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| **Lesson Title :** Engineering Design Challenge | **Unit #:**  **1** | **Lesson #:**  **2** | **Activity #:**  **3** |
| **Activity Title:** Copper Filtration Challenge |

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| **Estimated Lesson Duration:** | 8 days |
| **Estimated Activity Duration:** | 4 days |

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| **Setting:** | Classroom |

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| **Activity Objectives:**   1. Students will be able to list the steps of the Engineering Design Process. 2. Students will be able to defend their design based on evidence. 3. Students will be able to communicate results effectively. 4. Students will be able to develop a redesign strategy. |

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| **Activity Guiding Questions:**   1. What materials will uptake copper most effectively? 2. Does the order of materials affect the filtration of copper? 3. How does dilution affect copper concentration? |

| **Next Generation Science Standards (NGSS)** | |
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| **Science and Engineering Practices (Check all that apply)** | **Crosscutting Concepts (Check all that apply)** |
| Asking questions (for science) and defining problems (for engineering) | Patterns |
| Developing and using models | Cause and effect |
| Planning and carrying out investigations | Scale, proportion, and quantity |
| Analyzing and interpreting data | Systems and system models |
| Using mathematics and computational thinking | Energy and matter: Flows, cycles, and conservation |
| Constructing explanations (for science) and designing solutions (for engineering) | Structure and function. |
| Engaging in argument from evidence | Stability and change. |
| Obtaining, evaluating, and communicating information |  |

| **Ohio’s Learning Standards for Science (OLS)** |
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| **Expectations for Learning - Cognitive Demands (Check all that apply)** |
| Designing Technological/Engineering Solutions Using Science concepts **(T)** |
| Demonstrating Science Knowledge **(D)** |
| Interpreting and Communicating Science Concepts **(C)** |
| Recalling Accurate Science **(R)** |

| **Ohio’s Learning Standards for Math (OLS) and/or**  **Common Core State Standards -- Mathematics (CCSS)** | |
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| **Standards for Mathematical Practice (Check all that apply)** | |
| Make sense of problems and persevere in solving them | Useappropriate tools strategically |
| Reason abstractly and quantitatively | Attendto precision |
| Construct viable arguments and critique the reasoning of others | Look for and make use of structure |
| Model with mathematics | Look for and express regularity in repeated reasoning |

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| **Unit Academic Standards (NGSS, OLS and/or CCSS):** |

**Ohio’s New Learning Standard: Science Inquiry and Application (p. 228):**

During the years of grades 9 through 12, all students must use the following scientific processes with appropriate laboratory safety techniques to construct their knowledge and understanding in all science content areas:

* Identify questions and concepts that guide scientific investigations;
* Design and conduct scientific investigations;
* Recognize and analyze explanations and models;
* Communicate and support a scientific argument

**Ohio’s New Learning Standards (ONLS) Content Elaboration: Cells (p. 295):**

* Most cells function within a narrow range of temperature and pH. At very low temperatures, reaction rates are slow. High temperatures and/or extremes of pH can irreversibly change the structure of most protein molecules. Even small changes in pH can alter how molecules interact.
* A living cell is composed of a small number of elements, mainly carbon, hydrogen, nitrogen, oxygen, phosphorous and sulfur.

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| **Materials**: (Link Handouts, Power Points, Resources, Websites, Supplies) |

* Copper chloride (0.5 g per 1000mL)
* Printer Paper
* Construction Paper
* Various screen material
* Nylon
* Walnut shells
* Wood chips
* Paper Towels
* 2-Liter Bottle tops (cut the top of the bottle)
* Beakers
* Tape
* Storage containers
* Foil
* Soil

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| **Teacher Advance Preparation:** |

**Day 11**

* Set out all materials for design challenge

**Day 12**

* Set out all materials for design challenge

**Day 13**

* Set out all materials for design challenge

**Day 14**

* None

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| **Activity Procedures:** |

**Day 11: Design Challenge Preliminary Planning**

1. Set out supplies for students to begin brainstorming how to build their copper container.
2. Make sure each student has a copy of the EDC worksheet to students (1.1.3a).
3. Allow students half the class to gather information they feel they need for their design challenge. Students may use computers, books, etc.
4. Have each student group create three drawings for how they can test the water runoff concentration and how they plan to contain their copper.
5. Check off student models before allowing students to begin building.

**Day 12: Design Challenge Build & Test**

1. Give students the majority of the class time to build their testing system, as well as their copper container.
2. With 15 minutes left in class, walk around and pour 200 mL of water into the system. Have students collect the water runoff and test with copper-testing strips. Make sure students are recording their data.

**Day 13: Design Challenge Redesign & Retest**

1. Have students evaluate their current design as a group and draw out how they will redesign to achieve better results (check students before allowing them to build).
2. Put out all container supplies this time in order to stimulate new ways students can contain their copper as new material becomes available.
3. When students complete their container, let the class know that before this test there will be an “Earthquake” and their container will be shaken before the test.
4. Test the designs and ensure that students are collecting water samples and testing for copper after each test.

**Day 14: Informal Presentations**

1. Have students move their desks into two circles (two groups) that are heterogeneously mixed with students (i.e. do not but all the same lab group together—they should separate).
2. Give students 10 minutes to prepare for a 3-minute speech discussing the success of their design and defense on whether or not this filter is appropriate for protecting the city.
3. Allow each student (individually) time to communicate their results.
4. Ask each student to complete a peer-feedback form (1.1.2j).

**Formative Assessments:**

* Observations as students build their design.
* Student designs
* Peer-feedback form

**Summative Assessments:**

* None
* Peer-feedback form
* Student communication
* Rubric for EDP

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| **Differentiation:** |

* Limit some groups to only 2 additional supplies to make it more challenging.

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| **Reflection:** Reflect upon the successes and shortcomings of the lesson. |

**Days 14-17**

*Revisions to Lesson*- There were only minor revisions to this lesson. The first revision is in regards to the material. The copper powder did not dissolve in water therefore was not detectible with the copper testing strips. Instead of copper power, 0.5 grams of copper chloride was dissolved in 1000 mL of water. This accounts for the maximum copper concentration that the testing strips can detect (5mg/L); therefore, any uptake of copper from the water source will show in the final test. Another revision made to the lesson was reducing the town hall meeting into a one-day presentation. Students informally presented their design and discussed how effective their design was for protecting human cells. Almost all groups were successful with their design; therefore, a formal presentation did not seem necessary.

*Successes*- The design challenge itself was a huge success. Students saw a reduction in the amount of copper after the solution was poured into their filtration system. There was also variety in the results which was very exciting. This allowed from some great discussion about ways to improve the design. The informal presentation was an effective way to summarize the design challenge. Additionally, the engineering design challenge packet was a great tool for students. This packet walked students through each step of the process and prevented them from just jumping right into building the filter.

*Shortcomings-*Some students took a dilution approach to purifying the copper; however, copper still was present in the landfill system. Next year I will phrase the challenge to be “purify an environment of copper” in order to prevent students from using this loophole. Regardless, this failure did spark some very good discussions. Next year, I will also allow students to experiment with individual materials. We did not have enough testing strips to do this, yet I feel this is necessary because it allows students to make informed decisions about materials beyond the internet. Lastly, the redesign was difficult considering trace amounts of copper were in the filtration system. A whole new system was needed which took a lot of supplies and set-up. Next year, I will not be doing the redesign and will just have students brainstorm.