Designing Global Learning: Environmental Engineering Students Create Standards-Aligned K–12 Activities for *TeachEngineering*

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Abstract

Jr/Sr Environmental Engineering students at CU-Boulder developed a series of K–12 educational activities that bring real-world environmental challenges into the classroom. Each lesson includes hands-on, inquiry-based experiments, detailed lesson plans, and alignment with national science and engineering standards (NGSS and Common Core) to ensure classroom relevance. The activities, covering topics such as water quality, waste management, air pollution, and sustainable design, were created for a global audience and are hosted on the '*TeachEngineering*' [1] digital library. This project highlights how engineering education can extend beyond the university to inspire the next generation of problem solvers, foster STEM literacy, and promote sustainability through experiential learning.

Methods

This NSF-funded effort took place part of a term project in the EVEN 4404 course, where students were tasked with designing an open-ended, hands-on project. Specifically, they were asked to create an activity that educates a K-12 student about water chemistry principles.

- Activities were aligned with either of these K-12 educational STEM standards: Common Core State Standard, Next Generation Science Standards (NGSS), or International Technology and Engineering Educators Association (ITEEA) Standards for Technological Literacy (STL).
- Engineering students sought written input on their designed activity from their Design Mentors, who are Idea Forge's makerspace engineers.
- Engineering students sought written input on their design activity from their STEM Education Mentor, a K-12 STEM teacher recruited from the Boulder Valley School District, to help design developmentally appropriate content for the target grade or range of grades
- The designed curriculum is mapped to the 'TeachEngineering' digital library, a free, standards-aligned resource for K-12 engineering education. It engages students with over 1,800 lessons and hands-on activities contributed by 57 sources, including 40 NSF-funded GK-12 and RET grants, and serves over 3.5 million users annually.
- University of Colorado - Boulder IRB protocol #23-0388.

Published K-12 Curriculum

Dyed oil added to water
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HANDS-ON ACTIVITY

A Slippery Situation: Oil Spill Cleanup and Polarity

Learning Objectives

After this activity, students should be able to:

- Understand the concept of polarity and polar molecules.
- Explain whether polar and nonpolar molecules mix.
- Discuss the effects of oil spills on the environment.
- Brainstorm solutions to simple environmental issues.

Summary
Engineering Connection
Learning Objectives
Materials List
Worksheets and Attachments
More Curriculum Like This
Pre-Req Knowledge
Introduction/Motivation
Procedure
Vocabulary/Definitions
Assessment
Investigating Questions
Troubleshooting Tips
Activity Extensions
Activity Scaling
Additional Multimedia Support
User Comments & Tips

Worksheets and Attachments

Oil Spill Cleanup Worksheet (docx)
Oil Spill Cleanup Worksheet (pdf)
Oil Spill Cleanup Worksheet Answer Key (docx)
Oil Spill Cleanup Worksheet Answer Key (pdf)
Oil Spill Cleanup Presentation (pptx)
Oil Spill Cleanup Presentation (pdf)
Making Sense Assessment (docx)
Making Sense Assessment (pdf)

Vocabulary/Definitions

absorption: Technique to remove oil by using absorbents (i.e., filter).
covalent bonds: Bonds formed by sharing electrons.
hydrophobic: Repellent toward water; does not mix with water.
non-polar: A molecule where electrons are equally shared between atoms, creating zero dipole moment.
polar molecules: A molecule where distribution of electrons between atoms is uneven, creating a dipole moment (i.e., one end of the molecule is slightly positive while the other end is slightly negative).
polarity: The degree to which a molecule has properties of molecular attraction.
skimming: Technique used to physically separate oil from water (via adsorption) and place it in collection tanks (i.e., floating booms).

