

OIL CLEANUP

Team: The Spillage People

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Introduction

Grand Challenges

The Grand Challenges initiative from The National Academy of Engineering aims at motivating 20,000 potential engineers to prepare themselves to take on societal aspirations [1]. These aspirations include: personalized learning, solar energy, virtual reality, reverse-engineering the brain, better medicines, advanced health informatics, improved infrastructure, securing cyberspace, nuclear fusion, preventing nuclear terror, managing the nitrogen cycle, engineering the tools of scientific discovery, and providing access to clean water [1]. There exists a shortage of people in STEM (Science, Technology, Engineering, Mathematics) careers due to its growing importance in the 21st century. The Grand Challenges project attempts to curb this by focusing on younger generations. Hopefully, this strategy will cause students to become interested in learning more about STEM and pursue related careers.

Grand Challenge: Provide Access to Clean Water

Our group decided to focus on the “proving access to clean water” aspect of the Grand Challenges Project. We thought we could easily convey this idea to the children. Also, we felt that we could accurately represent this topic with a module that the kids would both enjoy and learn from. Both humans and the environment need clean water. All life relies on water in some way. Humans especially need clean water. Of course, people need to drink water to survive, but fishing, irrigation, sanitation, cooking, and recreation all necessitate a certain level of clean water. In some areas of the world, like Eastern Africa, people die from not having access to enough fresh water. As the basis for all life, access to clean water should get additional emphasis over the other aspects of The Grand Challenges Initiative. Solving this problem would greatly benefit the world, so we decided that we should teach this problem to the next generation.

Oil Cleanup

Specifically, we wanted to focus on oil spills. Oil spills make large amounts of water unusable for both humans and the environment. If a human ingests oil-contaminated water, they can face a slew of medical problems. Furthermore, oil contamination hinders irrigation, fishing, cooking, and recreation. Possibly more important, oil spills can devastate ecosystems. Our module will attempt to teach the students the importance of preventing oil spills by showing them how hard it is to remove oil from water. This module will meet many of the standards set by the Indiana

Science Standards as shown in appendix A. The module involves a fair test to help solve a real-world problem. Students will start with making predictions on the success of different materials and communicate on how to create and improve solutions. Also, students will complete follow-up questions and compare their results with that of different groups. The module will also allow students to use their creativity and the scientific method to engineer ways to remove the oil from water which will hopefully get them interested in STEM.

Technical Background

Humans need access to clean water for drinking, irrigation, and sanitation. However, humans only have usable access to 0.3% of clean fresh water [2]. In order to bolster the quality of life of humans, we must protect and expand access to clean, fresh water. Oil spills reduce the amount of usable water. This leads to a decrease in fishing, tourism, farming, and property value [3]. In areas where oil spills occur, the amount of drinking water available to the the people there drops greatly. Unfortunately, many of the areas in northern Africa already have problems with inadequate amounts of drinking water. Drinking water contaminated with oil or eating fish from contaminated water sources leads to cancer, respiratory problems, mental disorders, headaches, coughs, and severe skin/tissue conditions [4]. Preventing and cleaning oil from water supplies can reduce these issues. These negatives become compounded from the economical effects (especially in impoverished areas like northern Africa) of oils spills as well as the replacement of the oil lost [5].

Oil spills greatly impact the environment. In the months following the gulf BP oil spill, sea turtle strandings increased to more than six times average [56 The Exxon Valdez oil spill killed over 250,000 seabirds, 2,800 sea otters, 250 bald eagles, 300 harbor seals, and 22 killer whales [7]. Cleaning up an oil spills requires a painstaking process, so we should prioritize prevention.

Aside from the environmental costs, Oil spills present an enormous monetary loss for the company involved. Several private costs are involved, such as finding ways to stop the leak and prevent the spillage from growing, initial cleanup, and repairing any damage done to the oil rigs or pipelines. Additional external costs also arise from government agencies' cleanup efforts, loss of life or injury of workers, and lost income as a result of contaminating the water/land [8]. These internal and external costs can amount to several million and sometimes may reach the billion dollar range. The largest cost comes from "social costs", paid in fines, penalties, and other categories. From a recent spill concerning Exxon, social costs alone exceeded several billion dollars [8].

Activity Guide

Setup



Figure 1: Setup and Materials for the demonstration

Preparing the materials

1. To set up this activity, first place a drop-cloth over the table, as there may be a lot of spilling.
2. Next, place two empty plastic bins side by side on the table for each group (4 bins for 2 groups, 6 for 3 groups, 8 for 4 groups, etc.).
3. Split up cleaning materials (gloves, sponges, paper towels, handkerchiefs, cotton balls, and coffee filters) between each set of bins. Make sure there are at least one of each cleaning material for every group.
4. Fill up the 5 gallon bucket at least $\frac{3}{4}$ full with water, and have the corn oil, worksheets, measuring cup, and 2 oz. cup nearby, so that you are ready to use them once the activity begins.

