SAVE THE SOIL

facilitator's guide

Purple Plow
Uncovering STEM Solutions

Challenge Rationale

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Students can help conserve natural resources locally and protect local ecosystems by addressing current and historical problems associated with the erosion of topsoil that limits the ability to grow food. After thoughtful research to evaluate how these challenges exist globally and locally, students will design, test, and demonstrate a solution that reduces topsoil erosion for their unique location or situation to help conserve productive soil. The final product will be a model which demonstrates a measurable reduction in soil erosion.

Establishing the Challenge

Identify a Problem

According to the United States Department of Agriculture's Natural Resource and Conservation Service, soil erosion "will remain an important global issue for the 21st century because of its adverse impact on agronomic productivity, the environment, and its effect on food security and the quality of life." It is estimated that only 11% of our Earth's land surface has the topsoil considered suitable for producing food. In the United States, we are losing at least 3 billion tons of topsoil a year to erosion! Without topsoil, our land becomes a desert and is not capable of producing food. What can we do to start solving this global problem? To address the necessity of food production, we need to start at the soil level.

Response to Problem

With the challenge of losing over 3 billion tons of fertile topsoil each year, your team has been selected to design a prototype and construct a system that will reduce topsoil erosion.

This system must address the following needs:

- Address local erosion concerns.
- Reduce topsoil erosion.

Success will be determined by

- Design, create, and test a topsoil erosion simulation model which demonstrates a measurable reduction of topsoil erosion.
- Produce a presentation which shows the topsoil reduction model in use and communicates results.

Standards Addressed

Next Generation Science Standards

https://www.nextgenscience.org/

- **MS-ESS2-2** Construct an explanation based on evidence for how geoscience processes have changed Earth's surface at varying time and spatial scales.
- **MS-ESS3-1** Construct a scientific explanation based on evidence for how the uneven distributions of Earth's mineral, energy, and groundwater resources are the result of past and current geoscience processes.
- **MS-ESS3-3** Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.
- **MS-ETS1-1** Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.
- **MS-ETS1-2** Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.
- **MS-ETS1-3** Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.
- **MS-ETS1-4** Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved.

Suggested Pacing Guides

Middle-School School-Year Program

This sample pacing guide is created for a 90-day calendar with a 45-minute class. This is only a recommendation. The facilitator can modify it to meet their needs based on scope of project and time available.

Design Process Step	Timeline
Identify	5 days
Imagine	8 days
Design	5 days
Create	6 days
Test & Improve	61 days
Share	5 days

Middle-School Summer-School Program

This pacing guide is created for a 20-day calendar with a 3-hour block. This is only a recommendation. The facilitator can modify it to meet their needs based on scope of project and time available.

Design Process Step	Timeline
Identify	2 days
Imagine	2 days
Design	2 days
Create	3 days
Test & Improve	9 days
Share	2 days

After School- School Year Program

This sample pacing guide is created for 2 days a week for an 18-week semester. All days are calculated with a 90-minute timeframe. This is only a recommendation. The facilitator can modify it to meet their needs based on scope of project and time available.

Design Process Step	Timeline
Identify	2 days
Imagine	2 days
Design	2 days
Create	5 days
Test & Improve	21 days
Share	5 days

After School- Summer School Year Program

This pacing guide is created for a 20-day calendar with a 3-hour block. This is only a recommendation. The facilitator can modify it to meet their needs based on scope of project and time available.

Design Process Step	Timeline
Identify	2 days
Imagine	2 days
Design	2 days
Create	4 days
Test & Improve	8 days
Share	2 days

NOTE:

To fulfill the requirements of the challenge, you will need time beyond the allotted program time above. Possible options for competing include:

- Sending the constructed growing structure and related materials home with students wishing to compete (participating in regular progress monitoring of project with facilitator)
- Developing continuation options in an after-school or extra-curricular club with facilitator
- Including parents in the process of continuing the investigation (with option of providing space at school to keep project)

Materials List

Save the Soil
Suggested Materials List

The items listed below are suggested materials needed to conduct the challenge. Materials should be considered based upon which type of erosion you choose to investigate - wind, water, ice, or chemical. Facilitators and students are encouraged to be creative and inventive in acquiring the materials needed to complete the challenge (e.g., purchased, recycled, donated, etc.).

