Impact Crater Activity
Notes for Teachers

Activity Summary

Objective: The aim of the inquiry based lab is to expose students to planetary surface processes. On Earth, many factors (including wind, water, tectonic, and volcanic activity) play a role in shaping the landscapes we see. Elsewhere in our solar system, however, these processes are muted by one major process – impact cratering. This student-designed lab focuses on understanding the factors that play a role in the resulting crater formed after an impact.

Overview: 1) The teacher gives a background presentation (provided by CPSX) which describes crater processes throughout our solar system (specifically comparing Earth to other planets), the consequences of impacts on Earth, the origins of impactors (small bodies) in our solar system, and the mechanical process of an impact.

2) The teacher demonstrates an impact event. Students are to make observations in their lab handout, and sketch what they see.

3) Students (either individually or as a group, based on abilities) outline the independent variables, and design an experiment. This is conducted in groups after the proposed experiment is approved by the teacher.

4) Students draw conclusions on their experiment, and present results in the lab hand out and to their peers.

Outcome: Students will leave this activity with an understanding of the primary process affecting planetary surfaces, a stronger knowledge of planets, asteroids, comets, and meteorites, and the ability to employ the scientific method to design, execute, and assess the success of an experiment.

Curriculum Outcomes: From the Grade 9 Ontario Curriculum

D2.4 *– Identify properties of celestial objects in our solar system (e.g. planetary surfaces, etc.) (p. 55)*

D2.5 *– Compare and contrast properties of planetary bodies (Earth/Moon and Earth/Mars) (p.55)*

D3.3 *– Describe solar system components using appropriate scientific terminology (p.55)*

Procedure for Teachers

Preparation

This activity can be done in two days (minimum) or over the course of a week. Either way, the first day will be devoted to a power-point presentation and demonstration. Have the demonstration ready to go before class starts (described below).

Presentation

CPSX has designed a power-point presentation to accompany this activity. Before starting, hand out the lab worksheet and inform students that the first page will be used during the presentation. The presentation is an overview of cratering in our solar system. Speaker notes are included for every slide of the presentation, in the power-point file. As indicated in these speaker notes, there is an interactive section where a series of images of impact craters are shown. For each of the five images, students are to note what planet they think the crater is from, or, if they think it is from any planetary moon (including our own) they should write "moon." Once this is done, the images are shown again. Ask the students, or take a vote, to determine where the students think these craters exist. Then, tell them the answer and have them write this on their worksheet.

Demonstration

Preparing the Demonstration

Fill a large tray with ~10cm of white flour (kitty-litter boxes or tin lasagna pans work great!). Smooth the flour using a block or piece of cardboard to make the surface flat, but try not to compress the flour too much. Using a sieve, uniformly dust the surface of the flour with ~2mm of cocoa, hot chocolate mix, or some sort of dark powder. Choose a ball to use in the demonstration (e.g. squash ball or bouncy ball). The demonstration will be the "control group," so record the mass and diameter of the ball. Have a meter stick, pencil, and 30 cm ruler handy. Don't forget your safety glasses!

Conducting the Demonstration

After the presentation, have the students, with their worksheets, gather around where you have set up your tray. Review, from the presentation, how a crater forms – a small body from space is pulled in by the gravity of the planet and hits the surface. Instruct them to make observations of what they see before the demonstration is conducted (i.e. the surface of the tray is uniformly brown). Have one student hold the meter stick vertically, and measure 75cm above the surface of the tray. From this height, drop your impactor into the centre of the pan.

Be sure to let it fall freely. Carefully remove the impactor from the tray, while trying not to disturb the crater you have just formed.

Discussion of the Demonstration

Have the student make observations of the demonstration in their handout, and discuss what they see. Together, identify the rim and basin of the crater. You can introduce the concept of "rays," these are the long white streaks which extend out from craters. Have them sketch what they see, and label these features. As a group, measure the diameter (to the rim crests) and depth (at the deepest point) of the crater. You can also measure the rays, although point out that there is a range of ray lengths, so take an average of the three longest. Primarily, the diameter, depth, and ray length, are the three dependent variables in this activity. Next, ask the students what they could change in the experiment to get different results. This may include changing the height of the drop, and the mass or diameter of the impactor. Keen groups of students may also recognize that the angle of impact and the material which is being impacted play a role as well. These changes should be identified as being the independent variables. Finally, using a stiff piece of cardboard or plastic, vertically "cut" the crater through the centre and pull away half of the material. This will reveal a cross-section of the crater, which the students should sketch and label.

Background Research

These questions are intended to provide context for this experiment. An answer key for teachers provides detailed answers, which may surpass what is expected from students, but may help the teacher in explaining concepts.

