Birthday Candles

Imagine you are at a birthday party. A birthday cake with candles is put on a table in the middle of a room. The room is very large. You are standing at the end of the room, 10 meters away from the cake. You can see the candles. Circle the reponse that best describes how far the light from the candles traveled in order for you to see the flames.

A The light stays on the candle flames.

B The light travels a few centimeters from the candle flames.

C The light travels about 1 meter.

D The light travels about halfway to where you are standing.

E The light travels all the way to where you are standing.

Describe your thinking. Provide an explanation for your answer.

Birthday Candles

Teacher Notes

Purpose

The purpose of this assessment probe is to elicit students' ideas about how light travels outward from its source. The probe is designed to find out if students recognize that light will travel outward from its source, generally in a straight line regardless of distance, until it comes in contact with matter that may change its direction. It also helps determine if students recognize there is light in the space between the visible part of an object that they can clearly detect (the flame) and their eyes.

Related Concepts

light, light source, light transmission, vision

Explanation

The best response is E. The light from the candles will travel away from its source (the flame) to you as long as it is unobstructed by an object or material. Since you can see the candlelight, it has traveled outward from its source—the candle flame—through the room and to your eyes. For you to see the flame, the light emitted from the flame must reach your eye. The eyes are the object, or matter, that the light comes in contact with. Even though it may appear to the student in a lit room that there is only light around the candle, since that is what they can detect with their senses, light is radiating outward in all directions beyond the visible part of the flame, including the space between the light source and the eye of the observer.

Curricular and Instructional Considerations

Elementary Students

Students are beginning to develop early ideas about light as "straight lines or rays" that travel from their source until they contact an object or material. Knowing that light keeps moving in a straight line until it strikes an object is a grade-level expectation in the national standards. Students at this level begin to recognize that some objects, like a candle flame, give off their own light that radiates outward in all directions. While they may start to understand that light travels outward from its source, they may have difficulty conceptualizing that the light travels further than the actual light effect they can see. They may have various conceptual models that include light illuminating a limited space around its source. Their observations of the light surrounding a candle flame may limit their thinking about how far the light travels. This probe is useful in eliciting preconceptions that develop early on.

Middle School Students

When students begin middle school they should know that light keeps traveling in a given direction until it interacts with a material or object. Knowing that in order to see a luminous object, light emitted from a source (in this case the candle) must enter the eye is a grade-level expectation in the national standards. This probe is useful in determining whether students recognize that light exists between the source and the observer and continues to travel beyond the visible light seen around the candle flames to the eye of the observer. Combining these two ideas is slightly more sophisticated than the elementary notion that light travels outward until it strikes an object. This probe is useful in determining whether early preconceptions still persist after elementary grades instruction.

High School Students

At the high school level this probe is useful for identifying prerequisite ideas prior to light and optics instruction. It can be used to determine whether students still revert to their early preconceptions about light transmission held in earlier grades, even after formal concept development in middle school.

Administering the Probe

This probe scenario may be modeled with students. Have students stand around the outside of a room. Place a candle in the center of the room where all students can see it, have students observe the flame, and then pose the question. (*Safety note:* Use a candle wider than it is tall and have an ABC fire extinguisher at hand.)

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

K–4 Light, Heat, Electricity, and Magnetism

- ★ Light travels in a straight line until it strikes an object.

5–8 Transfer of Energy

- ★ Light interacts with matter by transmission.

★ Indicates a strong match between the ideas elicited by the probe and a national standard's learning goal.

To see an object, light from that object—emitted or scattered from it—must enter the eye.

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

3–5 Motion (New benchmark from "Waves" map in *Atlas of Scientific Literacy* [AAAS 2001])

- ★ Light travels and tends to maintain its direction of motion until it interacts with an object or material.

6–8 Motion

- ★ Something can be "seen" when light waves emitted or reflected by it enter the eye.

Related Research

- Studies of 10- and 11-year-old students show that they fail to recognize light as an entity that exists between its source and its effect. They fail to recognize light as something that travels. Two different conceptions of light exist among students that age: (1) light equated with a source and (2) light as an entity located in the space between its source and effect (Guesne 1985).
- The fact that the path that light takes is not directly visible results in comprehension difficulties for students (Ramadas and Driver 1989).
- A study conducted by Stead and Osborne (1980) used the context of a candle in the daytime and found that students did not think light traveled very far from its source.
- Students' reasoning about how far light travels may be related to intuitive rules described by Stavy and Tirosh (1995) in which more A equals more B. In other words, a more intense light (than a candle flame) results in a greater distance traveled.

Suggestions for Instruction and Assessment

- By experimenting with light, K–4 students begin to understand that phenomena can be observed, measured, and controlled in various ways (NRC 1996).
- Explicitly address the idea that light exists in the space between where we see its effect and its source, even though we may not be able to see it directly.
- Middle and high school students can use examples of sources that are very far away, such as the Sun, to explore the idea that light is in the space between its source and where we receive it.
- Project light from a flashlight or other projection device in a lit room. Have students think about ways to test whether there is light between the source and its projection on the wall. Students cannot see the light in between, but, when they hold their hand or a piece of paper in the path of the light, they see that the light projects on it. This phenomenon can help develop the idea that light is traveling in the space between the source and its observable effect.
- Use additional assessments with other examples besides the candle. Children may use a variety of prior ideas depending on

★ Indicates a strong match between the ideas elicited by the probe and a national standard's learning goal.

what the situation is, so it is difficult to ascertain their conceptual model based on one instance. Consider changing the context to a campfire, a lightbulb, a Halloween light stick, etc., and vary the conditions to include both night and day.

Related NSTA Science Store Publications and NSTA Journal Articles

American Association for the Advancement of Science (AAAS). 2001. *Atlas of science literacy.* (See "Waves," pp. 64–65.) New York: Oxford University Press.

Keeley, P. 2005. *Science curriculum topic study: Bridging the gap between standards and practice.* Thousand Oaks, CA: Corwin Press.

Robertson, W. 2003. *Light: Stop faking it! Finally understanding science so you can teach it.* Arlington, VA: NSTA Press.

Stavy, R., and D. Tirosh. 1995. *How students (mis-) understand science and mathematics: Intuitive rules.* New York: Teachers College Press.

Stepans, J. 2003. *Targeting students' science misconceptions: Physical science concepts using the conceptual change model.* (See section on light and color.) Tampa, FL: Showboard.

Related Curriculum Topic Study Guide
(Keeley 2005)
"Visible Light, Color, and Vision"

References

American Association for the Advancement of Science (AAAS). 1993. *Benchmarks for science literacy.* New York: Oxford University Press.

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Guesne, E. 1985. Light. In *Children's ideas in science,* eds. R. Driver, E. Guesne, and A. Tiberghien, 10–22. Milton Keynes, UK: Open University Press.

Keeley, P. 2005. *Science curriculum topic study: Bridging the gap between standards and practice.* Thousand Oaks, CA: Corwin Press.

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Ramadas, J., and R. Driver. 1989. *Aspects of secondary students' ideas about light.* Leeds, UK: University of Leeds Centre for Studies in Science and Mathematics Education.

Stavy, R., and D. Tirosh. 1995. *How students (mis-) understand science and mathematics: Intuitive rules.* New York: Teachers College Press.

Stead, B., and R. Osborne. 1980. Exploring students' concepts of light. *The Australian Science Teacher's Journal* 26 (3): 84–90.