Types of Engineering: Lesson 2

Water Filtration
Environmental Engineering

Overview

Students will construct a small slow sand water filter and evaluate its performance by conducting a turbidity test on the filtered water. Students will also have to build a LEGO structure to support their filter while holding it over a collection cup. A sample holder, filter and collection cup are shown below:

Goals	Expectations	Evidence
Students will understand: • What an environmental engineer does. • Water filtration.	Students should be able to: • Build a sturdy water filter. • Explain how their filter removed dirt particles.	Evidence of learning found in: • Water filters that result in cleaner water. • A class discussion water pollution and filtration. • *Environmental Engineering* worksheet.

Lesson 2

Water Filtration

Suggested Time

One 45-60 minute session

Vocabulary

Light Sensor

Slow Sand Filter

Turbidity

Water Quality

Materials

For each student:

- *Environmental Engineering* Worksheet

For each student pair:

- Small LEGO kit (~20 beams, friction pegs, bushings)
- 2 clear plastic cups (one with the bottom cut off for filter)
- 1 sq ft cheese cloth
- 2 rubber bands
- ½ c. gravel
- 2 coffee filters
- 10 cotton balls

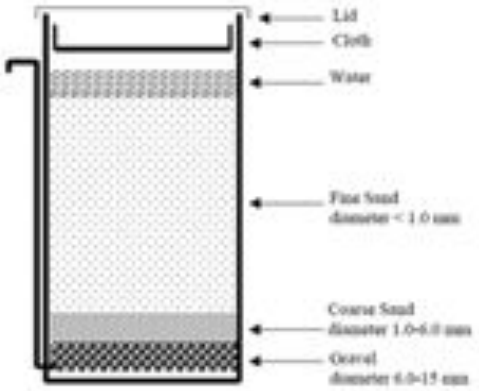
For classroom:

- Dirty & Clean Water (for testing)
- RCX/NXT light sensor
- RCX/NXT

Background

Environmental engineers design water filters. In addition to designing systems that clean water, environmental engineers design systems that clean air and land so that the earth remains a habitable place for humans.

The type of water filter that students will construct in this lesson is known as a **slow sand filter**. In this type of filter dirty water is run through a column of gravel and sand and results in clean water. This kind of filter requires no chemicals or electricity; however, the filtration process is slow. Slow sand filters are designed so that the coarsest particles (e.g. rough gravel) are at the bottom of the filter while the smallest particles (e.g. fine sand) are at the top. See diagram below:



http://rael.berkeley.edu/old-site/workshops/disinf_SSF.bmp

Water quality is an assessment of how dirty or clean water is by the characteristics such as dissolved oxygen content or pH. In this activity, we will evaluate water quality based on **turbidity**: the cloudiness or haziness of a fluid caused by small suspended particles that are generally, though not always, invisible to the naked eye.

Students will conduct a turbidity test by placing their filtered water sample in a clear cup and measuring it with an NXT/RCX **light sensor**. Since the light sensors can detect reflected light, this box will measure the amount of light that is allowed to pass through the water. The suspended particles reflect light and do not let light pass through the sample. The more reflected light the sensor detects, the dirtier the water.

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Preparation

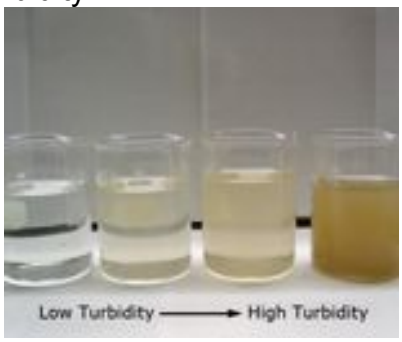
- Arrange students in groups of 2-3.
- Distribute worksheets and construction materials.
- Prepare a pitcher of dirty water (e.g. water w/dirt, mulch, etc).

How do I use the RCX light sensor?

Attach the light sensor to *Port 3* on the RCX and turn the RCX on. Place the cup about 1/8 inch away from the light sensor, and hit the "View" button on the RCX three times (i.e. until the arrow is pointing to *Port 3)*. Read the value to the left of the person on the RCX screen.

Note: *The light sensor is not very sensitive, therefore the light sensors values will not vary greatly. Dirty water might have a value around 40 while clean water has a value around 48.*

Water Increasing in Turbidity:



http://www.fondriest.com/images/science_library/turbidity_sensors.jpg

Instructions

Preparation: Building a Turbidity Tester 5 Minutes

To build the turbidity tester, wire a light sensor to one of the ports on an NXT/RCX brick. On the RCX you can view light sensor values by pressing the view button until a small triangle is pointed at the port the light sensor is wired to. On the NXT use the key pad to scroll to the menu that shows sensor values. Select the light sensor and the port that it is wired to.

PART I: Introduction to Water Filtration 10 minutes

1. Ask students if they know what environmental engineer does.
2. After a brief discussion, explain that the job of an environmental engineer is to design systems that clean air, land, and water. Give examples such as, cleaning an oil spill in the ocean, or figuring out what to do with nuclear waste.
3. Tell students that one way that environmental engineers design water filters to clean water.
4. Introduce the specific example of a **slow sand filter** as a means of improving **water quality**.
5. One way to test the quality of water is by measuring **turbidity**, the amount of suspended solid particles in the water.
6. Show students the turbidity tester they will be using for this activity. Explain that the light sensor is used to test for turbidity because it detects how much light is reflected from a surface. Place a clean water sample and a dirty water sample in the turbidity tester, run the NXT/RCX to read the light sensor reading and compare the results. This data should be the two extremes (i.e. the class' values should lie between these two points).

PART II: Constructing the Filters 30 minutes

1. Explain to students that they will be constructing their own water filters and testing their filtered water using the RCX light sensor.

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Water Filtration

Real World Connection

You may have seen water filters in your own home in the form of activated carbon filters on sinks or in pitchers in your refrigerator. However, even before you filter the water yourself, all tap water is first treated in a very large "water filter". Water treatment plants remove all toxins and visible particles from dirty water so that when it reaches your tap, it is clean enough for you to drink.

2. Tell students that they must also build a structure to support their filter so that water can be poured through the filter and be collected in a sample collection cup below.
3. Have students fill out the first question on their worksheets and design their filters. Have students label their designs
4. When an instructor has approved a design, allow students to begin building their filter and LEGO supportive structure.

PART III: Testing the Water — 10 minutes

1. As students finish their construction, allow them to test their design:
   - Students should pour approx. 2/3 cup of dirty water through the filter.
   - Students should test their clean water sample in the turbidity tester and record their clean water value on their worksheets.
2. Keep track of each groups value on the board for comparison.

PART IV: Discussion and Observation — 10 minutes

1. Ask students to share their filter designs.
2. Discuss differences in design and the resulting light sensor values.
3. Tell students about the typical design of slow sand filters in which the largest filter particles (e.g. gravel) are on top and the finest filter particles (e.g. sand) are on the bottom. Why this might this make an effective filter?

Extensions and Modifications

Collect the class' data and create a bar graph on the board. Plot the clean and dirty test values as well and see whether most of the filters are closer to the clean or the dirty water value.

Sample Projects and Photos

The RCX light sensor (attached at Port 3) reads a value of 40 for the dirty water. A previously taken reading of 48 is displayed for the clean water.