



Creating Craters

Children make craters by dropping balls into a tub of flour. They observe the properties of balls with different sizes and weights, make predictions, compare craters created by different balls, and compare the flour craters to images of real craters on the surface of the Moon.

 10–30 minutes

 Drop-in or Workshop

 3–4 children per adult



Content Learning Goals

Children begin to understand:

- The surface of the Moon has features called craters.
- The size, weight, and speed of the impactor (in this case, the ball) affect the size of the resulting crater.

Science Practices

Children will begin to investigate the phenomenon of craters on the Moon by:

- **Observing** the characteristics of lunar craters in photographs.
- Making **predictions** about how properties of the impactors (balls) will affect crater size.
- Using a **model** of the Moon's surface to investigate characteristics of lunar craters, based on observations of those craters in photographs.
- **Comparing and contrasting observations** of craters on the Moon and craters in flour.
- Using observations of craters in the model and in photographs to begin **constructing explanations** for how craters are made and why they have different sizes.

Materials

- Moon banner
- Crater images (pages 7–10)
- 2 wide bins or bowls to contain flour
- Flour* (enough to fill bins about 3-in. deep)
- Cocoa powder* in a shaker jar
- Several balls of different size and density (e.g. ping pong / golf / bouncy balls, marbles, wood spheres)
- Bowl or bin to hold the balls
- Hair pick or small rake
- Small semi-transparent stickers (optional)

**If you prefer to avoid food products, you could use fine white sand covered in a thin layer of colored sand, though the flour provides a more accurate model of the cratering process, with craters that better hold their shape.*

SET-UP

- **Spread the flour about three inches deep in the bins.** If this is a facilitated drop-in activity, it is good to have two bins so that you can always have one that is ready to go while the other is being reset. If this is a workshop activity, you should plan on one bin for every three or four children, with an adult at each bin.
- **Sprinkle a very thin layer of cocoa on the surface of the flour** (optional, but recommended) to provide contrast between the craters and surface. This works best if the cocoa is in a large shaker jar. Keep it to a thin layer: if you use too much cocoa, the scent can become overwhelming / distracting.
- **Hang the Moon banner and crater images** near your set-up area at a height such that the children can look at them closely.

ACTIVITY DESCRIPTION

We suggest a sequence of steps for this activity, and many questions to ask children along the way, but the children's interest should guide the process as much as possible. Let them ask questions, make predictions, and change course. Be flexible about changing the steps in this sequence, and don't feel you have to ask all of the suggested questions. Also, whenever possible, help children find the answers to their own questions through experimenting, rather than just verbally answering them.