Student Experiments

Following the demonstration, the students should complete a list of dependent and independent variables in their lab handout under "Experiment Design". In partners or groups, have the students choose two variables (one dependent and one independent) which they want to study the relationship between. They should write an "If… then…" hypothesis statement. For example, "If the impactor is more massive, then the crater will be deeper." Before moving forwards into the actual experiment, check the "Experiment Design" section for each group to make sure the proposed experiment is reasonable and possible given your resources. At minimum, each group will need:

- 1 tray for, prepared as done for the demonstration (nice to do before class)

- 1 metre stick
- 1 (or more) impactors
    - *Depending on what they chose to change, styrofoam balls, or making balls from clay or playdough work very well. Students can be creative though, consider changes in shape, angle, etc. The teacher can provide these materials, or, students can be tasked with making/bringing their own.*
- Personal rulers to measure crater dimensions

Running the experiments and making the observations should take at least an hour, so it is good to allow for a full class period to be devoted to experiments. Before starting, students should write the independent variable values (e.g. Trial 1: height = 20cm, Trial 2: height = 30cm, etc.), and then proceed with the trials. Students should be able to do at least four, if not six, "drops" in their tray. If the tray needs to be resurfaced, just mix the cocoa into the flour, smooth, and dust the top again. Students with ray-lengths as their dependent variable may want to smooth and re-surface their tray between each trial, so that they can drop into the middle without having the sides of the tray interfere with the rays. Students should also make basic qualitative observations of the other possible dependent variables that were not part of the main experiment. For example, if students are measuring changes in crater diameter with changing drop heights, did the crater depth and ray lengths also seem to change? How? Once all trials are done and the lab space is cleaned up, students should graph their results, complete the follow-up questions, and write their conclusions.

Follow-up

You can end this activity with the students handing in the labs, but it is also beneficial to have the students present their results to the rest of the class. Make a table on the board where students write their group name, independent and dependent variable, and a brief explanation of their findings (e.g. increased mass leads to deeper craters). If this is done before students write their conclusions, then students can comment on the findings of all the groups and note these trends in their lab.

Possible questions for your Unit test:

Why do we see more craters on the Moon than on Earth?

Earth's crust is constantly being recycled by the process of plate tectonics, and resurfaced by volcanic and erosional processes. As a result, craters on Earth become buried or are eroded away. These process do not occur on the Moon.

Note: The Moon is not preferentially hit by more impactors than Earth. Actually, due to its stronger gravitational field, Earth has been impacted more than the Moon!

How can pieces of the Moon or Mars come to be on the surface of Earth?

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If the surface of another planetary body experiences a large impact, pieces of that planet's surface can be ejected off the planet completely. If the orbit of Earth aligns with the flight path of this object, these planetary fragments may then fall to the surface of Earth.

Extra Notes, Recommendations and Alternate Approaches

- Above all, it is important for students to understand that they may only test changes in *one* independent variable. Explain that if they made changes to the drop height *and* impactor mass, for example, they would be unable to tell whether the observed changes in crater depth (or diameter) were due to height change, or mass change.

Common experiments

Independent Var.	**Dependent Var.**
Drop Height	Crater Depth
Drop Height	Crater Diameter
Drop Height	Ejecta ray Length
Impactor Mass	Crater Depth
Impactor Mass	Crater Diameter
Impactor Mass	Ejecta ray Length
Impactor Diameter	Crater Depth
Impactor Diameter	Crater Diameter
Impactor Diameter	Ejecta ray Length

Alternative experiments:

Independent Var.	**Dependent Var.**
Angle of Impact†	Crater Diameter
Angle of Impact	Ejecta ray Length
Impact Material*	Crater Depth
Impact Material	Crater Diameter
Impact Material	Ejecta ray Length

† To change the angle of impact, we have used a nerf-ball gun and a chalkboard-sized protractor. When measuring crater diameter, student can measure both the long and short axis, or choose one. More simply, student can tip their tray and use a protractor to determine the angle of impact.

* E.g. sand, soil, etc. For dark impact materials, dust flour (not cocoa) on the surface so that the rays can be seen.

- If preferred, this activity can be done as an extended demonstration, rather than a lab. Have the class as a whole choose the variables to change and measure, and run the experiment together.
- Keep the flour afterwards! The flour, with the dusting of cocoa, can be stored in a bin and used for future labs until the flour is too dark (from cocoa inclusion) to recognize the rays on the surface.

