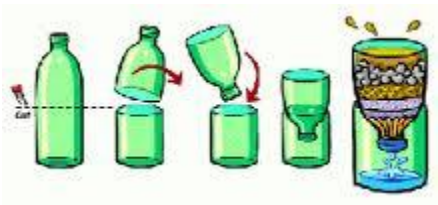
Grade 3 STEM DESIGN CHALLENGE
CORRESPONDING DESIGN LOOP STAGE IN RED

Unit 5: Natural Resources
Topic: Designing a Water Filter with Natural Resources
Subject/ Grade level: STEM/ Grade 3

Materials

For teams of 2-3 students



- 2 half-liter plastic water bottles with the bottom 2-3 cm / one inch cut off. This creates a "funnel" piece and a base for students to use.
- 1- 2L bottle to hold the "dirty" water (recipe below)
- Cheesecloth
- Window screen
- Plastic wrap
- Container for filtered wastewater, such as a clear plastic bowl
- Scissors
- Cotton balls
- Coffee filters
- Soil
- Gravel
- Rocks
- Sand, oil, dust, hair, salt, and other common things to dirty the water
- Food coloring (a few drops)
- A bucket for collecting dirty water
- Clean water in container
- Paper towels for cleanup
- Stopwatches or timers
- Handouts
  - "Cleaning Dirt"
  - "Cleaning Water Activity"
  - "NASA Water Filter"
  - "Build a Water Filter"
  - 21 Century Skills rubric to grade project
- Websites
  - http://www.youtube.com/watch?v=lV80p24QYjk
  - http://www.pbslearningmedia.org/resource/ess05.sci.ess.earthsys.waterfilter/earth-water-filter/
  - http://pbskids.org/zoom/activities/sci/waterfilter.html
  - http://pbskids.org/zoom/activities/sci/waterfilterpartii.html
  - http://tryscience.org/nld/handson2.html
  - http://pbskids.org/zoom/activities/sci/solarstill.html
  - http://www.thefactsaboutwater.org/correct-the-record/tap-and-bottled-water-are-both-regulated-get-the-facts
  - http://www.bbc.co.uk/schools/scienceclips/ages/7_8/characteristics_materials_fs.shtml

Recipe to Make "Dirty" Water:

- Measure the dry materials and place in the 3rd 2L bottle one at a time. Use oil, dust, sand, hair, salt, and other common things you can find.
- Add enough water to make 3 cups.
- Add 1–2 drops of food coloring.
- Stir to mix.

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(**Teacher Note:** Simulated wastewater will take approximately 15 minutes to make. Each team will need about 237 mL (a cup) of the wastewater. Thus, a 2-liter supply should be enough. Remind students not to taste the water.)

TEKS
Science
*ⓈSCI 3.7D Explore the characteristics of natural resources that make them useful in products and materials such as clothing and furniture and how resources may be conserved.

Ⓟ SCI 3.2B Collect data by observing and measuring using the metric system and recognize differences between observed and measured data.

Math
Ⓟ MATH 3.1A Apply mathematics to problems arising in everyday life, society, and the workplace.
Ⓟ MATH 3.1E Create and use representations to organize, record, and communicate mathematical ideas.

ELPS
C3D Speak using grade-level content area vocabulary in context to internalize new English words and build academic language proficiency
C5B Write newly acquired basic vocabulary and content-based grade level vocabulary

CCRS
Science
10D2 Understand the types, uses, and regulations of the various natural resources.
10E5 Understand how human practices affect air, water, and soil quality.

Math
9C2C Construct and use graphic organizers (e.g., tables, bubble maps, Venn diagrams, and tree diagrams).
10B1C Connect mathematically created tables, graphs, and functions to fit real life situations.

Cross-disciplinary
1C3D Present the collected data visually, describe the data collection procedure, and defend choosing that procedure over other possibilities.
1E2C Work in small groups to investigate a problem or conduct an experiment.

Lesson objective(s):
Students will design and create a water filter that capitalizes on the useful characteristics of natural resources.

Differentiation strategies to meet diverse learner needs:
- Implement flexible groups, such as mixed-ability or pairs, during the engineering design process activities.
- The teacher should adjust the pacing (break into smaller units) and/or scaffold activities for students as necessary.
- Provide several opportunities for students to repeat and explain directions as necessary.

IDENTIFY NEED
Introduce the design challenge in a fashion similar to the following: *"How is water purified? In nature, water filters through soil, rock, sand, gravel, and other layers before it gets to a well. Humans use filters, too. You can buy water filters for your drinking water for use in your kitchen or when you go camping. If you had to design a water filter, what issues would you need to think about?"*

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CORRESPONDING DESIGN LOOP STAGE IN RED

Design Task:
Tell the students, *"Your task will be to design and build a water filtration device using commonly available materials. To meet this challenge, you will test and measure the performance of your filtration device, analyze the data collected, and use this information to create an improved filter design." "Be prepared to discuss the process as you go along, and go back and redo it as you discover better ways to filter water."*

Formative Assessment (in design logs):
In teams, have students discuss the design problem and then write it in their own words in their design logs. An example writing prompt could be, "Explain the design problem in your own words."