Materials Required	Suggested Material Options
Computer with internet Access	Printer
Soil from locale	Stream table (e.g., https://www.enasco.com/product/SB01704M)
	Large fan
	Creative materials (e.g., scissors, glue, etc.)
	Coffee filters or other filtration materials
	Calculator
	Variety of paper (e.g., poster board, presentation board, construction paper, etc.)

Facilitating The Challenge

Facilitating The Challenge

Each Purple Plow Challenge can be implemented in a variety of methods, timeframes, and programs. Follow the steps below to help determine how this challenge will best fit the current situation and educational environment.

1. Review the Purple Plow "Design Process" and the "Content Packet" documents.
2. Examine the suggested pacing guides to determine ways to integrate the challenge into your specific program.
3. With the timeframe in mind, use the guidance provided in this section to help students progress through the challenge. This guidance includes suggested student prompts, guiding questions for students, signs of step completion, and journaling opportunities. The student prompts, guiding questions, and journal prompts are found in the "Save the Soil Student Guide." Facilitators or students may determine the method by which they record their research and discoveries found for these prompts and journal reflection questions.

1. Identify

PURPOSE OF STEP

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

STUDENT PROMPTS AND GUIDING QUESTIONS

- What is erosion?
- What are the various causes of erosion?
- Why is topsoil erosion a problem?
- How does soil erosion affect global agricultural practices?
- How does soil erosion affect local agricultural practices?
- Why is soil erosion a problem for agriculture, and more broadly, our society?
- What form of topsoil erosion presents a problem in your area (e.g., water, wind, ice, etc.)?
- How has erosion changed our world throughout history?
- How has soil erosion affected agriculture locally and globally throughout history?

SIGNS OF STEP COMPLETION

Students will present a description of the problem to the facilitator. Be sure to include how this problem 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, direct students to the reflection questions in the "Save the Soil Student Guide."

2: IMAGINE

PURPOSE OF STEP

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

STUDENT PROMPTS AND GUIDING QUESTIONS

- What is the desired result?
- What are current global solutions to the soil erosion problem?
- What solutions to soil erosion are being used in the United States?
- What erosion solutions are being used in your community or region?

SIGNS OF STEP COMPLETION

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

At the completion of this step, direct students to the reflection questions in the "Save the Soil Student Guide."

3: Design

PURPOSE OF STEP

Diagram the model. Identify the materials needed to build the model. Write out the steps to take. Describe the expected outcomes.

STUDENT PROMPTS AND GUIDING QUESTIONS

- Design a model that meets the demands set forth in the challenge and simulates erosion.
- Determine what specific materials will be used to make your model landscape and erosion simulation.
- How could you simulate topsoil erosion?
- In what unique ways could you design a system that reduces topsoil erosion?
- How will you provide evidence of topsoil erosion reduction with your system?
- Justify why particular design choices have been made.
- Identify, obtain, and track costs of materials for your topsoil erosion model.

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 a budget, detailed directions, and expected outcomes.

At the completion of this step, direct students to the reflection questions in the "Save the Soil Student Guide."

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 model.
- 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 reflections questions in the "Save the Soil Student Guide."

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 where needed.

STUDENT PROMPTS AND GUIDING QUESTIONS

- Create data tables, graphs, photographs showcasing data, etc.
- How does wind and/or water effect the movement of soil particles?
- Does size or weight of soil effect the movement of the soil particles?
- Calculate rate of erosion.
- How do plants affect the rate of erosion?
- What other factors are affecting the system and what observations can be collected?
- How will you collect and measure sediment within your model?
- What will need to be observed (qualitative data)?
- What information can be put into a chart or graph (quantitative data)?

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 of 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 reflections questions in the "Save the Soil Student Guide."

6: Share

PURPOSE OF STEP

Communicate what was learned. Share the design, data, and conclusions. Present results.

STUDENT PROMPTS AND GUIDING QUESTIONS

- Take pictures of your model.
- Film your topsoil erosion simulation in action.
- Develop a presentation including knowledge gained, design plans, and materials used to create the model, testing completed during challenge, and data analysis.

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

- Research the Dust Bowl of the 1930's.
- Investigate forms of erosion not addressed in the project.
- Invite a knowledgeable guest speaker (e.g., a farmer, a geologist, a civil engineer, etc.) to talk to the class about erosion and prevention strategies.
- Research your local United States Department of Agriculture's Natural Resource Conservation Service office and invite them in to review your models once complete.
- Visit a local farm with erosion prevention strategies in place.
- Investigate the effects of erosion on plant growth.

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