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Uncovering Student Ideas in Science

25 Formative Assessment Probes

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and Lynn Farrin

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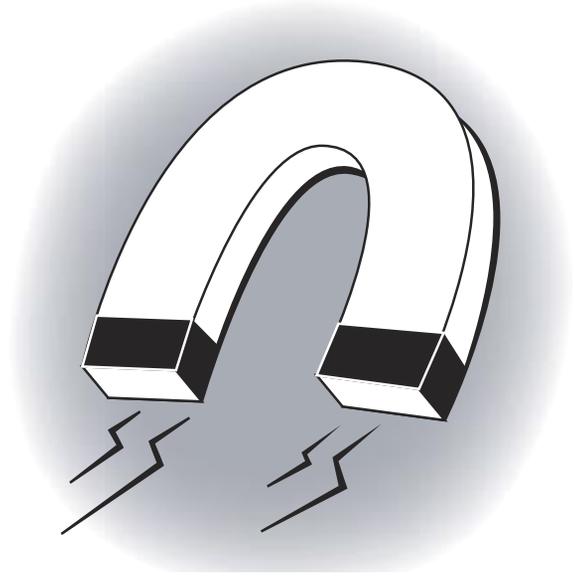


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Is It Matter?

Listed below is a list of things that are considered matter and things that are not considered matter. Put an X next to each of the things that you consider to be matter.

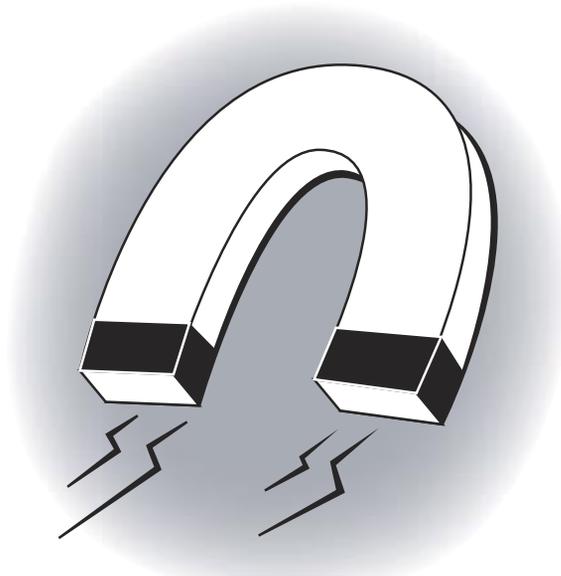
- | | | | |
|--------------------------------------|--|---|--|
| <input type="checkbox"/> rocks | <input type="checkbox"/> salt | | |
| <input type="checkbox"/> baby powder | <input type="checkbox"/> Mars | | |
| <input type="checkbox"/> milk | <input type="checkbox"/> Jupiter | | |
| <input type="checkbox"/> air | <input type="checkbox"/> steam | | |
| <input type="checkbox"/> light | <input type="checkbox"/> rotten apples | | |
| <input type="checkbox"/> dust | <input type="checkbox"/> heat | | |
| <input type="checkbox"/> love | <input type="checkbox"/> sound waves | | |
| <input type="checkbox"/> cells | <input type="checkbox"/> water | | |
| <input type="checkbox"/> atoms | <input type="checkbox"/> bacteria | | |
| <input type="checkbox"/> fire | <input type="checkbox"/> oxygen | <input type="checkbox"/> gravity | <input type="checkbox"/> dissolved sugar |
| <input type="checkbox"/> smoke | <input type="checkbox"/> stars | <input type="checkbox"/> magnetic force | <input type="checkbox"/> electricity |



Explain your thinking. Describe the “rule” or reason you used to decide whether something is or is not matter.

Is It Matter?

Teacher Notes



Purpose

The purpose of this assessment probe is to elicit students' ideas of what matter is. The probe is designed to determine whether students recognize forms of matter and can distinguish between things that are considered to be matter and things that are not (such as energy, forces, and emotions). The probe helps reveal what characteristics students use to decide if something is considered to be matter.

Related Concepts

matter, energy, solids, liquids, gases, mass or weight

Explanation

Items on the list considered to be matter are rocks, baby powder, milk, air, dust, cells, atoms, smoke, salt, Mars, Jupiter, steam, rotten apples, water, bacteria, oxygen, stars, and dissolved sugar. Responses to fire may vary depending on how the student thinks of fire. Fire may be considered matter or energy—the vaporized gases in the flame are matter but the light and heat emitted are energy. All matter is made up of particles (e.g., atoms or molecules); has weight and mass; takes up space (has volume); and exists in the forms of solid, liquid, gas, or plasma. In order to be considered matter, an object, material, or substance must meet these characteristics.

Curricular and Instructional Considerations

Elementary Students

By the end of the elementary grades, students frequently encounter the word *matter* in various topics such as states of matter, properties of matter, and changes in matter. National standards specifically target elementary grades as the time when students develop an understanding that matter exists as a solid, liquid, or gas and has properties that can be observed and measured, even with matter they cannot see, such as gases. The idea that air is a substance that we can feel and takes up space is a grade-level expectation in the national standards. Students develop a beginning notion of “stuff” as matter by examining the materials that make up objects. Energy is a more abstract idea at this stage. The probe is useful in determining what elementary students’ initial ideas are about what constitutes matter and what criteria they use. It is especially helpful to determine if they recognize gases as something that fits with their conception of matter.

