5th Grade STEM DESIGN CHALLENGE
CORRESPONDING ENGINEERING DESIGN PROCESS STAGE IN RED

Unit 6: Earth's Resources
Topic: Designing a Model of Sedimentary Rock Formation
Subject/ Grade level: STEM/ Grade 5

Materials:

Suggestion: For each team of 3 students

- Design logs
- Handouts
  - Math Connection activity
  - Syringe Activity
  - "Make Your Own Sedimentary Rock" handout
  - 21 Century Skills rubric for project grade
- Slideshows
  - "Land Forms"
  - "Sedimentary Rock"
- 2 plastic syringes with the nozzle cut off
- Tray
- Eye protection
- Disposable cups
- Plastic spoons
- Water dropper
- Glue/flour
- Bowls
- stirrers
- Powdered clay (10g)
- Plaster of Paris alternative (see website link)
- Water
- Means for testing strength of the "rocks," e.g., files, masses, heavy ball-bearings
- Legos
- Websites
  - http://www.buzzle.com/articles/plaster-of-paris-recipe.html
  - http://www.turtlediary.com/kids-science-experiments/sediments-experiment.html
  - http://www.usgs.gov/
  - http://www.rsc.org/education/teachers/resources/jesei/sedimen/students.htm
  - http://www.kineticcity.com/mindgames/warper/
  - http://tinyurl.com/34beggs
  - http://education.nationalgeographic.com/education/encyclopedia/landform/?ar_a=1
  - http://education.nationalgeographic.com/education/topics/erosion/?ar_a=1
  - http://education.usgs.gov/lessons/schoolyard/RockSedimentary.html
  - http://weirdsciencekids.com/Makesedimentarylayer.html
  - http://www.earthlearningidea.com/PDF/Make_your_own_rock.pdf
  - http://pbskids.org/designsquad/blog/what-prototype/
  - http://www.youtube.com/watch?v=UHAtv5J76FM
- Materials for individual designs may vary. See "model design ideas" section for more suggestions.
  - Small Clear Plastic Water Bottle and Cap
  - Gravel
  - Sand
  - Plaster of Paris alternative
  - Water
  - Coffee Filter
  - Scissors
  - Tablespoon

TEKS

Science

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*ⓇSCI 5.7A Explore the processes that led to the formation of sedimentary rocks and fossil fuels.
Ⓟ SCI.5.2D Analyze and interpret information to construct reasonable explanations from direct observable and indirect inferred evidence.

Math
Ⓟ MATH 5.1A Apply mathematics to problems arising in everyday life, society, and the workplace.
Ⓟ MATH 5.1D Communicate mathematical ideas, reasoning, and their implications using multiple representations, including symbols, diagrams, graphs, and language as appropriate.

ELPS

C1E Internalize new basic and academic language by using and reusing it in meaningful ways in speaking and writing activities that build concept and language attainment.
C2I Demonstrate listening comprehension of increasingly complex spoken English by following directions, retelling, or summarizing spoken messages, responding to questions and requests, collaborating with peers, and taking notes commensurate with content and grade-level needs.

CCRS

Science
5E1A Create a model of a system and use that model to predict the behavior of a larger system.
9E4B Classify and describe the formation of rocks (igneous, metamorphic, sedimentary).

Math
6B2B Read and interpret graphical displays of data.
10A2A Use mathematical models to solve problems in areas such as science, business, and economics.

Cross-Disciplinary
1A1A Identify what is known, not known, and what one wants to know in a problem.
1D2A Manage time effectively to complete tasks on time.

Lesson objective(s):

Students will demonstrate their understanding of sedimentary rock formation, and its role in the creation of fossil fuels, by designing a model of the processes it involves.

Differentiation strategies to meet diverse learner needs:

- Website: http://www.turtlediary.com/kids-science-experiments/sediments-experiment.html can be used to demonstrate the sedimentation process or maybe used a possible model suggestion for student teams that need greater scaffolding when designing.
- Students with difficulty writing will want to use the word bank to guide their paragraph writing in the "Communicate their Design" formative assessment. The teacher may further reduce the number of words to include in this writing assessment, if appropriate.
- Advanced students should conduct research on the USGS organization to share who they are and what they do with the class, and to provide a context for the design problem. This information is most readily available by going to http://www.usgs.gov/.

IDENTIFY NEED

Pose the following scenario to students:
"The United States Geological Survey (USGS) agency needs your help. Portions of the Palo Duro Canyon in Texas are disappearing! USGS needs you to find out what's happening.

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1. You will work with a team to investigate the situation.
2. Each team will work to discover how the landform was created and what force or forces are causing the landform to change.
3. Each team will present their findings to the class.
4. Each team will also have to design a model that demonstrates which forces or processes are causing the landform to change.

