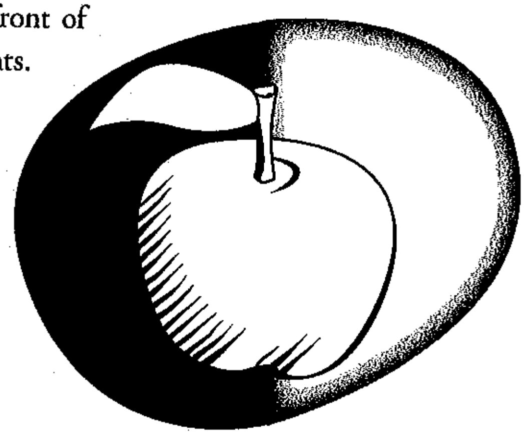
Apple in the Dark



Imagine you are sitting at a table with a red apple in front of you. Your friend closes the door and turns off all the lights. It is totally dark in the room. There are no windows in the room or cracks around the door. No light can enter the room.

Circle the statement you believe best describes how you would see the apple in the dark:

A You will not see the red apple, regardless of how long you are in the room.

B You will see the red apple after your eyes have had time to adjust to the darkness.

C You will see the apple after your eyes have had time to adjust to the darkness, but you will not see the red color.

D You will see only the shadow of the apple after your eyes have had time to adjust to the darkness.

E You will see only a faint outline of the apple after your eyes have had time to adjust to the darkness.

Describe your thinking. Provide an explanation for your answer.

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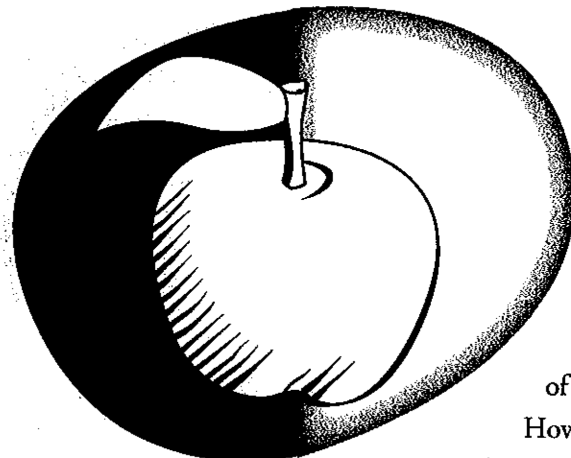
Teacher Notes



Purpose

The purpose of this assessment probe is to elicit students' ideas about how we see objects. The probe is designed to find out if students know that light must be reflected off an object and enter the eye in order for a non-light-emitting object to be visible. The probe helps teachers identify various conceptual models students use to link the role of light to vision.

Related Concepts

light, light reflection, light transmission, color, vision

Explanation

The best response is A. In order to see an object, light must be emitted from or reflected off an object so that it reaches the eye. The path of light is from the object to the eye. It is impossible to see an object in the absence of light (total darkness). However, it is important to be aware that choosing the correct response and explaining that light is needed is not sufficient evidence that students understand that emitted or reflected light must enter the eye in order to see an object. They may simply think that an object is illuminated by light in the room or the eye is the activator of vision when light is present.

Curricular and Instructional Considerations

Elementary Students

Students are beginning to develop ideas about light as something that travels from its source and strikes objects. They begin to recognize that some objects, like a lightbulb, give off their own light and others reflect light. While they may begin to develop an understanding that light travels and is reflected off objects, they have difficulty connecting this idea to how we see. They use various conceptual models that include or do not include light reflection to explain how objects are seen. This probe is useful for finding out elementary students' beginning ideas about light and color and about darkness as the absence of light. It also determines whether students are starting to make a connection between light and how we see.

Middle School Students

Students begin to connect the idea that light reflects off an object to their understanding of how vision works. Knowing that objects become visible when the light emitted or reflected by them enters the eye is a grade-level expectation in the national standards. This probe is useful for identifying middle school students' prior conceptions before designing instruction explicitly aimed at the connection between light and vision.

High School Students

At this level the probe is useful for identifying the middle school prerequisite ideas prior to more sophisticated light and optics instruction in high school. Examining students' responses to this probe can help physics or physical science teachers determine whether students retain alternative ideas about "seeing in the dark" even years after formal concept development in middle school.

Administering the Probe

Make sure students understand there is no light in the room. Although this is explicitly stated in the probe, some students may assume there is some light present because the experience of total darkness is unfamiliar to many.

