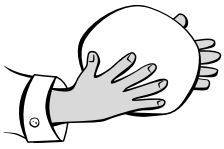
Pizza Dough

Nellie makes pizzas at the local pizza parlor. She starts with a ball of pizza dough. She flattens it by hand. She then tosses the flattened dough until it is stretched into the shape of a large circle.



Part 1: Which best describes what happens to the **weight** of the pizza dough after it is stretched out to make a pizza? Circle the best answer.

A The weight of the dough increases after it is stretched out.

B The weight of the dough decreases after it is stretched out.

C The weight of the dough stays the same after it is stretched out.

Part 2: Which best describes what happens to the **mass** of the pizza dough after it is stretched out to make a pizza? Circle the best answer.

A The mass of the dough increases after it is stretched out.

B The mass of the dough decreases after it is stretched out.

C The mass of the dough stays the same after it is stretched out.

Explain your thinking. What rule or reasoning did you use to decide what happens to the weight and mass of the dough after it is stretched?

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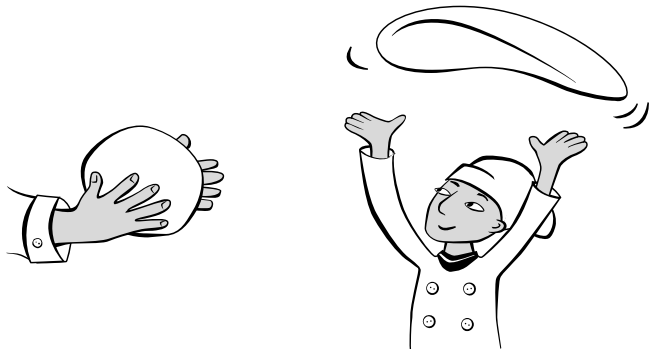
Pizza Dough

Teacher Notes



Purpose

The purpose of this assessment probe is to elicit students' ideas about weight and mass when a property of an object changes. The probe is specifically designed to determine whether students recognize that although weight and mass are different, both the weight and mass of an object stay the same when the object changes shape. Because many students learn that an object's mass is the same on the Earth and the Moon but its weight differs (the object will weigh less on the Moon than on the Earth), they may apply this rule to contexts other than location, such as change in shape.

Related Concepts

conservation of mass, mass, weight

Explanation

The best answer to each part is C: The weight and mass of the dough stay the same after the dough is stretched out. *Weight* and *mass* are terms that students have difficulty distinguishing between. Sometimes when they learn the difference between weight and mass, particularly in contexts such as comparing weight and mass on the Moon versus on Earth, they may develop a misconception that weight and mass must also be different when a property changes, such as the shape of the pizza dough.

On Earth, the gravitational pull of the Earth on an object is measured as weight. Top-loading or hanging-spring scales are typically used to measure weight by the distance a spring stretches or compresses as a result of the load placed on the scale. Weight depends on where an object is located—the weight of an object on top of a high mountain would be a little less than at sea level because the object is further from Earth's center. Weight also differs when an object is located beyond Earth. The weight of an object on the Moon is less than the weight of the object on Earth because the gravitational attraction between the object and the Moon is less than the gravitational attraction between the object and Earth. Likewise,

an object would weigh more on Jupiter than on Earth because of the much larger mass of Jupiter and hence the greater pull by Jupiter on the object. However, regardless of where the object is, if the shape of the object is changed in the same location, its weight is unchanged. (*Note:* The radii of the Moon, Earth, and Jupiter also affect the size of the gravitational force acting on an object. The closer the distance to the planet—the smaller the radius—the larger the gravitational force exerted on an object. However, the difference in mass when comparing the gravitational forces on the Moon, Jupiter, and the Earth is far greater than the effect of distance.)

The gravitational attraction between the Earth and the balled and the stretched-out pizza dough is the same because the Earth pulls on the dough in the same way regardless of shape as long as the nearness to the Earth remains the same. Therefore, the weight remains the same.