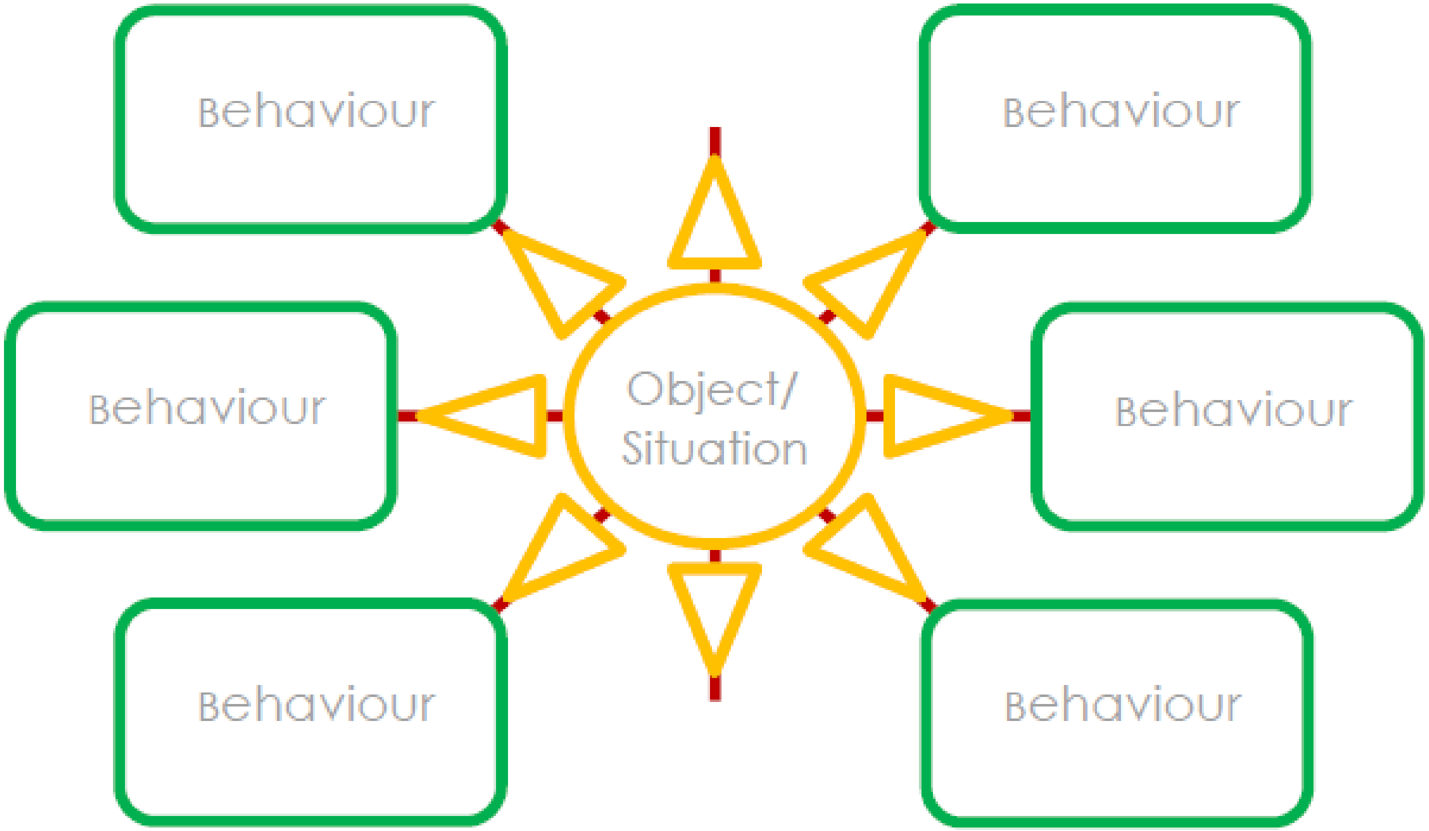
Closing Notes

Thank you for participating in the education and outreach initiatives of the Centre for Planetary Science and Exploration! We are always thinking of new Planetary Science focused activities to share in classrooms and with the public. If you have any comments, questions, recommendations for how we can make this program stronger, or want a Planetary Scientist to visit your classroom (even virtually!) please field your thoughts to:

The Centre for Planetary Science and Exploration
Outreach Program Coordinator
Email: cpsxoutreach@uwo.ca
Phone: 519-661-2111 x88508

The following Smarter Science diagrams could be used with this exercise.
To learn more about the Smart Science program visit: http://smarterscience.youthscience.ca/

INITIATE AND PLAN STEP 1: BEHAVIOURS STARBURST DIAGRAM



Behaviour of interest becomes the dependent variable or DV for the study.

DV is ______________________________

INITIATE AND PLAN   STEP 2: BRAINSTORM

List all variables that may change the DV's behaviour.

INITIATE AND PLAN STEP 3: FISHBONE – EXPERIMENT ORGANIZER