Design A Filtration System

Name: Carlos Perla
Grade level: 4th
TOPIC of lesson: Earth materials and ground water

Rationale: *(Why have you developed this lesson? Where does it fit in your curriculum? What student/curricular need are you meeting?)*

This lesson is designed to help students understand that role that water plays in shaping the earth. This involves the processes of erosion, deposition, and weathering. This is directly connected to how water interacts with various earth materials. In this activity, students investigate different methods for removing pollutants from water using the properties of how water interacts with those materials. This interaction creates a source of water known as ground water. This same process is how water is also able to breakdown larger rocks into smaller ones, through water penetration and freezing.

After being exposed to the problem of the lack of clean water around the world, the students will be tasked with designing and building their own water filters, mimicking Earth processes, to help provide solutions to this problem.

Learner Analysis

Student Characteristics

Students will be coming in with a good science foundation as STEM is an integral part of the school. There are students who may not excel in certain aspects of science and these characteristics will be determined through prior projects geared towards showing the proper elements of experimentation, data collection and analysis, and drawing conclusions for application. As students are evaluated in these aspects, lessons will be designed to address these areas and students will be put into science groups where students' strengths and weaknesses are complemented. This ensures that every student has the opportunity to learn from other members of the group.

Common Misconceptions and Preconceptions

Misconceptions	Methods to Address
1. Ground water exists in large caves underground. 2. There is no water in the desert. 3. All dirt is the same. 4. When something is full, nothing more can fit. 5. Rivers passively flow over the land.	1. After studying properties of materials, build an aquifer model to see how those properties allow water to exist underground. 2. Through building of aquifer models, deeper analysis will take place to describe where water from rain goes in the deserts. 3. Analysis of earth material separation and looking at samples from different regions will show that composition of SOIL is different in different regions. 4. Although something appears full, the pore space between particles can still be filled. 5. Investigations involving water speed will display elements of erosion that carve the landscape.

Objective:

- Identify the pollutants in a water sample using sight and smell.
- Explore how material created through Earth process can filter water in aquifers.
- Design, build and test a water filtration system.
- Understand the role of engineers in water treatment systems.

State Curriculum Standards:

S4C2PO3: Describe the role that water plays in the following processes that alter the Earth's surface features: • erosion • deposition • weathering

S4C3PO1: Identify the sources of water within an environment (e.g. ground water, surface water, atmospheric water, glaciers).

S2C2PO2: Describe the interaction of components in a system (e.g., flashlight, radio).

K-ESS2-2: Construct an argument supported by evidence for how plants and animals (including humans) can change the environment to meet their needs.

4-ESS2-1: Make observations and/or measurements to provide evidence of the effects of weathering or the rate of erosion by water, ice, wind, or vegetation.

5-ESS2-2: Describe and graph the amounts and percentages of water and fresh water in various reservoirs to provide evidence about the distribution of water on Earth.

MS-ESS2-4: Develop a model to describe the cycling of water through Earth's systems driven by energy from the sun and the force of gravity.

3-5-ETS1-2: Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.

3-5-ETS1-2: Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.

3-5-ETS1-2: Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.

Instructional Strategies*: (direct instruction, inquiry-based, discussion)*

Direct Instruction: Direct instruction will occur during language arts small groups as articles relating to the content are introduced and dissected using Key ideas and Details as well as the Craft and Structure of the articles themselves.

Direct instruction will also occur in math as differing methods for data collection and representations are explored.

Inquiry-based: The data collection process and investigation of Earth properties will all be inquiry based. Students will pose their own ideas through Model Based Inquiry, by creating pictures of how they perceive things to be. They will then proceed to investigate their ideas and pose questions on how the information they collect will serve to solve the problem they are faced with.

Discussion: Due to the fact that students will not have all the data for all materials at their disposal, discussion will be a key element in collecting the information that they are lacking through their investigations. Only through thoughtful discussion will new information and ideas be obtained to improve on their designs.