The USGS is counting on you to solve this mystery. Go to the suggested websites to conduct research and begin to collect the resources you need for your investigation. Good luck!"

Formative Assessment:
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.

RESEARCH THE PROBLEM

1. Have students view the "Landforms" slideshow and/or conduct their own research on land forms, including canyons, sand dunes, and deltas.
2. To learn more about the creation of sedimentary rock and fossil formation, the result of weathering, erosion, and deposition, students can view the "Sedimentary Rock" slideshow and/or conduct their own research on the processes of weathering, erosion, deposition, compaction, and cementation.
3. To further explore the processes of compaction and cementation, lead students through the following activity: http://www.rsc.org/education/teachers/resources/jesei/sedimen/students.htm (also available in pdf).

Other suggested research resources:
Game on Erosion:
http://www.kineticcity.com/mindgames/warper/
Excellent simulation on deposition process:
http://tinyurl.com/34beggs
Other videos of interest:
http://education.nationalgeographic.com/education/encyclopedia/landform/?ar_a=1
http://education.nationalgeographic.com/education/topics/erosion/?ar_a=1

Differentiation:
The following website can be used to virtually demonstrate the sedimentation process via experimentation, or maybe used as a possible model suggestion for student teams that need greater scaffolding to design.
Website: http://www.turtlediary.com/kids-science-experiments/sediments-experiment.html

Formative Assessment (kinesthetic):
Using Legos to Reinforce the Weathering Process!

Directions:
Step 1: Teams build a Lego "landform" of their choice.
Step 2: A member from each team pulls a piece off of the landform. Question prompt, *"What process does this*

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represent?" (weathering)
Step 3: Teammate takes it to other part of the room. Question prompt, *"What process does this represent?"* (erosion)
Step 4: The next team member begins to build a new landform. Question prompt, "*What process does this represent?"* (deposition)
Step 5: Students continue taking turns transporting pieces from one side of the room to the other until their original landform is completely weathered away!

DEVELOP POSSIBLE SOLUTIONS

As a team, students will use their researched information to create and sketch model designs to demonstrate the forces and the processes of change at the location (the Palo Duro Canyon).

Resources for model design ideas (internet research):

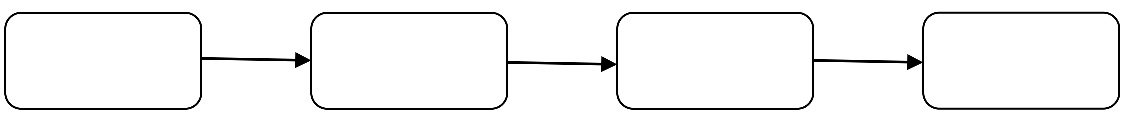
1. http://education.usgs.gov/lessons/schoolyard/RockSedimentary.html
2. http://weirdsciencekids.com/Makesedimentarylayer.html
3. http://www.earthlearningidea.com/PDF/Make_your_own_rock.pdf
4. "Make Your Own Sedimentary Rock" handout

Differentiation (in design logs):
Sequence the events in the flow chart to show the most logical order for the sedimentary rock sandstone to form.

(**Teacher Note:** This graphic organizer serves as a scaffold to help teams plan for their explanations of their design.)

Events to Order in the boxes below:

- New layer of sandstone is formed by the earth
- Sediments are deposited in a new location
- Old rock is weathered into sediments
- Sediments are pressed and sealed together



Formative Assessment (in design logs):
Before students begin the actual construction of their model that demonstrates which forces or processes are causing the landform to change, team members will sketch two ideas in their design logs using their research and the materials and tools available.

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

Safety Questions

1. Would you be following school and safety rules if you built each design?
2. Could you get hurt working with the tools and materials you have chosen? How?

SELECT THE MOST PROMISING SOLUTION

Based on the criteria and constraints (time, safety, cost, space, and materials that the class establishes), teams will decide which of the two designs to develop and construct into a prototype.
Formative Assessment (in design logs):

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Each team member should write in their design log which one of the designs was chosen by their team, and WHY.

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

Problem	Goal

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

Decision	Reason

Extension (in design logs):
Have students answer questions in their design logs to guide their design decisions. Sample questions to help with this process follow:

Materials and Tools Constraint Questions:
1. “What materials will you need in order to make your design(s)?”
2. “What tools will you need?”
3. “Are the materials and tools available? If not, can you get them? How?”

Cost and Time Constraint Questions:
4. Cost: “Will you have to buy something in order to build this design? Can you?”
5. Time: “How long will it take you to build your design? Do you have enough time?”