- 1. Invite children into the space and introduce them to craters:** *"We're exploring the Moon today. Here's a picture of the Moon. What do you see on the Moon? Do you see any shapes you know?"* If children do not bring up craters, you can apply that word to their observations of holes or circles. If they are reluctant to talk, suggest that they come up and point to something round on the image then let them know those are holes in the Moon called craters. *"What do you think could have made those holes called craters?"* Some children may know that rocks from space hit the Moon. Otherwise, explain that a crater is a hole left on the Moon after a rock hit the surface and exploded.
- 2. Optional: Ask children to find and name the craters.** Explain that many of the craters on the moon were named after scientists. Ask them if they would like to be a scientist when they grow up. Invite them to pick their favorite crater and put a sticker on it. Then it can be "William Crater" or "Beth Crater", or "Mom Crater" for the shy ones. Children get excited about taking ownership of the craters. Semi-transparent stickers are recommended so that the crater is still visible underneath. This is also a good opportunity for children to make close observations of their personal craters. Ask, *Why did you pick that crater? Or, What do you notice about your crater?*
- 3. Make craters in the flour.** Invite children to the flour bins to make their own craters:
 - Explain that you made a **model** of the surface of the Moon that will help them test their ideas about how rocks from space (asteroids) could have made the Moon's craters. Tell them that the flour is the Moon's surface and the balls are pretend rocks.
 - Have the first child pick a ball, but not drop it yet. Holding the bowl of balls over the flour helps discourage premature dropping.
 - Ask the child to describe the properties of the ball — large, squishy, hard, light, heavy (e.g.: *"My ball is heavy. What kind of ball did you pick?"*). Ask the child to pass around the ball to the others in the group so that they can all observe these properties. If you are working with a group of children in a camp or workshop, it works best to take turns, so that only one child at a time is holding a ball.
 - Encourage the child to predict what will happen when he or she drops the ball (see *Suggested Questions* below).
 - Give the child specific instructions to hold the ball out and let it drop in the bowl.
 - After making the first crater, let the child take the ball out. Ask children to **observe** the crater: *"What kind of crater did it make?"*
- 4. Make a second, different crater in the flour.**
 - Ask children if they think they can make a different sized crater. This is open-ended and doesn't specify wider, deeper, splashier, etc. Children will often choose a different size ball. Ask them to describe how the new ball is different from the first ball and ask them to make a **prediction** of what kind of crater they think it will make (see *Suggested Questions* below). They may use words such as top/bottom and up/down for deep/shallow.
 - Once they drop the ball and make this second crater, ask them to **compare** it to the first crater they made. First, encourage the children to describe the observable difference in the two craters. Then ask them why they think one is wider/deeper/bigger (use their descriptive words) than the other. Many 4- and 5-year-olds are able to use their observations of the model to **make a claim** that the heavier objects make deeper craters.
 - If children want to keep dropping more balls, ask more complex questions: *How can you make different sized craters with the same ball? Or with two balls of the same size? Which two different balls might make the same size crater?*
 - If working with a group of children (up to four at a time), have them each make a crater in the same tub and then compare them. Then as they each pick a second ball, have them pass them around until they get their original back. Ask them to make predictions as above for the second round.
- 5. Compare the model's craters to pictures of craters on the Moon.**
 - After the children have begun to develop some explanations for how different sized craters are made, you can also ask them to apply this to the pictures of the Moon. Ask them to find craters in the pictures that look like the ones

they made. They may notice white streaks highlighted against the dark cocoa on the surface. These are similar to the rays that can be seen in the image of the crater Tycho on page 8. You might also say something like: “It looks like “Beth Crater” is bigger than “William Crater.” Why do you think this one crater on the Moon is bigger than another?” This will help the children connect what they are learning back to the Moon and help you assess their ideas about how craters are formed.

6. At the end of a round, ask the children to help set up the model Moon surface for the next scientists.

- This part can get messy! If you don't mind the mess, it can be fun to see if the children can find all of the balls, either with a hair pick/rake or with their hands. For 3- and 4-year olds, this can be an exercise in counting and memory; they enjoy trying to remember which balls are still missing. Smoothing out the top layer with the rake can be accomplished by even the very young, but it's best to demonstrate how to do it or else they will just keep digging. The digging is actually good for keeping the flour fluffy.
- After all the balls are removed and the top layer is smoothed, you (the educator) should sprinkle a thin layer of cocoa on top. Then thank the young scientists for making craters and say farewell, or, if they want more, start another round with more challenging questions.
- Before the children leave, remind them of the new word they learned: *Do you remember what those holes we made are called? Right, craters!*



Suggested Questions

Before dropping:

- Do you think that will make a big or little crater?
- Can you show me with your hands how big the crater will be?

After the dropping:

- What shape are the craters?
- Which was the biggest/widest?
- Which was the deepest?
- Why did that little one go so deep?
- Would you like to try again from higher?

DEVELOPMENTALLY APPROPRIATE STRATEGIES

Children will be very excited about the invitation to drop balls into a tub of flour. What fun! Facilitation of this activity using developmentally appropriate strategies, however, is essential to transform this from activity from a messy tactile activity to one in which children can extend their science-related understandings and science practices. The activity description contains multiple examples of developmentally appropriate **questioning** strategies for encouraging children to extend their inquiry and notice the outcomes of what they are doing.

An additional strategy that is central to this activity is that of **providing information**. To make the connection between the experiential activity and the Moon's surface, children must first understand the Moon itself. This will require facilitators to support children in noticing the structure of the Moon in the images provided and introducing new vocabulary and information (e.g., “You're noticing the circles on the Moon's surface; those craters were formed when rocks from space hit the Moon's surface a long time ago.”).