Middle School Students

In middle school, students move from examining objects and materials to investigating substances. They start to develop a particulate model of matter that includes a beginning conception of atoms and molecules. The probe is useful in determining whether students link the ideas of observable and measurable properties (such as weight or mass, volume, size, and shape); existence in different states (solids, liq-

uids, gases); and tangible material or particles (substances, atoms, or molecules) to an explanation of whether something is considered to be matter. It can also be used to determine whether students are context-bound in their thinking about matter. This can happen if their prior experiences in learning about matter involved primarily solids and liquids or occurred primarily in a physical science context. The probe can alert teachers to the need to provide experiences with a variety of types of matter, including gases and living matter. It can also be used to provide feedback to the teacher on whether students distinguish between matter and forms of energy, informing instruction in energy-related concepts as well.

High School Students

As the particulate notion of matter becomes more sophisticated in high school, students may still lack a complete idea of what constitutes matter. Although being able to define matter is not explicitly stated in the standards, developing a conception of matter is prerequisite to understanding several standards-based high school ideas, including flow of matter through ecosystems, states of matter, nature of energy, relationship between matter and energy, and behavior and characteristics of gases. This probe is useful in finding out if students retain their preconceptions about matter even after instruction.

Administering the Probe

Make sure students are familiar with the items on the list. You may wish to remove items that

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Physical Science Assessment Probes



Topic: Matter
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elementary students have little or no familiarity with. This probe can also be used as a card sort. In small groups, students can sort cards listing each item into two groups—those that are matter and those that are not. Listening carefully to students' discussions with each other as they sort can lend insight into their thinking. This probe can also be combined with "Ice Cubes in a Bag" (p. 49) and "Lemonade" (p. 55) since students' conservation reasoning is often linked to their conception of matter.

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

K–4 Properties of Objects and Materials

- Objects have many observable properties, including size, weight, and shape.
- Materials can exist in different states—solid, liquid, and gas.

9–12 Structure and Properties of Matter

- Matter is made up of minute particles called atoms.

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

K–2 Structure of Matter

- Objects can be described in terms of the materials they are made of and their physical properties.

3–5 The Earth

- Air is a substance that surrounds us, takes up space, and whose movement we feel as wind.

3–5 Structure of Matter

- Materials may be composed of parts that are too small to be seen without magnification.

6–8 Structure of Matter

- All matter is made up of atoms, which are far too small to see directly through a microscope.

Related Research

- In a study conducted to find out the meaning students gave to the word *matter*, 20% of middle-school-age students described it as something tangible, meaning it could be handled and took up space. By age 16, 66% of students described it this way (Bouma, Brandt, and Sutton 1990).
- Student in grades 4–8 may think that everything that exists, including forms of energy, is matter. Alternatively, they may accept solids as matter but not liquids and gases (AAAS 1993).
- Having a correct conception of matter is necessary for students to understand ideas such as conservation of matter and weight/mass (AAAS 1993).
- Several studies have examined students' ideas about gases. These studies show that students have difficulty accepting the idea that air and other gases have material char-

acter and that they have weight or mass (Driver et al. 1994).

- Some students think of energy as an ingredient (Driver et al. 1994).

Suggestions for Instruction and Assessment

- Knowing students' conception of matter is prerequisite to designing instruction around several matter-related concepts.
- Do not assume that students know what matter is when you use the term. Start with a familiar, operative word, such as *stuff*, until students are ready to use the scientific word *matter*. Be aware that providing a definition such as “matter is anything that has mass and occupies space” is meaningless to students if they don't know what mass and volume are.
- Provide students with experiences that demonstrate (a) all three states of matter, particularly gases, when learning about matter and its properties; (b) physical and chemical changes; (c) conservation of matter; (d) measurement of properties; (e) mass and volume relationships; (f) atoms as building blocks; and (g) classifying matter as elements, compounds, and mixtures.
- Be explicit in defining what matter is, starting with student-developed operational definitions and refining definitions to become more scientific as students gain additional knowledge. Use the operational and scientific definition to provide examples of things that are not matter.
- Develop a “rule” with students for deter-

mining what matter is and have students use the rule to justify ideas about whether something is matter.

- Have students determine weight or mass (if they are familiar with the term *mass*) of seemingly “weightless” materials, such as gases and powders.
- Have students demonstrate what it means to “take up space” with solids, liquids, and gases. Show evidence for the existence of gases and how they take up space, such as feeling the wind, blowing up a balloon, or turning a glass with a tissue stuffed in it upside down in water. Test the idea on things that do not take up space (light, sound).
- Teach and assess the idea of matter in multiple contexts, not just physical science (living matter, Earth materials, and matter in space).
- Sophisticated ideas that may contradict a basic notion of matter such as a particle model of light and light having mass should wait until high school when students are ready to comprehend the matter and energy relationship and understand how a particle of light (photon) differs from a particle of matter.

Related NSTA Science Store Publications and Journal Articles

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Related Curriculum Topic Study Guides

(Keeley 2005)

“Properties of Matter”

“Particulate Nature of Matter”

“States of Matter”