Differentiation:
Provide students with a word bank to assist them in including all important information of the design challenge into their reworded summary of the challenge. (**Teacher Note:** Words underlined are ideal for a word bank).

RESEARCH THE PROBLEM

1. Pass out a cup (8 oz., or about 237 mL) of dirty water to each team (see simulated wastewater directions in materials list) for each group.
2. Explain to the students that they must design a plan to clean the dirty water that uses natural resources to filter the dirty water.
3. To get them thinking about the task, ask them to think of what they could do to prevent the sand from going right through the funnel.

(**Teacher Note:** If they do not understand what you are asking them, demonstrate. Hold a funnel over a bucket and pour the sand in. The sand will immediately drop through the bottom of the funnel. The students will need to put one large piece of gravel at the bottom of the funnel in order to prevent the sand from just washing through.)

Differentiation:
The following video clips will help struggling students who need to see concrete examples of prototypes. Encourage them to make changes to them, however, to foster creativity:

- Zoom's "Water Filter" at http://www.youtube.com/watch?v=IV80p24QYjk
- Zoom's "Earth Water Filter" at http://www.pbslearningmedia.org/resource/ess05.sci.ess.earthsys.waterfilter/earth-water-filter/

Some web resources for further research:

- http://pbskids.org/zoom/activities/sci/waterfilter.html
- http://pbskids.org/zoom/activities/sci/waterfilterpartii.html
- http://tryscience.org/nld/handson2.html

Some handouts for further research:

- "Cleaning Dirt" handout
- "Cleaning Water Activity" handout
- "NASA Water Filter" handout
- "Build a Water Filter" handout

Formative Assessment (in design logs):
Have students write a "One Minute Paper" in their design logs. Students should spend a minute responding to the following question, "What are some key things you learned about the design challenge today?" The teacher should

review these to quickly see what students are learning. Their questions should be used to continue the design challenge discussion.

Extension:
Extend the "One Minute Paper" assignment further by including the following additional question:
"What questions do you still have about the design challenge?"

DEVELOP POSSIBLE SOLUTIONS

1. Ask students to rate the initial clarity of the water using the 1-5 scale (see formative assessment model).
2. Next, teams will draw or describe two possible plans for filtering the dirty water.

Differentiation:
Using the Think-Pair-Share strategy, have students work first on their own, then in pairs, and then as a team to come up with their 2 ideas. This method builds confidence and encourages individual responsibility.

3. Remind them that there is no right or wrong method. Their challenge is that they need to use whatever materials they decide to use to try to get their water the cleanest. (**Teacher Note**: Students may try to simply dilute the dirty water with the clean water in the materials list. Emphasize that the clean water in the materials list is just for *rinsing* equipment and sediments.)
4. Once the student groups have agreed upon their plans, students should make a prediction about which design will be the fastest and which will make the water the cleanest. (**Teacher Note:** Student teams should suggest and collect materials that they think would make their filter work well. They should think about what is in their water and what would be needed to filter each component out. **The building materials in the materials list are only suggestions.** Teams can use the suggested materials or other materials that they think would work well to build their filter.)

Formative Assessment (in design logs):
1. Rate the initial water clarity of your team's sample.

Initial Observation:	**Water Clarity (circle one) -**	**1**	**2**	**3**	**4**	**5**
			1 = very dirty----------5 = very clean			

2. What is the volume in mL of your initial amount of water to be filtered?
3. Draw and label 2 detailed sketches of your team's designs.

Extension (in design logs):
Additional high-level questions you may choose to assign follow:
4. Prediction: Which of your 2 designs do you think will filter water the fastest? Why?
5. Prediction: Which of your 2 designs do you think will clean the water best? Why?

SELECT THE MOST PROMISING SOLUTION

Based on the criteria and constraints of design (e.g., the time, safety, cost, space, and approved materials as decided upon by you, the teacher), student teams will decide as a group which one of their two designs to develop and construct into a prototype. The following formative assessment will help guide the decision-making process.

Formative Assessment (in design log):

1. What materials will you need in order to make each of your 2 designs?
2. What tools will you need?
3. Are the materials and tools available? If not, how can your team get them?
4. About how long will it take you to build each of your designs?

Extension (in design logs):
Additional high-level questions you may choose to assign follow:

5. Would you be following school and safety rules if you built each design?
6. Could you get hurt working with the tools and materials you have chosen? How?
7. What would your team need in order to build each design safely?
8. Which 1 of the 2 designs did your team select? Why?