Materials: *(necessary hands-on items for use by teacher and students)*

Each group should have:

- 1 copy of the Data Collection Worksheet set
- 1 2-liter bottle that is cut in half
  - The bottom half should have a mark at 100 ML
- 1 3-5 inch square piece of mesh material. Screen or fine fabric will work well.
- 1 spoon
- Time measuring device such as a stop watch

For groups to share:

- Filter materials:
  - Coffee Filter
  - Cotton balls
  - Sand
  - Humus (potting soil)
  - Small gravel
  - Pebbles (approximately 1-2 inches in size)
- Measuring cups
- Dirty Water.

Resources: *(books, articles, website URL's)*

Learn about Acid Rain
http://www.epa.gov/acidrain/education/site_students/index.html
Learn about Water Pollution
http://eschooltoday.com/pollution/water-pollution/types-of-water-pollution.html
Articles on aquifers
http://education.nationalgeographic.com/education/encyclopedia/aquifer/?ar_a=1
Interactive Build Your Own Aquifer
http://www.epa.gov/ogwdw/kids/flash/flash_aquifer.html
Interactive Water Plant
http://www.fcwa.org/education/the_plant/index.html

Activities: *(What will the teacher/students do?)*

Data Collection

- Divide the students into groups of 4.
- Distribute Group Roles and allow students to assign roles.
- Distribute a Data Collection Worksheet set to each group.
- Have a discussion about water and how often we worry about it. Show a clip of a video of the problems with clean water around the world. There are many that show the effects of dirty water on children. Dirty water is the number 1 cause of death for children under 5 around the world. For people, without access to clean water, could there be a solution to the problem using natural materials? Can we replicate whatever process the Earth uses to filter water, as evidence by water from wells? The important factors in this filtering will be time (how long it takes to filter), and clarity (how clean the water is).
- Provide students with 2-liter bottle, sample of dirty water drank around the world, and one filter material.
- Ask each students to collect data on the water on their data collection sheets.
- Have students discuss their filter material and what effect it may have on the dirty water. Students will make a prediction on their data sheet.

- Students will then test their filter by putting it in the inverted top of the bottle. The bottom part of the cut plastic bottle will be used to collect the water.
- Students will stir their dirty water and pour the contents into their filters. This first pour will be a sample so they can get "feel" for how the process will work. They are looking to collect a 100 ML sample of "filtered" water.
- After sample pour, Procedures Manager will prepare to time. When materials are reset, time is started and water is poured into filter. When 100ML sample is reached, time is called and recorded. It is ok of the sample exceeds 100ML as long as the time for 100ML is recorded. Students will then classify the water's clarity on 5 point scale.
    - 1: Water looks practically the same (all materials are still in it)
    - 2: Larger materials have been removed
    - 3: Larger and medium size material (small rocks and sand) have been removed
    - 4: Most material has been removed but still cloudy
    - 5: Water is mostly clear
- This process should be repeated several times to collect multiple data points.
    - After all the groups have collected their data, share the results as a class.
    - Have students analyze all the data and determine if they have any questions that might require additional testing of a material. If so allow time for those groups to test a material further. Share that data with the class as well.
    - Students will then be assigned the task of using the data to determine what the best design for a water filter will be that will both: filter quickly and provide adequate clarity.

Engineering Design

- Students will design a filtration system and document its rationale in their data collection sheets.
- Students will then build a prototype of their filters and include pictures in their collection sheets.
- Students should be given a deadline for final submissions. Until the deadline, they continue to refine their designs.
- Students should then collect data on their final design's water filtration. They should draw their final version and results of the water before and after.
- Students will compare their data with other groups.
- After all the groups are finished, label and line up the samples. Ask each group to present their filter system to the class. Have a class vote and discussion about which water is the cleanest and why.

