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IMPACT CRATERS

Adapted from: "Hypothesis Based Learning" (Oklahoma State University)
(Grades 6-9)

Standards

Science

- A7 – Understand how the earth changes because of plate tectonics, earthquakes, volcanoes, erosion and deposition, and living things
- B1 – Use the processes of science
- B2 – Design and conduct scientific investigations using appropriate instruments
- B4 – understand that personal integrity, skepticism, openness to new ideas, creativity, collaborative effort, and logical reasoning are all aspects of scientific inquiry
- B6 – Employ strict adherence to safety procedures in conducting scientific investigations
- C2 – Understand that scientific knowledge is validated by repeated specific experiments that conclude in similar results
- D2 – Understand that scientific innovations may affect our… safety

Math

- MA2 – Estimate and measure various dimensions
- ME1 – Apply mathematical skills and processes to science

Writing

- EA1 – Apply elements of effective writing (ideas, organization, vocabulary, sentence structure and personal style)

Cultural Standard

- E3 – Demonstrate an understanding of the relationship between world view and the way knowledge is formed and used

Science Concept

Craters of different dimensions are formed from the kinetic energy of falling objects acting on different materials.

Materials

- ✓ Science notebooks
- ✓ "Journey Through the Science Process"

For each group of students:

- ✓ One metal, cardboard, or plastic 18 x 24-inch tub with sides three to four inches high
- ✓ All-purpose flour
- ✓ Fine colored sand, colored powdered drink mix or dry tempera paint
- ✓ Newspapers or drop-cloth to catch spills
- ✓ Fine sieve, flour sifter, or shaker
- ✓ Steel ball bearings of various sizes
- ✓ Golf ball
- ✓ Large marble (same density as the small marble)
- ✓ Small marble (same density as the large marble)
- ✓ Scale (to weigh objects)
- ✓ Measuring tape (to measure heights of falling objects)
- ✓ Ruler (to measure the depth and diameter of craters plus distance of drop)
- ✓ Broom and dust pan or vacuum cleaner
- ✓ Calculator

Vocabulary

- Science Process Skills
- Crater

DAY #1

Gear-Up (Observation, Prediction, Inferring)

- ❑ Ask students what they think will happen when an object (serving as a meteorite) that is held in your hand at shoulder height drops into the center of a tub filled with flour.
- ❑ Open your hand and drop the object into the center of one of the tubs. The object should fall perpendicularly to the surface of the material in the tub.
- ❑ Do not remove the object from the crater it forms.
- ❑ Elicit student inference:
  - What did you observe?
  - Why do you think this happened?
  - What do you think is going to happen if I drop an object that is different in either size or density from the first object? (Record ideas on the whiteboard)
- ❑ Hold one of these objects in your hand and extend your arm at shoulder height.
- ❑ Open your hand and drop this object into the center of another prepared tub. As before, the object should fall perpendicularly to the surface of the material in the tub.
- ❑ Gently remove the objects from their craters being careful not to disturb the craters or ejected debris.
- ❑ Have students write down ten qualitative and quantitative observations in their science notebooks. (Discuss and record ideas on the board – reinforce the difference between observations, explanations/predictions, or inferences)
- ❑ After observations have been written on the board, ask students to share explanations for each one.
- ❑ Have students include explanations for each of their observations in their science notebooks.
- ❑ Explain to students what they are going to do:
  - In pairs, you will be given a variety of objects to make observations, explanations/predictions, and inferences.
  - Discuss safety and lab expectations…

Explore (Observation, Inferring, Measurement)

1. Direct each pair of students to make at least 5 qualitative observations for each object they have been given and record them in their science notebooks **(encourage students to draw pictures, sketches, data tables, and diagrams)**. Allow them to begin exploring and discovering what happens. ENCOURAGE THE SCIENTIFIC PROCESS!
2. As students make their observations they should identify what is most interesting to them and have him/her write down the information and provide an explanation – How can that explanation be tested?

Generalize (Communicating, Predicting, Inferring)

- Have students collaborate and share their observations and record them on the white board. Compare them with their predictions.
- Elicit student inference:
  - What do you think would happen if…
  - Why do you think that would happen?
  - Introduce the vocabulary word ***crater***.

Day #1 Homework – Write about one observation they wish to test.

1. *How do they explain the observation?*
2. *What does the explanation predict?*
3. *How would they test the prediction?*

DAY #2

Experiment (Observation, Inferring, Hypothesizing, Measurement, Controlling Variables, Designing Investigations, Experimenting, Collecting Data, Making Graphs)