Differentiation:
Have students use a graphic organizer like the one pictured below to organize their 2 ideas visually.

Problem	Goal

Possible Solutions	Pros (+) and Cons (-)
#1	+
	-
#2	+
	-

Decision	Reason

CONSTRUCT A PROTOTYPE

Tell the students the following: "*Now that you have selected your design, it is time to build your prototype, or working model. You may have to make adjustments to your selected design. Just be sure to record these changes in your design log as you proceed.*"

"Teams, you should be prepared to 1) select as your collection container something that is capable of holding 150 mL of water, and 2) use a timer or stopwatch to record how long it takes to collect the filtered water. Good luck!"

Formative Assessment (in design log):
Have students think more deeply about their designs by answering the following questions:

1. Which of the filtration material(s) will effectively filter each of the following:
   a. hair
   b. oil
   c. food coloring
   d. sand
2. Will the order in which you place your filtering materials make any difference? Explain why or why not.

Differentiation:
To help students pay special attention to the properties of various materials, have them play the following online game: http://www.bbc.co.uk/schools/scienceclips/ages/7_8/characteristics_materials_fs.shtml (**Teacher Note:** Students will need your assistance at first to model how to drag and test items.)

Extension (in design log):
Have students write in a paragraph how they constructed their team's filter in clearly written steps.

TEST AND EVALUATE PROTOTYPE

Tell students the following: *"Now that you have built your filtration device, it is time to filter your water, and examine the resulting water."*

Formative Assessment (in design log):

1. Have students create the following table in their design log to collect *quantitative data* (numbers):

Water Filter Testing Data of Team

Team Name	Materials Used in Design	Total Time to Filter Water (in sec.)	Outflow Collected (in mL)

2.

End Results:	**Water Clarity (circle one) -**	**1**	**2**	**3**	**4**	**5**
		1 = very dirty----------			----------5 = very clean	

Extension (in design log):
Students can collect *qualitative data* (describing words) about their project.

3. Does your water look clean? How does it smell?
4. When you shake it, can you hear debris?
5. Were you able to build your water filter exactly as planned? Why or why not?

COMMUNICATE THEIR DESIGN

Once teams have formally tested their design solutions, have a class discussion about the process and have each group share out. Teams should answer the following formative assessment questions in their design logs as a follow-up to this discussion.

Formative Assessment(in design logs):

1. What different methods were used by the class?
2. Why did some designs work better?
3. What tools and/or materials did other teams use that your team did not?
4. What different research resources did teams use to develop their water filter designs? (e.g., books, internet, an expert, etc.)

MATH CONNECTION

As a class, have each team record their data together in a table and display it in a prominent place. Students will use this table and its data to complete the formative assessment to follow.

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CORRESPONDING DESIGN LOOP STAGE IN RED

Water Filter Testing Data of Class

Team	Materials Used in Design	Total Time to Filter Water (in sec.)	Outflow Collected (in mL)	Water Clarity Rating

Formative Assessment (in design logs):
1. Which group filtered the water in the quickest amount of time? What was their total time?
2. Which group filtered the water in the slowest amount of time? What was their total time?
3. Which group had the cleanest water? What was their total time?
4. Which group had the dirtiest water after testing? What was their total time?

Extension (in design logs):
Additional high-level questions you may choose to assign follow:
5. What is the difference between your team's time and the team's with the cleanest water?
6. Look at the materials used section in the table. What material(s) do you think cleaned the water the best? Why?
7. Do slow filters lead to cleaner water? Explain your answer.

REDESIGN

Tell the students the following: *"In the United States there are two federal agencies that have jurisdiction over drinking water. The U.S. Food and Drug Administration (FDA) regulate bottled water. The Environmental Protection Agency (EPA) sets regulations for our public drinking water systems."*

Pose this redesign problem to the students: "*Why do you think the FDA regulates bottled water, while EPA regulates public drinking water systems and ground water? Look at the website summary of the two agencies. What do the regulations stress?"* Website: http://www.thefactsaboutwater.org/correct-the-record/tap-and-bottled-water-are-both-regulated-get-the-facts

Differentiation:
Using a "Jigsaw" strategy, assign each team member to be an expert of either the FDA or EPA section. Then have the team regroup and share their expertise of each section. Finally working together, have each team apply their collective "expertise" to the redesign. Using this information, teams should plan for a redesign of their filter and see if they can get better results. To do this, teams should make changes to their design.

Formative Assessment (in design log):
1. If you were to retest with the same polluted water, what changes would you make to your filtration system?
2. Sketch your team's redesigned filter solution.
3. List the materials you would use to make this new, redesigned filter.

Extension:
Students can pour their filtered water into a Solar Still (http://pbskids.org/zoom/activities/sci/solarstill.html) and wait for it to evaporate, condense, and collect. Students can then reflect on what was left in the pan, and why.