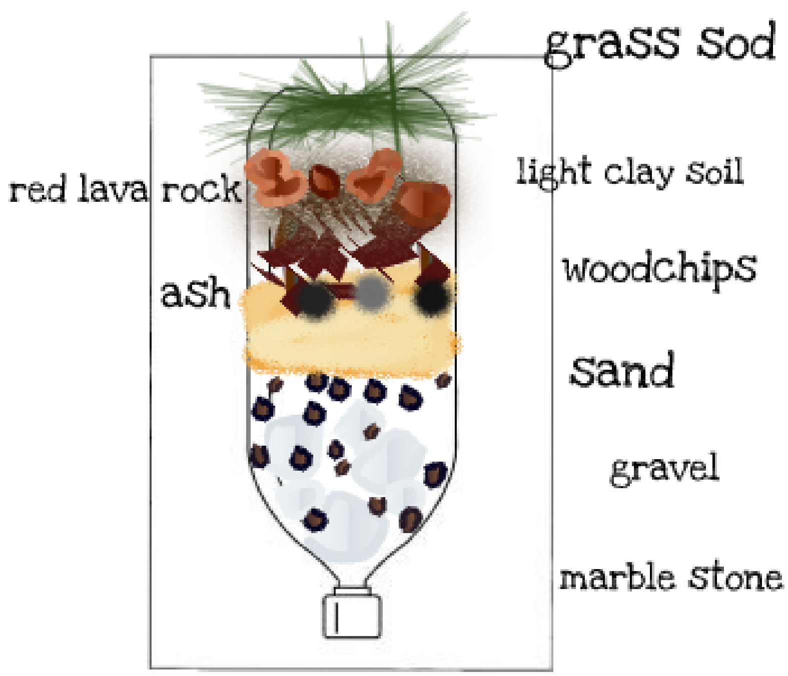
How can you solve the problems that happened during your test? Draw a new design.

We could pre-wet each system with water so that the variable of absorption is not a factor.
We could test each material separately to check its effectiveness independently.

We could include pumice higher in a system to hold the nitrogen above the mulch which should break it down.

I started with the model that worked well, but I added ash and red lava rock.
My plan is that the red lava rock will absorb the nitrogen and hold it long enough for the mulch beneath it to work.
The ash acts as a carbon filter.

Hopefully this design will clear even more nitrogen from the run off.



REFLECTION

After completing this lab, I understand more about surface area playing a role in filtration. The porous pumice really traps things because of its surface area. I wonder if the incline of the slope would affect the filtration?

I think this solution would work on a larger scale surrounding a farm. If all farms and neighborhoods using fertilizer could ensure there was a zone with this system between them and the water, we could reduce the amount of nitrogen that makes it into the water.

In the future, I would like to see if any materials do a better job of filtering phosphorous.

A REFLECTION BY THE AUTHOR :

I had so much fun designing this experiment. I actually built a whole flow table for a larger trial, but ran out of time. I am hoping to use the flow table in the future for lots of other labs.

This lab really surprised me. My assumptions kept getting challenged, and I think that is what Science and Engineering design is all about. If anyone reading this decides to try this lab out, I highly recommend that you tie the issue to the larger water system (the ocean) and then work backwards from there. That way you can connect it to wherever you live.

The first time I have students try this, I will make each of the materials cost a different amount of money. Then I will give them a budget. That will reflect a real life constraint that exists around this problem. I would also recommend nitrogen test strips as opposed to the capsules. There are less steps and the kids could test the water much easier.

If you need to modify it for a younger group you could try just doing the test with 6 different materials separately, or make the constraint that kids can only pick two materials.

To extend this design challenge you could try doing these layers in a flow table. You can have kids add elevation, and see if "pooling" helps the absorption rate.

The most exciting addition I thought up later was to get a sample of algae, place it in the nitrogen solution, then place some in each kid's runoff to see which one grows the most.

You could also introduce heat, which would start questions about climate change.

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