Because some children will be as excited by the experience of just dropping the balls and making holes, they may not

respond to your encouragement to verbalize their process and observations. This is okay! Playing in a more exploratory way also helps children build their conceptual understanding of gravity, weight, velocity, and energy. Two important strategies to use in this situation are to: **acknowledge** children’s emotions (e.g., “*You’re having a lot of fun dropping the balls in the tub!*”) and to **model** your interest by narrating your observations of their behaviors (“*You’re dropping the balls from different heights. I’m noticing that the craters you’re making look different too!*”). These approaches tell children that what they are doing is acceptable, but also subtly invites them to engage more intentionally in noticing the outcomes of their actions.

Some children may still be developing their vocabulary for spatial concepts. Use hand gestures to help them interpret the meanings of spatial words such as deeper, shallower, and wider. Ask to them to show with their hands their predictions of how wide or deep a crater will be. Recognize when they use words such as top/bottom or up/down for deep/shallow, and repeat their observations using the correct term. For example:

Child: *This crater is up high.*

Educator: *Yes, I see that it is shallow.* [Gesture with your hands to show what shallow looks like.] *What else do you notice about that crater?*

BACKGROUND INFORMATION

The following background information about the learning science and astronomy is intended for the educator who will facilitate the “Creating Craters” activity. The activity is a developmentally appropriate first step toward the children eventually understanding the concepts explained below, perhaps years later. We do not intend the educator to cover most of these concepts with the children during the activity. This information is provided to give the educator a good basic understanding of the scientific concepts that the activity is moving toward, and preparation to answer questions from very curious children or adults.

LEARNING SCIENCES

Surface of the Moon

Though prior research has not assessed preschool-aged children’s ideas about the composition of the Moon, a study with 6–7 year olds suggests that many children already believe that the Moon’s surface is rocky or hard.¹ They often described the Moon’s surface as being bumpy or with holes in it. A smaller number of children were unsure what the surface of the Moon was like, or only described its color (“white”) and that it would have “big holes in the ground.” Preschool-age children made similar comments describing the Moon’s surface during pilot testing of *My Sky Tonight* activities.² The Moon’s surface is actually grey when seen up-close, though children’s descriptions of holes are a good beginning to describing the craters of the Moon.

Factors that affect crater size

In this activity, children are learning to compare properties of the projectile to the depth and diameter of the craters they make. Rather than focusing on mass, children can consider the notion of weight (determined by an object’s mass and the pull of gravity); children have a tangible sense of the sensation of an object’s weight pulling on their hand and consider this to be a property of the object.³ Children also notice the size of the projectiles and begin to make sense of how this relates to the crater’s size; however, size is complicated by the fact that depending on the density of the object, projectiles may be high mass or low mass but the same size.

Young children’s notions of size and weight are emerging but are not yet reaching an understanding of density. Density is a difficult concept to understand, even for adults, and thus this is not a goal for this activity. Many preschool age children may not combine their understanding of an object’s perceived size with their notion of its weight; in other words, they may not have considered an object to be *heavy for its size*. Smith, Carey, and Wiser found that this *heavy for size* concept (a precursor to the notion of density) developed between ages 5–7 years. In addition, young children often generalize from materials to weight broadly, such as “steel is a heavy material; wood is a light material” even though

¹ Plummer, J.D. & Small, K.J. (2015). *Children’s ideas about the surface of the Moon*. Unpublished study, Pennsylvania State University, University Park, PA.

² Jipson, J. (2015). Unpublished Study.

³ Smith, C., Carey, S., & Wiser, M. (1985). On differentiation: A case study of the development of the concepts of size, weight, and density. *Cognition*, 21 (3), 177–237.



these generalizations may not lead to accurate comparisons when taking size in consideration.³

Controlling variables

While preschool-age children are able to identify different features of objects, they are unlikely to systematically control for variables when making craters, as studies with early elementary students have found that most do not attempt to control for variables without prior instruction.⁴ Thus, the children may not try to keep the height of the ball the same between tests on their own when they are comparing balls of different mass. In a study with 6-year-olds making craters, only two out of twenty-two children controlled for both height and weight while making craters^{5,6}. However, preschool-age children are likely to do trial-and-error comparing aspects of objects, which is a good start towards controlling variables.