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. 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 Science Literacy* [AAAS 2001])

- Light travels and tends to maintain its direction of motion until it interacts with an object or material. Light can be absorbed, redirected, bounced back, or allowed to pass through.

6–8 Motion

- ★ Something can be "seen" when light waves

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

emitted or reflected by it enter the eye.

Related Research

- Several studies have shown that students of all ages have difficulty understanding that light must enter the eye in order to see an object. Elementary and middle school students who do not understand that light is something that travels away from its source to another place have difficulty explaining reflection of light off objects (AAAS 1993).
- A variety of alternative conceptual models used by students have been identified to explain the role or absence of light in explaining vision (Driver et al. 1994).
- Ramadas and Driver (1989) asked 456 high school students to explain what happens between a book and the eyes of a girl who is reading the book. Only 31% of the students were able to describe a correct model of light reflection and vision. This was combined with a similar study conducted by Andersson and Karrqvist (1983) of 12- to 15-year-olds who revealed various alternative ideas, including simply that light helps us see better, the eye is the activator of vision rather than the receiver, something goes from the eye to the book, something goes back and forth between the eye and the book, light illuminates an object so we can see it, and a contrast with dark helps us to see.
- Ramadas and Driver (1989; see Driver et al. 1994) reported that "many children did not recognize the necessity of light for vision and thought it was possible to see when it was dark. Having not experienced total darkness, they did not appreciate that light must be present in a room if they could see objects, however faintly" (p. 42).
- The idea that the eye can see without anything linking it to an object is a persistent notion that exists even after students have had traditional instruction in optics (Guesne 1985).
- Fetherstonhaugh and Treagust (1990) investigated students' ideas about seeing in the dark. They found a significant number of children believe that people can see in the dark and that this was more prevalent among city dwellers than children who live in rural areas. However, in both groups of children, over 40% believe that cats can see in total darkness.
- The Annenberg/CPB Private Universe Project (1995) conducted interviews with students in the dark to find out if they believed they would see an object and its color in total darkness. The students interviewed held persistently to the idea that if they waited long enough, they would eventually see the object.

Suggestions for Instruction and Assessment

- The National Science Education Standards (NRC 1996) encourage investigation by elementary students so that they may begin to understand that phenomena can be observed, measured, and controlled in various ways. Phenomena that provide observational evidence for light traveling from a source and reflection should begin to be investigated in elementary grades.

- Most students have never experienced total darkness. Even in a dark room or outside, there is some light diffusing or reflected from a source that allows students to see faint images. Having students experience total darkness in a sealed-off room, photographic darkroom, or dark box may be helpful. Also, ask students to think of areas where there would be total darkness (e.g., in a mine shaft or deep within a cave).
- The ideas in this task can be tested by students in school or at home. After students commit to an outcome, have them test it with an apple in a darkened, windowless room, closet, or dark box. Encourage students to think about their observations, and discuss reasons that could explain why their experience did not match their prediction. Students may come up with the correct explanation on their own through a dissonance-resolving discussion.
- Combine learning about the nature of light with the nature of vision. Explicitly link how light travels from an emitting source or reflection off an object with how we see objects. Students may understand how light reflects in straight lines, refracts, and scatters but may still fail to link these concepts to how we see objects unless it is addressed in instruction.
- Use a variety of contexts. Students may understand the idea of direction of reflection of light and how it enters the eye when working with mirrors or shiny surfaces but may fail to apply ideas to light sources, ordinary objects like an apple, or dull surfaces.
- Be aware that activities such as observing pupils of the eye getting larger in the dark and learning about nocturnal animals with large eyes may contribute to the idea that it is the eye alone that is responsible for seeing. Emphasize that these biological features are intended to maximize the amount of light that can enter the eye.
- Encourage students to draw directional diagrams that include a light source, an object, and the eye to show how the eye sees an object. Ask students to explain their diagrams.
- Modify the assessment to contrast ideas about black, white, and different-colored objects.

Related NSTA Science Store Publications and NSTA Journal Articles

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

Driver, R., A. Squires, P. Rushworth, and V. Wood-Robinson. 1994. *Making sense of secondary science: Research into children's ideas.* London and New York: RoutledgeFalmer.

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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 Guides
(Keeley 2005)
"Visible Light, Color, and Vision"
"Senses"

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