Go with the Flow!

student guide

Purple Plow
Uncovering STEM Solutions

Challenge Rationale

When rain falls or snow melts, it does not simply stay in one place or seep into the ground to replenish groundwater; most of it begins to move. When water flows over land, it is called surface runoff, and it is an important part of the water cycle, but have you ever wondered where your runoff is running off to? What's in your runoff? What is the runoff doing to the environment once it has settled? Around the world, there are more than 400 dead zones in oceans and lakes, where the water contains so little oxygen that aquatic life can no longer survive. In large part, this is due to excess nutrient pollution found in our runoff as a result of home, agricultural, and industrial practices as well as population growth. In this challenge, students will learn about the impact of runoff in rural and urban areas and its effects on the environment as well as plan for solutions to this growing issue of dead zones, hypoxia, and overall water quality.

Establishing the Challenge

Identify the Challenge

Eutrophication is a big word that describes a big problem in our world's estuaries. Harmful algal blooms, dead zones, and fish kills are a result of eutrophication. Nitrogen and phosphorous are the culprits that come from runoff sources like fertilizer, untreated wastewater, and atmospheric fallout from burning fossil fuels. This problem should matter to you whether you live near an ocean or not because the problem starts where you live and ends in resources we all use and enjoy. In this challenge, students will learn about protection of marine resources through home practices, agricultural practices, and waste management practices. We all play a part in ensuring a thriving planet which includes ensuring water quality for generations to come.

Eutrophic events have increased because of the rapid rise in intense agricultural practices, industrial practices, and population growth. These three processes emit large amounts of nitrogen and phosphorus in runoff which cause dead zones also known as hypoxic zones. These are areas that are so deprived of oxygen that aquatic life can no longer survive.

Different areas of the world emit different levels of these nutrients. The United States, along with nations in the European Union, use animal manure and commercial fertilizers in agriculture and are the main contributors to eutrophication. Runoff from larger agricultural fields enters creeks and bays because of rain, snow melt, or irrigation practices. In the developing countries of Latin America, Africa, and Asia, untreated wastewater from sewage and industry are the main contributors to eutrophication. Land development through urbanization such as pavement, rooftops, roads, etc. also increases surface runoff as the water cannot seep through these impervious surfaces. Urban runoff carries with it many pollutants such as petroleum, sediment, and fertilizers. Atmospheric sources of nitrogen also contribute to eutrophication.

Eutrophication has severe environmental impacts on ecosystems and poses major problems for all living things. Reducing eutrophication, while also maintaining natural runoff, is an important component to ensuring a sustainable future.

Challenge Question

How can we improve the quality of our runoff and, in turn, reduce dead zones in our water resources?

This solution must address the following needs

- Address dead zone concerns through industrial, agricultural, or population growth
- Reduce amounts or sizes of dead zones
- Reduce contaminated runoff
- Ways we can improve the quality of our runoff
- Trade-offs of using eco-friendly practices as it relates to runoff
- Economic, environmental, and societal needs

Success will be determined by

- Producing and sharing a presentation of knowledge gained
- Sharing progress and results on social media by tagging @ThePurplePlow
- Production of a model solution for higher-quality water runoff or the reduction of highly-polluted runoff

1. Identify

PURPOSE OF STEP

Define the need and how it affects life globally, nationally, and locally. Research and consider how others have approached solving the need including how people have addressed this need historically. Describe why this challenge needs a solution and determine constraints (e.g., time, space, resources, etc.).

STUDENT PROMPTS AND GUIDING QUESTIONS

- What is runoff?
- What is in runoff?
- How does runoff move?
- Where does runoff go?
- Why is runoff an important part of the water cycle?
- What is eutrophication, and how does eutrophication affect populations locally and globally?
- How does runoff contribute to eutrophication?
- Compare and contrast runoff in rural and urban locations.
- How do we residential, agricultural, and industrial practices impact runoff and water quality?
- How does runoff affect me, our food, and our earth?

SIGNS OF STEP COMPLETION

Students will present a description of the challenge to the facilitator. The description should include how this challenge affects communities globally, nationally, and locally. The description should also include ways in which others have addressed finding a solution and constraints to be considered (e.g., time, space, resources, etc.).

At the completion of this step, discuss the reflection questions led by the facilitator.

1. Identify Reflection

Important discoveries during this step:

Define the problem as it relates to you locally:

Plans for the next step (e.g., knowledge to gain, questions to answer, preparations to make, etc.):

2: Imagine

PURPOSE OF STEP

Brainstorm solutions to the challenge. List all of your ideas – don't hold back! Discuss and select the best possible solutions.

STUDENT PROMPTS AND GUIDING QUESTIONS

- What practices at home, in agriculture and in industry can be changed to improve the quality of our runoff?
- What has already been done to improve the quality of our runoff?
- How can we decrease the number or size of dead zones in our waters?
- Which areas produce the most polluted runoff?