Quick Look

Partial design process

GRADE LEVEL:	7 (6 – 8)
TIME REQUIRED:	1 hours 45 minutes (two 50-minute class periods: one period to introduce concepts and get familiar with setup, and one period to design a solution and test it.)
GROUP SIZE:	3
SUBJECT AREAS:	Chemistry, Earth and Space, Measurement, Physical Science, Problem Solving
NGSS PERFORMANCE EXPECTATIONS:	MS-ETS1-1, MS-ETS1-2, MS-PS1-1

Procedure

Students brainstorming oil spill mitigation

Making Sense Assessment

Make sense of what you learned by writing a short reflection about the phenomena you explored, the science and engineering skills you used, and one question or idea you have about what was learned. Answer the prompts in complete sentences.

3 — Three science concepts that I learned and applied in this activity are:

2 — Two science and engineering skills that I used are:

Science and Engineering Practices:
- ❑ Asking questions (for science) and defining problems (for engineering)
- ❑ Developing and using models
- ❑ Planning and carrying out investigations
- ❑ Analyzing and interpreting data
- ❑ Using mathematics and computational thinking
- ❑ Constructing explanations (for science) and designing solutions (for engineering)
- ❑ Engaging in argument from evidence
- ❑ Obtaining, evaluating, and communicating information

Engineering Design Process:
- ❑ Ask: Identify the Need & Constraints
- ❑ Research the Problem
- ❑ Imagine: Develop Possible Solutions
- ❑ Plan: Select a Promising Solution
- ❑ Create: Build a Prototype
- ❑ Test and Evaluate Prototype
- ❑ Improve: Redesign as Needed

Engineering Design Thinking:
- ❑ Formulating Problems
- ❑ Seeking Solutions
- ❑ Thriving in Uncertainty
- ❑ Collaborating Constantly
- ❑ Prototyping Ideas
- ❑ Iterating Options
- ❑ Reflecting Frequently

1 — One question I have or an idea I would like to further explore is:

TeachEngineering.org — Making Sense Assessment — Brought to you by: Engineering

Students cleaning an oil spill

Students mixing dye in water

K-12 Curriculum Scheduled for Publication

- More than 30 K-12 activities focused on environmental engineering have yet to be published, including:

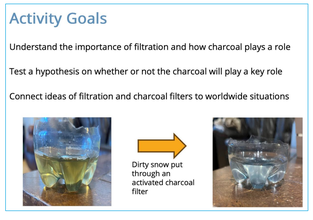
Charcoal, Charcoal Make the Water Sparkle

Activity Goals

Understand the importance of filtration and how charcoal plays a role

Test a hypothesis on whether or not the charcoal will play a key role

Connect ideas of filtration and charcoal filters to worldwide situations



Engineering students presenting their final K-12 designed curriculum to K-12 STEM mentor and design mentors.

The Power of pH and Plants

Methods
Following the completion of first day tasks:
- Make initial observations. Do the samples look different? What challenges can this create when trying to determine water quality?
- Hypothesize which in which pH's the plants will thrive.

Connections
The links to the outside world...
- Ocean Acidification
  - Increased CO_2 in the atmosphere leads to the pH of the ocean decreasing
  - Makes it harder for animals to build their shells
  - Bleaches coral reefs
- Pollution
  - Trash in water systems can leach chemicals into the water
  - Manufacturing processes sometimes dump chemicals
  - Many of these chemicals are toxic and can also cause other effects such as changing the pH

Ocean Acidification, Dolphinark — Climate Change, NOAA — Pollution, Earth.Org

Observations
When performing your experiment here are a few things to look out for:
- **Growth:** is the plant getting bigger or sprouting any new leaves
- **Color:** Has the plant yellowed or changed color
- **Damage:** Have any leaves began to wither or detach

Where observations should be recorded!

Future Work

- Classroom testing of the K-12 designed activities.
- Publishing the classroom tested activities on '*TeachEngineering.org*.'

Acknowledgments

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Reference:
[1] TeachEngineering, "*STEM curriculum for K-12—TeachEngineering*," Available: https://www.teachengineering.org/ [Accessed January 15, 2022].