Seeing Double: 3D Vision

Take home points:

- Binocular vision lets us see how far away something is; because our eyes are in slightly different places, they see different things, and our brains combine them into one image.
- 3D glasses work by showing our eyes two different images; our brains combine them into one image that is nearer or farther away than the individual lines are.
- This is how 3D movies work!

**Part 1: Binocular Vision and Depth Perception**

Discussion: How do we know how far away something is? Ask for suggestions: some responses could be "how things overlap," "how big something looks", "whether something is sharp or fuzzy." One other way is because we have two eyes. Let's see why that helps.

Experiment 1:

Supplies:

- Pennies
- Small cups
- A table

Put a cup about 2 feet in front of the student.
Ask the student to close one eye.
Hold one of the pennies in the air about 18 inches above the table. Move it slowly (front and back, not side to side)

Tell the student that you'll drop the penny whenever he or she says, "Now!" The idea is for the student — with one eye closed — to judge when the penny is over the cup so the penny will drop into the cup.

Give the students five tries with one eye closed, then five tries with both eyes open. Demonstrate this with one student, then students can pair up and try with their partner.

Have students hold the penny at arms length and close first one eye, and then the other eye. How does the position of the penny change (compared to things behind it)? Try this with the penny closer and farther away (have the student's partner hold the penny farther away). How does the distance it "jumps" change?

How do you have to move your head to make the right eye position to appear where the left eye position was (it may help to have their partner hold the penny for them)?

Where does the penny appear to be when they open both eyes?

Discussion:

Why do you think it is harder to get the penny in the cup with 1 eye closed? Why does the position seem to change when you switch eyes?
*Because your eyes are in different positions, they see things from slightly different angles.*
What does your brain do with the two images?
*It combines them into 1 picture that is halfway between what each of the eyes sees.*
How does that help us see in 3D and tell how far away something is?
*The distance between the two images changes depending on how far away something is, so your brain "knows" how far away it is.*

**Part 2: Tricking Your Brain with 3D Glasses**

Discussion: Have you ever been to a 3D movie? Did you try closing one eye or taking off your glasses? What did you see? How do you think 3D movies work? That's what we'll be learning next.

Experiment 2:

Supplies:

- Red/Blue 3D glasses
- Simple 3D line drawings
- 3D paper
- Black pens or thin black markers
- 3D drawing tool (optional)
- 3D Mars photos

Discussion:

> Why is the red lens of the glasses red? Why is the blue one blue?
> *Don't let them struggle with this for too long. The red one is red because it only lets red light through, and the blue one only lets blue light through.*

Hand out the 3D glasses and red/blue line drawings. Have students look at the line drawings without the glasses first, and then with the glasses on. Have them close one eye and then the other.

Have the students place a finger on the part of the picture that looks the "closest" to them and then take off the glasses. Are the lines close together or far apart at that point? Which line is on which side?

Have them look at the drawing while rotating it 180 degrees. What happens? Now which side looks the closest? Have students point to it and take off their glasses. Which line is on which side?

Discussion:
Which lines do you see with just your right eye? Which with just your left? Why is that?
*Because the blue lens only lets blue light through, you can only see the blue lines, etc.*
What do the two images remind you of? Why do you think the picture "pops" above the page?
*This should remind them of the left and right-eye images of the penny. The picture is 3D because your brain combines the two images to make something closer than the page.*
Why do you think the "distances" of different parts of the picture changed when you rotated the page?
*When the blue line is on the same side as your "red eye" (relative to the red line) it looks closer. When it is on the side of your "blue eye" it looks further away. Your brain sets the "distance" to make the red and blue lines fall on top of each other. If you point from each of your eyes to the line of the same color at a "close point" of the drawing, you'll see that the lines cross above the page. That's where your brain thinks the drawing is when your glasses are on.*

Give each of the students a sheet of 3D paper. Have them look at the blank sheet with and without the glasses on. What do they think will happen when they draw on it in black?

Have the students draw something on the sheet in black marker (or inky black pen) and then look at it with the glasses on. How does it look?

Discussion:
Why does your picture "pop" above the page?
*Your brain thinks the lines you drew are in the same place on both grids, which is only possible if the lines are closer to you than the page.*

*This is the same technique, basically, that is used for 3D movies. Students may ask why the glasses they wear at the movies aren't red and blue. 3D movies these days use left- and right-circularly polarized images instead, but that's going to be difficult to explain. You can explain that the light waves "point in different directions."*

Pass around the images of Mars from NASA to show how even complex photos can be made 3D this way.

If there is extra time, students can take turns trying to draw 3D images on white paper using the compass-like 3D doodling tool.