ASTRONOMICAL SCIENCE

How were the craters on the Moon formed and why are they all round?

When we drop balls of different sizes and weights into the flour they make dents or impressions in the loose flour, but when rocks from space hit the Moon, they were traveling much faster and exploded when they hit the surface. The nearly circular shape is from material being blasted out equally in all directions. Scientists didn't figure this out until the 1960s. Before that, it was thought that they were volcanic.

When were the craters on the Moon formed?

Most of the craters on the Moon were formed in the early days of the Solar System, 4 billion years ago when there were a lot more asteroids that were left over from building the planets. The gravity from large planets like Jupiter and Saturn was flinging asteroids in all directions throughout the Solar System. There were so many asteroids traveling through our Solar System that impacts were happening frequently on all the rocky bodies closer to the Sun than Jupiter (asteroids, Mars, Earth, Moon, Venus, Mercury). When an asteroid hit the Moon, it would be travelling so quickly that it would explode on impact, making a crater, often surrounded by rays of material ejected from below (called ejecta), as you can see in the image of the crater Tycho on page 8. In the flour model, you will sometimes see rays of white flour against the dark cocoa on the surface.

Did the Moon look the same to the dinosaurs?

Fortunately, there aren't many large rocks in space left that could hit the Moon or Earth today to make craters. Smaller craters are still being formed on the Moon, but one of the youngest craters is Tycho. If they were watching, the dinosaurs roaming the Earth 100 million years ago may have seen the impact and explosion that formed that crater.

Why don't we see craters on the Earth?

These asteroids were also hitting the Earth and forming craters here, but the wind, rain, volcanoes, and earthquakes on Earth erased many of the craters. Some of the asteroids hit the oceans that cover 70% of the Earth's surface, where no craters could be formed, and the atmosphere of the Earth slowed down many of the smaller asteroids and meteors enough that they would explode or vaporize before hitting the land. But without any weather or atmosphere on the Moon, the craters on the lunar surface have stayed in place for millions of years.

Are there different kinds of craters?

Yes, the lunar surface has two types of terrain: the highlands, which are old and covered in craters; and the maria, which are younger and smoother. The maria were formed by volcanic activity flooding the surface with lava, and are mostly found on the side of the Moon facing the Earth. Maria are peppered with younger craters that formed after the volcanic lava cooled.

There are two basic kinds of craters: simple craters are shaped like a bowl, are smaller, and have smooth sides; complex craters are larger, have flat bottoms, sometimes with a central peak, and the sides are often slumped and look like terraces. Ejecta and bright rays of material are more often associated with complex craters.

⁴ Chen, Z., & Klahr, D. (1999). All other things being equal: Acquisition and transfer of the control of variables strategy. *Child development*, 1098–1120.

⁵ Hadzigeorgiou, Y. (2001a). *Young children's (4–6 year old) ideas about natural phenomena and their implications for curriculum and instruction*. Unpublished document, School of Education, University of the Aegean, Rhodes.

⁶ Hadzigeorgiou (2015). Young children's ideas about physical science concepts (Chapter 4). In *Research in Early Childhood Science Education* (K.C. Trundle & M. Sackes, Eds.). Springer: New York.



Most of the Moon's surface is covered by regolith, fine dust and rocks created by impacts.

- For more about the formation of craters, see:
http://www.lpi.usra.edu/education/explore/shaping_the_planets/impact_cratering.shtml
- For a map of some of the features you can observe on the Moon, see:
<http://nightsky.jpl.nasa.gov/docs/ObserveMoon.pdf>
- For interactive videos of the crater formation process, see:
http://www.fossweb.com/delegate/ssi-foss-ucm/Contribution%20Folders/FOSS/multimedia/Planetary_Science/binders/craters/crater_formation/crater_formation_on_the_moon_1.html



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