CONSTRUCT A PROTOTYPE

After identifying the best design, allow time for students to create their model. Students should use the materials they have identified in their materials list. Access to a wide variety of appropriate materials and tools is often desirable.

Differentiation:
Have students watch this very short clip with a simple explanation of what a prototype is.
Website: http://pbskids.org/designsquad/blog/what-prototype/

Formative Assessment (in design log):
As a separate entry in their design logs, teams should record 1) the directions for building their model and 2) any problems they experienced when building.

Extension (in design log):
Additional high-level questions you may decide to assign:
1. “Were you able to build your selected design exactly as planned? Why or why not?”

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2. “Did the process of actually building your model change your mind about what is possible? How?”

TEST AND EVALUATE PROTOTYPE

Students will test and evaluate the effectiveness of their model. Students should be encouraged to make changes as necessary, but be sure to document their changes. This will be particularly helpful should more than one design team have the same idea (the team with adequate documentation should get credit for a design idea). Make sure students don’t get stuck in the revising stage of their design. Remind students that engineers also must deal with design flaws, changes, and failures when they plan and build designs.

Differentiation:
Give students a question such as, “What are you trying to learn from your prototype?” to help them focus on the main goal of the evaluation process.

What are you trying to learn from your prototype?

Formative Assessment (in design log):
Have students answer the following questions.

1. “What additional changes did you make to your design? Why?”
2. “What feedback did you receive by others, and/or by testing your design, might help you to improve it even further?

Extension (in design log):
Have students collect feedback about their prototype from two other students/teams. The following graphic organizer can scaffold this task. Encourage teams to draw pictures and include notations as an alternative to writing alone in the boxes. (**Teacher Note:** Creators of the prototype, not the prototype evaluators, should fill this in.)

Test 1	**Test 2**
What are you going to find out?	*What are you going to find out?*
Picture of Prototype	*Picture of Prototype*
What did you learn? What are you going to do next?	*What did you learn? What are you going to do next?*

MATH CONNECTION

“Relationship of Transported Particle Size to Water Velocity” handout
In this exercise, students will gain practice interpreting a graph of how fast water must be moving in order to be able to transport different sized rock material.

Formative Assessment:
This activity will require significant scaffolding, but is important to connect the science and math ideas of the design challenge. To guide students in the appropriate use of the chart, familiarize them with the following instructions and

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do a sample problem together. If needed additionally, a fantastic description of how to read it is provided at the following link: http://www.youtube.com/watch?v=UHAtv5J76FM

1. Look at all the titles for both the X and Y axes.
2. Notice that the axes are NOT linear. They are called a logarithmic or exponential scale. This means that each major division is 10X the previous value.
3. Remember: Go to the information you are ***GIVEN*** in the problem you must solve. Then either go ***up to*** or ***over to*** the curved line.
4. Proceed carefully ***over*** or ***down to*** the other axis to read your final answer.
5. When asked to ***NAME*** particles, go to the **stream velocity** and then go up to the curved line and notice the name of the particle at the exact point where you have stopped. This particle and all others below it ***can*** be carried at that water velocity. Particles above that point ***cannot*** be carried.
6. You should use the edge of a piece of paper to align your water velocity and/or particle diameter with the curved line. If you try to "eye ball" your answer, you may get an incorrect answer.

Extension: Have students complete the “Challenge Activity” section for more practice with the graph.

COMMUNICATE THEIR DESIGN

Once teams have formally tested their design solutions, have a class discussion about the process of sedimentary rock formation. Each group share details of their design process as well.

Formative Assessment (in design log):
Have students answer the question, *“Based on your research on sedimentary rock formations, explain how you think the Palo Duro Canyon was formed in your design log.”*

Differentiation:
Provide students that need it a word bank for this writing task. (Possible word bank words: river, deposit, sedimentary rock, deposition, pressure, time, cemented together, formation, erosion, and processes.)

REDESIGN

Pose the following question to students: *“How could you redesign your model so that it provides an explanation for the creation of the fossil fuel (sedimentary rock), coal?”*

Formative Assessment:
Have students explain what they would do differently in their design. Ask them, “*What specifically would you need to include in your sediment for coal formation? “* Have them document their responses in their design logs and draw a sketch of their redesigned model.

Differentiation (in design log):
Fossil Fuel Process- Sequence the following sentences so that they describe the formation of the fossil fuel, coal.
_____Over time, pressure inside the Earth changes the plant material into a fossil fuel called coal
_____ The coal is burned and the energy stored inside the prehistoric plant material is released
_____ The plants die and are buried under deep deposits of sediment
_____ Humans mine the coal by digging it out of the Earth
_____ Plants growing in prehistoric swamps and forests store energy received from the sun

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