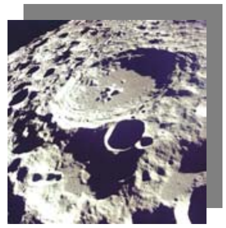
Multiple Impact Craters 

Engineering Design Brief

Narrative: Geologists have been studying craters on Earth for a very long time. Scientists, and the general population, have wondered how they were formed. Questions have been asked about how big were the impactors that caused the craters, will there be more impactors in the future, and how might another large impact affect life on Earth? These questions and many more have not yet been answered completely.

Scientific knowledge about lunar impact craters was greatly expanded by the NASA ***Apollo missions***[1] to the Moon in the mid twentieth century. Before Apollo, the origin of lunar impact craters was not fully understood and the origin of similar craters on Earth was highly debated. Information gathered from the Apollo explorations has given us a greater understanding of the timescales for the evolution of the ***terrestrial planets***[2].

Scientists want to learn more about the history and effects of ***multiple impact craters***[3] on the inner planets. Since no humans have yet set foot on Mercury, Venus, or Mars, we must study the geology of these planets from photographs (***photogeology***[4]) collected by robotic space flights and/or earthbound telescopes.

NASA scientists work with NASA engineers to design and create devices and models to better understand how objects in the solar system behave. Designing and creating devices that can replicate events in nature can help scientists to better predict future events or to better understand patterns of events that have already occurred. In this case, we will be studying the formation of multiple impact craters.

Problem: You are part of a team of NASA engineers who have been asked to design and create a prototype of a "crater replication device" that will replicate multiple impact craters.

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[1] ***Apollo missions:*** six lunar landing missions that took place between 1969 and 1972.
[2] ***Terrestrial planets:*** Mercury, Venus, Earth, and Mars.
[3] ***Multiple*** i***mpact craters:*** occurrences of multiple circular, raised-rimmed depressions formed by explosions that occur when comets and asteroids collide with the Moon (or other planetary surface) at high velocity in a given area.
[4] ***Photogeology:*** studying geology using pictures

Learning Standards: Grades 6-8

Physical Science	Earth Science	Technology/Engineering
Explain and give examples of how the motion of an object can be described by its position, direction of motion, and speed.	Recognize, interpret and be able to create models of the earth's common physical features in various mapping representations, including contour maps. Describe and give examples of ways in which the earth's surface is built up and torn down by natural processes, including deposition of sediments, rock formation, erosion and weathering.	Appropriate materials, tools, and machines enable us to solve problems. Engineering design is an iterative process involving modeling and optimizing for developing technological solutions to problems within given constraints. Ideas can be communicated through engineering drawings, written reports, and pictures.

Research the Need or Problem:
http://www.exploratorium.com/exploring/space/space5.html Asteroids and Early Earth History
http://www.lpi.usra.edu/expmoon/science/craterstructure.html Lunar Impact Crater Geology and Structure
http://www.enchantedlearning.com/subjects/astronomy/moon/Craters.shtml Impact Craters on the Moon
http://www.lpl.arizona.edu/SIC/impact_cratering/intro/ Terrestrial Impact Craters and Their Environmental Effects
http://spacelink.nasa.gov/Instructional.Materials/NASA.Educational.Products/Once.and.Future.Moon/Once.and.Future.Moon.pdf

http://www.lpl.arizona.edu/SIC/poster1.html Environmental Effects of Impact Cratering Poster

Materials:
Aluminum pie pans, flour, cocoa, clay, newspaper, watering can, duct tape, pebbles, steel balls, straws, string, rubber bands, eye dropper, turkey baster, digital camera.

Brainstorming:
Students will be divided into engineering design teams of three to five students.
Cubing Activity (Attached)

Best Possible Solution:
Team members will work together to consolidate and organize their brainstorming ideas by answering the following questions: (Attached)

- What do we think we know about the formation of multiple impact craters?
- What do we still need to learn about the formation of multiple impact craters?
- What do we need to know in order to create a prototype of a crater replication device?

Based on available materials, teams will sketch the device they have designed to replicate multiple impact craters.
Each team will present its proposals and sketches to promote their ideas for the crater replication device on flip charts.

Construct a Prototype:
Each team will choose materials available to create a prototype of the device to replicate the multiple impact craters observed in the photographs.

Test and Evaluate the Solution:

1. Use the crater replication device to replicate multiple impact craters as seen in the photographs.
2. Use the digital camera to photograph the multiple impact craters you have created. Compare your craters and your photographs to original photos.

Communicate the Solution:

1. How do the photographs of the multiple impact craters you have created with the crater replication device compare with the photographs of real craters?
2. Student self-assessment. (Attached)
3. Teacher and student evaluate the design process using the rubric provided. (Attached)

Redesign:
Based on the test results, what changes/modifications could be made to improve the crater replication device?

Multiple Impact Craters
Cubing Brainstorming Activity
(Teacher Page)

Background:

Cubing is a technique for *swiftly* considering a subject from 6 points of view. The emphasis is on ***swiftly*** and ***6***.