Extensions: *(Possible additional activities, follow-up lesson ideas, websites)*

- Have students measure how much water is captured by the filters by comparing what they put in to what they got out. Can they explain why it wasn't the same? Is this the same for every attempt, or it is worse for the first filtration attempt? Why is this?
- Use microscopes to allow students to student the dirty water and the filtered water. What differences do they see? Why would some similarities exist despite filtration?
- Experiment with different order of materials.
- Experiment with other materials for filtration.

Special Education Accommodations & Modifications: *(not known, of course, until you are teaching your classes)*

For students who might find this too complex, try this activity as a demo with only a couple of filter choices. Do each filter type individually and then ask the students to predict what will happen when you use both of the filter types together. Ask the students to draw pictures of the results.

Assessment: *(How will you determine if students have met your objectives? How will you know what the students have learned? Incorporate formative as well as summative assessments.)*

Pre-Activity Assessment: Collection

Picture Drawing: Ask each student to draw a picture of their group's "polluted water" in the space provided on their Data Collection Worksheet.

Prediction: Ask students to write down a prediction for what they think their particular filter material will do in the space provided on their Data Collection Worksheet.

Recorded Observations: Ask students to stir the solution and record their observations on their Data Collection Worksheet.

Pre-Activity Assessment: Design

Picture Drawing: Ask the students to draw a picture of their best water filter in the space provided on the Data Collection Worksheet.

Activity Embedded Assessment: Collection and design

Recorded Observations: Students should observe and record what happens during the filtration process.

Picture Drawing: Have students draw a picture of the filtered water in the space provided on their Data Collection Worksheet.

Post Activity Assessment: Collection

Data Recording: After all the groups have collected their data, share the results as a class (fill in the information on the transparency or chart you made earlier). Students should record all groups' results in the Class Data Section on their Data Collection Worksheet as well. Googleforms work well for students to enter data as they experiment. The results can then be shared with class.

Filtration Design Project: Ask students to work in their engineering design groups to design the best water filter system given the filter choices. There is space provided on their Data Collection Worksheet for them to record and explain their choices.

Post Activity Assessment: Design

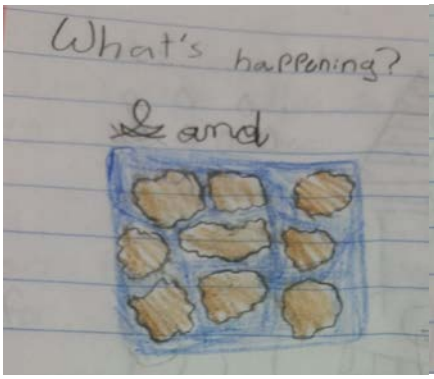
Worksheet: Have students complete the discussion questions on their Data Collection Worksheets and compare answers with a group member.

Engineering Presentations: Ask each group to present their filter system to the class. Have a class vote and discussion about which water is the cleanest and why.

Reflection:

The lessons went off extremely well. We had covered content from the STC Land and Water kits. These lessons help to set the foundation for this STEM activity. The students had the content, but were not sure what ground water actually was other than that it came from the ground. They had the knowledge but lacked the understanding. This was evident from their illustrations, even after the lessons.

From the image included, many students continued with the idea that ground water came from actual rivers that are underground, or a view that there is some sort of an ocean under the ground that is tapped into to get water.



Student illustrating ground water as rivers underground.

After going through these lessons and investigating the different properties of the materials and seeing the water seep through the materials, they came to understand exactly what is happening in the soil. When asked to re-examine their ideas of where the water is in the ground, it was no longer rivers and oceans underground, but rather that the water existed within the pore spaces of the material. The following illustrations show this new level of understanding:

Student representation of where water exists in the ground.

This understanding lead to the breakthrough that this must be how the Earth filters water. Only the water is able to get through and eventually all the "dirty" particles in the water are eliminated. Based on this concept, they explored the different properties of Earth materials in filtering.

Each material had it's own properties and by building on the properties together, they were able to design filters that could do a decent job of cleaning really dirty water.

The sample of water that were used to filter were what might be pulled from a water hole in a remote area. The challenge was to clean this so that it could then be boiled and drank safely.

