AR-Assisted Learning

Using augmented reality to teach physics

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Target Grade Levels: 11-12

Subject Areas: Physics

Time Required: 15 to 20 minutes per group of two to three students for using app

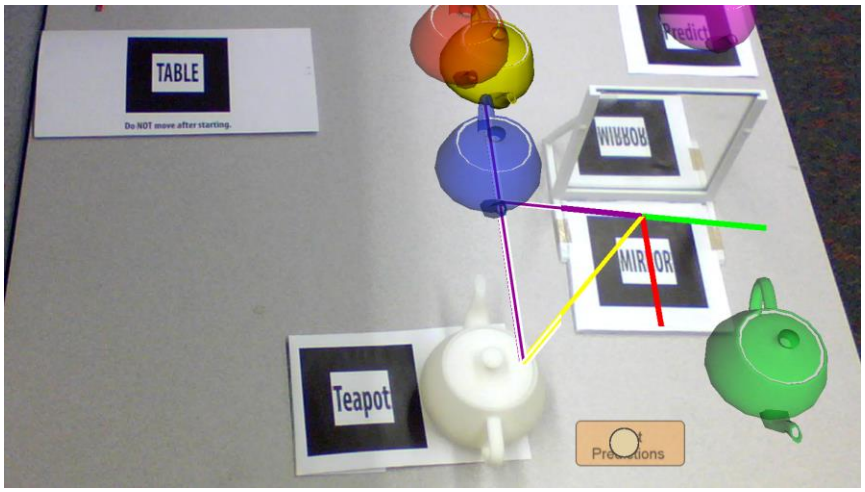
Lesson Objectives:

1. Plan and conduct investigations to determine the effect of placing objects made with different materials in the path of a beam of light. [NGSS 1-PS4-3]
2. Use tools and materials to design and build a device that uses light or sound to solve the problem of communicating over a distance. [NGSS 1-PS4-4]
3. Cause and Effect: Simple tests can be designed to gather evidence to support or refute student ideas about causes. [NGSS Cross-Cutting Concept]
4. Energy can be transferred … by light waves. [Iowa Core S.9-12.PS.17]
5. Waves transfer energy when they interact with matter. [Iowa Core S.9-12.PS.18]

Materials Required:

- 5 AR Markers [free PDF]
- Mirror and Stand [purchased and 3D printed]
- 3D Print of "Utah teapot" [free file]
- Tablet computer running Windows with installed software [free software]
- A clear table for the objects used for interaction

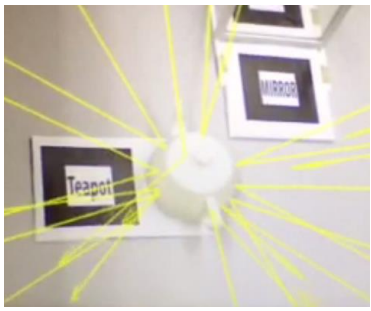
Resources available at:
http://arlab.me.iastate.edu/ar-physics



Lesson Summary

Our app (screenshot above) takes students through a sequence that helps them learn about how light travels, and how this relates to images formed in the presence of mirrors.

When a student first starts the app, she is given visual directions to place the augmented reality markers on the table. (AR markers are pieces of paper or cardboard that have a 2D pattern that the tablet can use to place 3D objects in the scene.)



The student is then reminded how light behaves when it hits an object - bouncing in all directions.

Then student and her team-mates are prompted to place a prediction AR marker where they believe the *image* of the teapot is located. The app then shows them the true location of the image, as well as ray diagrams. This is shown above.

The app concludes by allowing high school students to investigate light and reflection models in an interactive way, while representing information about the travel of light in different ways:

- With or without animation,
- Single light rays,
- Multiple light rays,
- Waves, and
- Particles.