The process of cubing is one that writers use when they can't get going on a topic. It forces the writer to look at a subject from different perspectives in a 3 to 5 minute time period and then move quickly to another perspective. It is simply a technique.

The topic we will focus on in this activity is Multiple Impact Craters. The goal is to have students brainstorm and focus on impact craters from a variety of different perspectives. They must describe, compare, analyze, associate, apply, sketch, and make an argument to support their theory of the formation of impact craters.

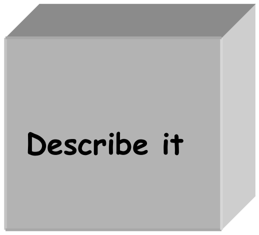
Students will be divided into groups of three to five students. Each group will be given photographs of multiple impact craters and a cube with six perspectives on the sides. Students will follow the **Rules for Cubing** on their activity page.

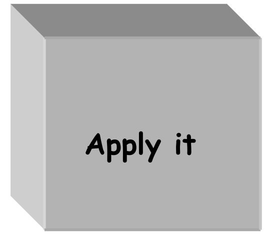
Upon completion of the cubing/brainstorming activity, groups should be encouraged to share their perspectives with the whole class.

As a result of this brainstorming activity, students will have had an opportunity to express their prior ideas about impact craters from a variety of perspectives.

C U B I N G

Multiple Impact Craters





RULES FOR CUBING

1. Use all six sides of the cube in any order.
2. Move fast. Don't allow yourself more than 3 to 5 minutes on each side of the cube.
3. Jot down your ideas as you progress from side to side.

For the cubing technique, you need to use all six sides. This is not an exercise in describing, analyzing, or arguing. It is simply a technique to help you brainstorm and look at multiple impact craters from different perspectives. There are no wrong answers in a brainstorming activity.

- Describe it. Look at the photo of the multiple impact craters closely and describe what you see. Colors, shapes, sizes, and so forth.

- Compare it. What is it similar to? What is it different from?

- Associate it. What comes to mind when you think of it? Just let your mind go and see what associations you have with this photograph.

- Analyze it. Tell how you think it was made or formed.

- Apply it. Tell what you can do with it. How can it be used?

- Argue for or against it. Go ahead and take a stand. Make an argument based on how you think the craters were formed.

Now go back and reread the notes you have jotted down and prepare to share your team's perspectives with the rest of the class.

Sketch it. Based on available materials, make a sketch of the device you will create to replicate the multiple impact craters you have seen in the photographs. Your team must then work together to create a proposal, which you will present to the class, about what that device will look like.

Multiple Impact Craters Engineering Design Process				
	Literal	**Developed**	**In-depth**	**Sophisticated**
Step 1: **Identify the need or problem - Cubing**	Limited perspective, many inaccuracies	Generally accurate assessment, but lacks perspective and/or accurate supportive information	Accurate and generally revealing, but needs more perspective from differing points of view	Clearly and accurately identifies problem verified by using differing perspectives
Step 2: **Research the need or problem - Evidence of Research**	Limited examination of the current state of the issue and current solutions	Generally accurate assessment, but lacks perspective and/or accurate supportive information	Thorough and accurate assessment, but needs more supportive evidence	Thorough and accurate assessment supported with strong evidence
Step 3: **Develop possible solutions – Possible Solutions Activity**	Limited perspective and limited academic disciplines explored	Limited brainstorming for possible solutions, and consideration of math or science	Good solution(s) and articulation of solution(s) in 2-3 dimensions, some use of math and science	Refined possible solution(s),articulated best solution in 2-3 dimensions, meaningful use of math and science
Step 4: **Select the best possible solutions - Flipchart PresentationI**	Unclear about the relationship between the original requirements and the solutions	Clear understanding of the problem and the solutions, but insufficient data to determine the best solution	Good hypothesis, but lacks enough evidence even though data is extensive	Determination of best solution verified by evidence, trial and/or argument in relation to the original requirements
Step 5: **Construct a prototype**	Solutions remain in abstraction	Solution(s) can be modeled in limited dimensions	Good solution(s),but they are unable to be modeled in 2-3 dimensions	The selected solution(s) can be modeled in 2-3 dimensions
Step 6: **Test and evaluate solution(s)**	The prototype meets none of the original design constraints	The prototype meets some of the original design constraints	The prototype meets most of the original design constraints	The prototype meets the original design constraints
Step 7: **Communicate the solution(s) - Photogeology Comparision**	Weak presentation of how the solution best meets the needs of the problem, no inclusion of societal impact	Fair presentation of how the solution best meets the needs of the problem, some inclusion of societal impact	Good presentation and discussion of how the solution best meets the needs of the problem, societal impact and trade-offs	Excellent engineering presentation including discussion of prototype, societal impact and trade-offs
Step 8: **Redesign and Self-Assessment**	No revision, and/or little or no information	Incomplete revision, little information	Good revision, needs more information	Excellent revision based on information gathered during the tests and presentation