Demonstration and Hypothesis

1. Begin by handing out the worksheets (and writing utensils if necessary) to the students.
2. Show the students the bucket with water, and inform them that this represents all the water on Earth.

3. Ask students how much water on Earth is fresh and accessible. Students can raise their hands to answer the question, and should also record their responses on the worksheet.
4. When students have sufficiently responded to the question, fill shot glass with water from the bucket. Compare the volumes of the shot glass and bucket, as this is the ratio of fresh/accessible water to total water, about 0.3%.



Figure 2: Visualization of the water on earth (5 gallon bucket) with fresh, accessible water (2oz blue cup)

5. Students can now look at and examine the cleaning materials. The students will guess which will work best and why, and record their hypothesis on the worksheet.
6. For each pair of plastic bins, fill one of them about $\frac{1}{3}$ full with the water from the bucket.
7. Mark water level with dry erase marker.
8. Now, add two cups of corn oil (use measuring cup) to each container with water.

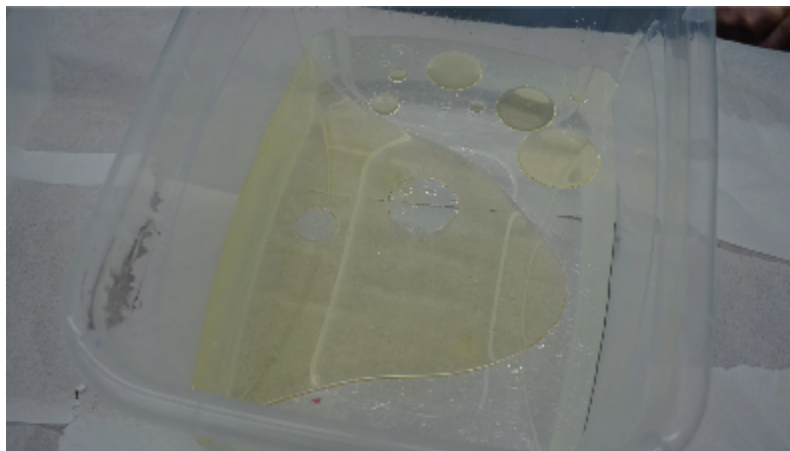


Figure 3: Oil settling on the surface of the water

9. Assign each group of students to a specific work stations. Students should put on the vinyl gloves before they get started.

Main Activity

1. Students will be given 10 - 15 minutes to remove the oil from their bin.
2. The cotton balls, coffee filters, and paper towels can be placed into the trash bin when full of oil.
3. The sponges and handkerchiefs can be wrung out over the trash bin and reused.
4. After 10 - 15 minutes, check the amount of oil in the student's bins. You will know the students are done when the water returns to its clear color with a thin glossy film of oil on top. (See Figure 4 below)