Mass is the amount of matter in an object. It is independent of location. In school, mass is typically measured with a balance. To do this, an object is placed in one pan and known masses are placed in the opposite pan until the object and masses are balanced. (*Note:* Weight can be measured with a balance as well.) Regardless of where an object is located, on Earth or beyond Earth, its mass always remains the same. In addition, changing the shape of an object does not change its mass. The ball of pizza dough and the stretched-out pizza dough have the same mass. That's because they both contain the same amount of matter. No matter was lost or gained when the dough was stretched; therefore the mass remains the same.

Administering the Probe

This probe can be used with upper elementary, middle school, and high school students once students have learned to distinguish between weight and mass. The teacher can introduce the probe to the class by working with a ball of actual pizza dough, modeling clay, or other substance that can be shaped into a ball and stretched into a pancake shape.

Related Ideas in *National Science Education Standards* (NRC 1996)

K–4 Properties of Objects and Materials

- Objects have many observable properties, including size, weight, shape, color, temperature, and the ability to react with other substances. Those properties can be measured using tools such as rulers, balances, and thermometers.

Related Ideas in *Benchmarks for Science Literacy* (AAAS 1993, 2009)

K–2 Structure of Matter

- Objects can be described in terms of their properties.

K–2 Manipulation and Observation

- Weigh objects using a scale.

6–8 Manipulation and Observation

- Make accurate measurements of length, volume, weight, elapsed time, rates, and temperature by using appropriate devices.

Related Research

- Researchers have found that children, from an early age, notice how objects differ in how they "press down." This "felt weight" is an early conception of the property of weight (Driver at al. 1994).
- The concept of weight as a pulling-down force and the concept of mass develop slowly. The word *mass* is often associated by students with the phonetically similar word

massive, and thus students often think the mass changes if there is a change in size or volume. Students often compare mass by bulk appearance (Driver et al. 1994).
- The physicist's idea of weight as the force of gravity on an object did not appear to be a firmly held idea in studies of secondary students (Ruggiero et al. 1985).

Suggestions for Instruction and Assessment

- This probe can be used as a P-E-O-E probe (Keeley 2008). Have students *predict* what will happen to the weight before and after changing the shape of the pizza dough or similar material and have them support their predictions with *explanations.* Have them test their predictions using a device that measures weight (e.g., top-loading spring scale). When students' *observations* do not match their predictions, encourage them to revisit and revise their *explanations.* Repeat with mass, using a mass-measuring device (e.g., a balance scale).
- Use caution when explaining the difference between weight and mass based on location. Typically, teachers use the-weight-and-mass-on-Earth versus the-weight-and-mass-on-the-Moon as the phenomenon to explain the difference between weight and mass. However, there is a danger that students may develop a generalization that whenever one thing changes (not just location) weight will be different and mass will always stay the same. Be sure to include examples in which *both* weight and mass do not change.
- If the teacher combines a definition of mass versus weight with a discussion of how their measurement devices differ—for example, how the devices function on Earth versus in other locations such as the Moon—students may be better able to conceptualize the difference between weight and mass.
- Teachers should consider the age, experience, and readiness of their students to determine when it is appropriate to distinguish between weight and mass. "Weight" is sometimes used as a stepping-stone to mass because students can conceptualize "felt weight." Although teachers recognize that *mass* is the correct scientific term to use when referring to the amount of matter an object contains, and that the term *weight* refers to the measurement of gravitational pull on the object, some children just are not developmentally ready to learn the distinction. (There are times, however, when it is fine to use *weight* instead of *mass,* such as when applying conservation reasoning.) The national science standards do not introduce mass until middle school; teachers should therefore refer to their own state or local curricula when deciding whether to use *mass* or *weight* with younger children.
- Teachers should help students be aware that throughout our society, the two terms *weight* and *mass* are frequently used interchangeably. In the supermarket, you will find many products on which the net weight is listed both in English and in metric units—for example, on a bag of Hershey's Extra Dark Chocolate pieces, you will find "NET WT 5.1 oz. (144 g)." The English units are indeed a weight (in this case, ounces), but the metric units are actually a measure of mass (grams). The reason this does not cause any real confusion is that as long as one stays on the surface of the Earth, the ratio of mass to weight is fixed (ignoring extremely small variations in the force of gravity on the surface of the Earth).

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