ARLAB

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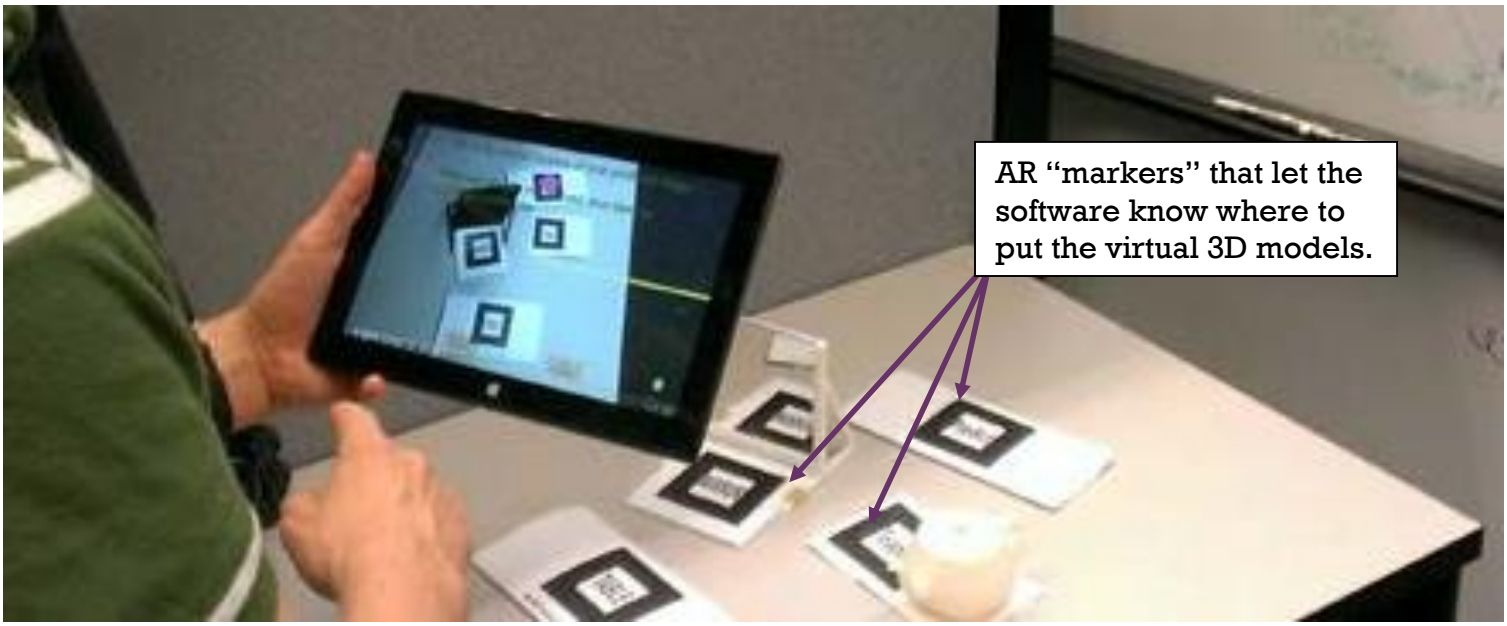

Options for prepping students:

1. By observing light from a laser, students develop understanding of how light is reflected from source to observer in different ways - using small-group and whole-class Socratic dialog.
2. Formalize this new understanding by drawing ray diagrams to describe the paths that light takes.
3. Use a partially covered light bulb to help demonstrate that light can radiate in all directions from each point on an object.

Options for Next Steps

1. Use real world mirrors of different shapes (concave and convex) and different focal lengths to observe the location of the images generated.
2. Refer back to the application to aid with making hand-drawn ray diagrams to explain these observations.

Assessment Option

We recommend use of the Goldberg/McDermott interview method for assessing students' understanding of the behavior of light. This will be available at the website listed in the materials section.

Extension

This application will soon include support for:

- concave and convex mirrors,
- concave and convex lenses, and
- multiple optical objects simultaneously.

A subsequent application will address electromagnetism, visualizing:

- electric and magnetic field lines,
- equipotential surfaces, and
- effects of fields on moving charged particles

AR in Education

Augmented Reality is a technology that interfaces with virtual imagery with the real world in an interactive way.
It has been used in education to **make the invisible visible**.
This frees their cognitive faculties for higher order thinking.

The combination of AR's strengths with guidance from physics education research presents promise for teaching about geometric optics and more.