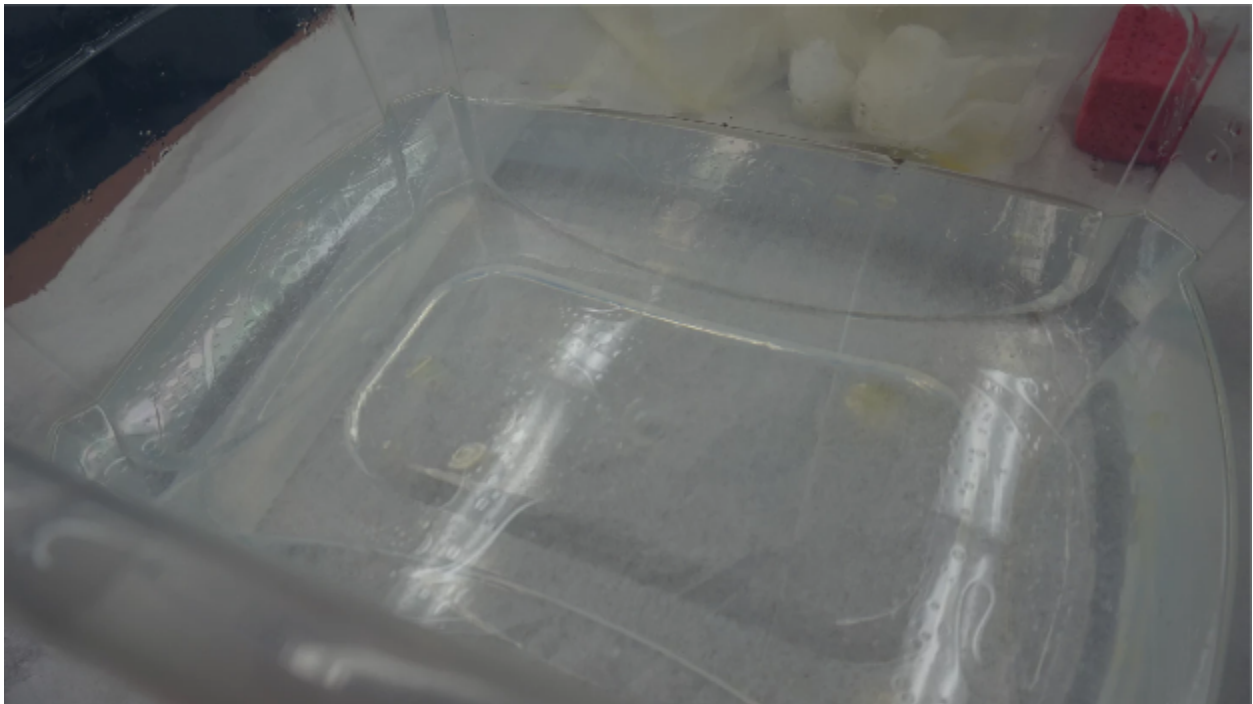


Figure 4: Example of what a tub looks like after the demonstration is concluded

5. Ask the students if they believe the oil could be removed completely. Use this to transition into a discussion about the importance of preventing oil spills.
6. Although the focus of the activity is not a competition between groups, the students will now want to walk around and compare bins.

7. Remind the students that even though removing oil is important, removing too much water can also be detrimental. Advise students to compare changes in water level between groups.



Figure 5: Observe the distance between the current water level and the original marking

8. Tell students to remove their gloves and finish the worksheet.
9. Discuss which materials worked well and why they worked well.
10. Lastly, have students brainstorm which other household materials would work well to remove the oil.

Cleanup

1. As mentioned above, students should place all used cotton balls, coffee filters, and paper towels in the designated trash container.
2. Any oil collected with the sponge or handkerchief should also be wrung out in the trash container.
3. At the end of the activity, the used gloves should also be placed in the designated trash container.

4. Upon completion of the activity, all the used oil pickup materials except for the handkerchiefs and sponges should be carefully disposed of in a nearby trash can.
5. The remaining oil and water can be disposed of by dumping it into the main discard tub and then down a nearby sink or toilet. It is recommended to pour the oil and water down the toilet to avoid leaving an oil residue behind in the sink.
6. Clean the plastic tubs and 5 gallon buckets with soap and water. This will insure that any of the oil remaining in the tubs or buckets will be properly remove.
7. Wash the handkerchiefs in the washing machine to remove the oil on them.
8. Wash the sponges with soap and water and leave to dry.
9. Store the clean materials for future use.

Materials and Costs

The materials and prices listed below accommodate 6 groups with each group containing 2-3 students. These amount of materials can change to accommodate many different class sizes. Some of the materials such as paper towels and gloves might not contribute to the overall cost if they already exist in the classroom. These prices are based on store costs from Meijer's. This is a good location to buy all the supplies for a good price.

Vinyl Gloves (100 ct.)	\$5
Cotton Balls (100 ct.)	\$2
Paper Towels (6 rolls)	\$6
Sponges (2 large)	\$6
Handkerchiefs (10 ct.)	\$5
Coffee Filters (100 ct.)	\$1
Corn Oil (1 Gal.)	\$9
Plastic Tubs (6 ct.)	\$15
5 Gallon Bucket (x2)	\$6
Total	\$55

Documentation

[1] Engineeringchallenges.org, "Grand Challenges - Provide Access to Clean Water", 2016. [Online]. Available: <http://www.engineeringchallenges.org/challenges/water.aspx>. [Accessed: 14- Jan- 2016].

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[6] Nwf.org, "Oil Spill Impacts on Sea Turtles - National Wildlife Federation", 2016. [Online]. Available: <https://www.nwf.org/What-We-Do/Protect-Habitat/Gulf-Restoration/Oil-Spill/Effects-on-Wildlife/Sea-Turtles.aspx>. [Accessed: 14- Jan- 2016].

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Appendix A - Science Standards for Grade 5

The Design Process:

As citizens of the constructed world, students will participate in the design process. Students will learn to use materials and tools safely and employ the basic principles of the engineering design process in order to find solutions to problems.

- Identify a need or problem to be solved.
- Brainstorm potential solutions.
- Document the design throughout the entire design process.
- Select a solution to the need or problem.
- Select the most appropriate materials to develop a solution that will meet the need.
- Create the solution through a prototype.
- Test and evaluate how well the solution meets the goal.
- Evaluate and test the design using measurement.

Indiana's Academic Standards for Science-2010

Appendix B - Student Handout

OIL CLEANUP

Out of all of the water on Earth, what percentage do you think is fresh and accessible?



Which of the five household materials below do you think will clean up oil the best? (Circle one)

Cotton balls Handkerchief Sponge
Coffee filter Paper towels

Why do you think that material would work better than the others?



Each of the five materials will be passed out to you now. Try to Remove the oil from your tub with each material.

Which material worked the best?

Why do you think this material worked the best?

What other household materials do you think would work well to remove oil floating on water?