The designs varied and each had its own positives and minuses. In the end many students were successfully able to create filters that did a decent job of cleaning particulate levels in water to an extremely low amount compared to the original content.

Filter in action.

Before and after filtration.

Overall, the lesson did a good job of getting
students to a conceptual understanding of how water interacts with the Earth materials. These interactions is what causes aquifers to form and even explains the fracturing of larger boulders into smaller rocks. This connection was made very easily as they easily recognized that the "water gets into the pore spaces of the rock and freezes, breaking it into smaller pieces."

Students building a water filter

Students testing filtration properties of course sand.

Students building a water filter

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Team Members: _____ **Date:** _____

_____ _____

Design a Filtration System –
Data Collection Worksheet

Description of the polluted water before treatment

A picture of our polluted water	Observations of our polluted water

Filter material being tested:_____

What do you predict this material will do?_____

_____

_____

_____

Why do you think this will happen?_____

_____

_____

_____

Team Members: _____ **Date:** _____

_____ _____

A picture of our filter system

Description of the filtered water after treatment

A picture of our filtered water	Observations of our filtered water

Results

TEST NUMBER	Time to collect 100ML	Water Clarity (Scale1-5)
Test 1		
Test 2		
Test 3		
Test 4		
Test 5		

Water Clarity Scale

1. Water looks practically the same (all materials are still in it)
2. Larger materials have been removed
3. Larger and medium size material (small rocks and sand) have been removed
4. Most material has been removed but still cloudy
5. Water is mostly clear

Team Members: _____ **Date:** _____

_____ _____

Class Data

Type of treatment	Time to Filter 100ML	Water Clarity (1-5)
MESH FILTER ONLY		
COTTON BALL FILTER		
FILTER PAPER		
SAND FILTER		
SOIL FILTER		
GRAVEL		
LARGE PEBBLES FILTER		

We need to collect addition data on the following filter material:_____

Questions we hope to answer by further research on this material:_____

_____

_____

_____

Team Members: _____ **Date:** _____

_____ _____

Plan for the Best Water Filter

We will use (material) _____ in our filter because _____ _____

_____

_____

We will use (material) _____ in our filter because _____

_____

_____

We will use (material) _____ in our filter because _____

_____

_____

We will use (material) _____ in our filter because _____ _____

_____

_____

We will use (material) _____ in our filter because _____ _____

_____

_____

We will use (material) _____ in our filter because _____ _____

_____

_____

Team Members: _____ **Date:** _____

_____ _____

Design a Filtration System –

Design Worksheet

A picture of our best water filter setup

Team Members: _____ **Date:** _____

_____ _____

Description of the filtered water after treatment

A picture of our filtered water	Observations of our filtered water

Questions

Did your filter work as you expected it to? Explain why or why not.

_____

_____

_____

_____

_____

_____

_____

_____

Do you think the filtered water is clean enough to drink? Explain why or why not.

Team Members: _____ **Date:** _____

_____ _____

_____

_____

_____

_____

_____

_____

List some ideas for ways you might be able to improve on your design.

_____

_____

_____

_____

_____

_____

Based on what you learned, illustrate how the planet's aquifer systems filter ground water and how water can exist underground.

Science Group Roles

Data Manager

- Keeps notes for absent members
- Completes group lab notes (as necessary)
- Reports group data for class data
- Combines with Leader if only two members in the group

Team Manager

- Keeps group members on task
- Keeps track of time for group tasks
- Assigns additional jobs as needed
- Serves as the speaker for the group
- Asks teacher for help as necessary for the group

Materials Manager

- Gets materials for lab activities
- Returns materials for lab activities
- Reports broken or missing equipment to teacher

Procedures Manager

- Determines procedures for lab activities
- Assigns steps of procedures to group members
- Makes sure everyone gets to participate in lab activities
- Assists Materials Manager in getting/returning materials as needed by Materials Manager
- Combines with Materials Manager if only 3 members in the group