1. Explain to the students that from their observations and possible explanations/predictions that they have made, they will create their own experiment. They will be determining how their self-selected independent variable affects their dependent variable.
2. Review the steps of science process skills ("Journey Through the Science Process")
3. From the observations and explanations made, ask the students how they are going to test one of their observations. What are their independent and dependent variables are going to be *and* what variables they are going to control for (example: distance from which the object is dropped)?
4. REMIND STUDENTS TO SEPARATE THE EFFECTS OF 2 INDEPENDENT VARIABLES (the SIZE and DENSITY of different falling objects):
    a. If 2 objects of different size but the same density are being used, the students can directly compare results of the falling objects and draw conclusions about the effect of size alone on the size of craters and/or distance that material is ejected.
    b. If students use objects that are the same size, but different density, then they can form conclusions about the effect of density on crater size and ejecta.
    c. If students use only one object but drop it from different heights, they can draw conclusions about the effect of falling height on crater size and ejecta.
5. Ask students to create a research question, form a hypothesis, and share their hypothesis with their lab partner.
    ALL INFORMATION SHOULD BE WRITTEN IN THE STUDENTS' SCIENCE NOTEBOOKS!
6. Have students conduct their experiment and their science notebooks they should:
    1. Write a detailed and descriptive procedure **(use pictures, sketches, & diagrams)**
    2. Create a data table to record results (distance of drop, distance material was ejected, diameter of the crater, and the depth of the crater).
    3. To measure their craters, students must:
        a. Measure the distance from which the object is dropped.
        b. Measure the distance that material is ejected from the crater by measuring the radius from the center of the crater to the edge of the continuous blanket of ejected material; not the furthest speck.
        c. Measure the diameter at the top of the crater to get the maximum width measurement.
        d. Measure the depth of the crater.
    4. Graph results
    5. Analysis:
        a. Explain what happened – draw diagrams and figures to support your explanation
        b. Did your data support your hypothesis?
    6. Conclusions:
        a. What can be concluded?
        b. What factors do you think causes the crater to be formed?
        c. What is your evidence?
7. If students finish, encourage them to circulate the room, observing other teams.

DAY #3

Interpret (Inferring, Generalizing)

1. Describe specific student experiments (mention experiments that do not go in intended content directions).
2. Describe different student techniques (discuss experiments where student ability to follow directions my have affected the outcome of the experiment).
3. Discuss differences/similarities in student hypotheses.

a. A spokesperson from each group will describe what variable they chose to test and their hypothesis.
b. Did they really isolate the effects of that one variable? (If students don't control other variables, the cause-and-effect they may think exist could be confused by the effects of other variables.)

4. Content focus:
    - Describe dependent and independent variables. Have students share their graphs of data.
    - The depth and diameter of craters will get larger and the distance that material is ejected will increase as:
        - the object size gets larger (because kinetic energy increases), with all other variables held constant
        - objects get more dense (because kinetic energy increases), with all other variables held constant
        - the height that objects fall increases (because kinetic energy increases), with all other variables held constant.
        - **All of the observations above depend on kinetic energy of the falling object.**
            - What would happen if a small amount of water was added to the tray of flour? This might simulate rock becoming molten upon impact

Apply/Assess (Inferring, Communicating)
Using the attached "Lab Write-Up" rubric, student procedures, observations, hypotheses, hypotheses testing, analysis, and conclusions will be assessed. Discuss:

- How would you do your experiment differently?
- How do you think we can use this information in our lives? Why?
- How have other cultures used this information to create their own understanding of the Earth?

Final thought… Why are fewer impact craters found on Earth than on the Moon or Mars?

Accomodations

- Allow students to work at their level of understanding (example: using one independent variable - the distance from which the object is dropped versus examining multiple independent variables).
- Drawings, sketches, diagrams, picture charts, etc. to demonstrate process and understanding for second-language learners.

Extensions

- The Hazard on Earth from Meteor and Asteroid Impacts
- Dinosaur Extinction

Technology
National Geographic Society: "Asteroids: Deadly Impact"
An online game where students use knowledge of asteroids and impact craters to "crack the case"

IMPACT CRATERS GRADING RUBRIC

OBSERVATIONS

Score	Criteria
1	No record of observations but some approximate recording of some physical measures
2	Records some observations and some estimates of physical parameters
3	Records precise or detailed physical measurements
Comments:	

HYPOTHESIS

Score	Criteria
1	Hypothesis or questions stated but confusing and not clear
2	Hypothesis or questions stated with less confusion
3	Hypothesis or questions well written or well stated
Comments:	

PROCEDURE

Score	Criteria
1	Steps written, but considerable confusion of meaning
2	Steps written, but have two to three mistakes
3	Well-written steps, but have one or two mistakes
4	Well-written steps with high degree of accuracy
Comments:	

TESTING OF HYPOTHESIS

Score	Criteria
1	Some evidence of test(s) performed (e.g., I did this…)
2	Test(s) performed with some data collected
3	Tests performed, relevant data collected for the test, data does not match
4	Tests performed, relevant data collected, conclusions drawn from the data collected
Comments:	

ANALYSIS

Score	Criteria
1	Some analysis but not clear
2	Analysis with no mistakes but no supporting data/diagrams etc.
3	Clear explanation with diagrams/figures/data to support
Comments:	

CONCLUSIONS

Score	Criteria
1	Evidence of conclusion written, BUT not clear
2	Conclusion written BUT not supported by findings
3	Conclusion written with diagrams/figures/data to support
Comments:	