SIGNS OF STEP COMPLETION

Students will present a list of possible solutions to the identified challenge to the facilitator.

At the completion of this step, direct students to the reflection questions in the "Go With the Flow Student Guide."

2: Imagine Reflection

Important discoveries during this step:

List your possible solutions:

Identify the solution that you think will be achievable:

Plans for the next step (e.g., knowledge to gain, questions to answer, preparations to make, etc.):

3: Design

PURPOSE OF STEP

Diagram the model and identify the materials needed to build the model. Write out the steps to take and describe the expected outcomes.

STUDENT PROMPTS AND GUIDING QUESTIONS

- How will you demonstrate the improvement of the quality of runoff?
- What materials are needed?
- How do cost and material constraints factor in?
- What environmental factors should be considered?
- Justify your particular design choice.

SIGNS OF STEP COMPLETION

The students will present a detailed diagram of the prototype as well as a written plan of how it will be built. Look for the following in the plan: a materials list with budget (if building a physical model), detailed directions, and expected outcomes.

At the completion of this step, direct students to the reflection questions in the "Go With the Flow Student Guide."

3: Design Reflection

Important discoveries during this step:

Justify your model design and the materials you will need:

Plans for the next step (e.g., knowledge to gain, questions to answer, preparations to make, etc.):

4: Create

PURPOSE OF STEP

Follow the design plan and build the model or prototype.

STUDENT PROMPTS AND GUIDING QUESTIONS

- Use all research, knowledge gained, and the design plan to create the solution
- Repeat any of the previous steps should issues arise during the building process
- Consider the parameters of the challenge and what needs to be accomplished for a successful challenge

SIGNS OF STEP COMPLETION

The students will build the model and share with the facilitator.

At the completion of this step, direct students to the reflection questions in the "Go With the Flow Student Guide."

4: Create Reflection

Important discoveries during this step:

Describe any barriers you overcame in creating your model.

Plans for the next step (e.g., knowledge to gain, questions to answer, preparations to make, etc.):

5: Test + Improve

PURPOSE OF STEP

Test the design and collect qualitative and quantitative data. Discuss results and compare with the expected outcome. Seek areas of improvement and make changes as needed.

STUDENT PROMPTS AND GUIDING QUESTIONS

- What will need to be observed?
- What information can be put into a chart or graph?
- Create charts, graphs, photographs, etc. to showcase data.
- How will you demonstrate improvement of runoff quality?
- How will you evaluate the trade-offs of your solution?

SIGNS OF STEP COMPLETION

The students will keep records of all test trials and share data with the facilitator. Entries should include both qualitative and quantitative data. The students will also share recordings any improvements made to the design prototype and the effect they had on the outcome.

At the completion of this step, direct students to the reflection questions in the "Go With the Flow Student Guide."

5. Test + Improve Reflection

Important discoveries during this step:

Impacts to the global, national, and local community:

Plans for the next step (e.g., knowledge to gain, questions to answer, preparations to make, etc.):

6: Share

PURPOSE OF STEP

Communicate what was learned throughout the challenge. Share the design process, data, and conclusions on how the model answers the challenge question.

STUDENT PROMPTS AND GUIDING QUESTIONS

- Design a presentation including knowledge gained, design plan, materials used, tests completed, and data analysis.
- How is your design approach appropriate and realistic to the challenge?
- Does your design address budgetary issues, timelines, and other constraints?
- How successful was your solution in addressing the issue of dead zones in our waters?
- Describe what you learned from this challenge?

SIGNS OF STEP COMPLETION

The students will present what was learned through the design process, including sharing how the prototype addresses the problem, key aspects of design, data from test trials, and end results.

EXTENSION POSSIBILITIES

- Visit a local water shed and conduct research on the quality of water.
- Interview a local farmer on their agricultural practices as it relates to runoff.
- Attend a freshwater studies program.

Resources

Phys.org's "Dead Zones are a Global Water Pollution Challenge":
https://phys.org/news/2018-05-dead-zones-global-pollution-sustained.html

National Geographic Resource Library "Runoff" Entry:
https://www.nationalgeographic.org/encyclopedia/runoff/

USGS: Science for a Changing World's "Runoff: Surface and Overland Water Runoff":
https://www.usgs.gov/special-topic/water-science-school/science/runoff-surface-and-overland-water-runoff?qt-science_center_objects=0#qt-science_center_objects

NOA: National Ocean Service's "What is Eutrophication?":
https://oceanservice.noaa.gov/facts/eutrophication.html

United Nations Goal #6: Clean Water and Sanitation
https://sustainabledevelopment.un.org/sdg6

United Nations Goal #14: Life Below Water
https://sustainabledevelopment.un.org/sdg14

United Nations Goal #15: Life on Land
https://sustainabledevelopment.un.org/sdg15

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