

Evo Classroom Application: Demonstration of the Optics of Thin Convex and Concave Lenses

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Introduction

A thin lens is one for which its thickness is considerably small when compared to distances associated with its optical properties such as the radii of curvature of its spherical surfaces, its primary and secondary focal lengths, and object and image distances. When light passes through any lens, refraction at each of its surfaces is responsible for its image-forming properties. Every thin lens in air has two focal points, one on each side of the lens, and equidistant from the lens center. The **central axis** of a thin lens is a straight line perpendicular to the two lens faces and passing through the geometric center of the lens.

This Ozobot classroom application can be used to demonstrate the optical behavior of thin convex and concave lenses. Figure 1 shows the difference in the shapes of **convex** and **concave** lenses. With Evo *simulating* a ray of light as it moves on the provided OzoMaps, students can visualize how light is bent by these lenses as well as how real and virtual images are formed.

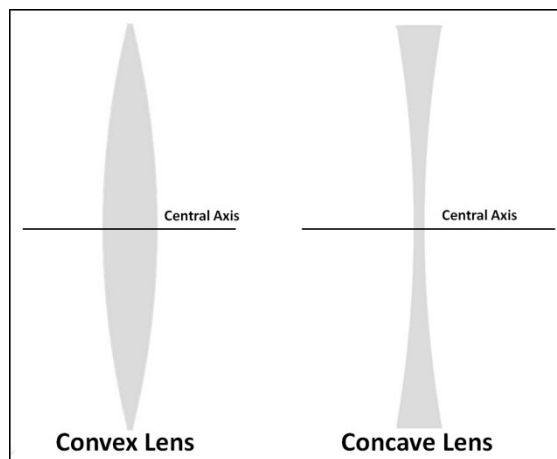


Figure 1

As can be seen in Figure 1, convex lenses are thicker on the central axis, whereas concave lenses are thinner there. When parallel rays of light enter one side of a convex lens, they get closer together or converge on the other side. However, when parallel rays of light enter one side of a concave lens, they spread out or diverge on the other side. Convex and concave lenses are therefore often referred to as *converging* and *diverging* lenses, respectively.

The OzoMaps and OzoBlockly Programs for This Lesson

There are two OzoMaps for this lesson—one for demonstrating properties of a convex lens and one for a concave lens. Each of the OzoMaps requires a different OzoBlockly program. Make sure that the program *ConvexLens.ozocode* (share code is **q2yqu3**) is used with the convex lens OzoMap and the program *ConcaveLens.ozocode* (share code is **a6zpaw**) is used with the concave lens OzoMap. For reference purposes while discussing this classroom application, Figures 2(a) and 2(b) contain small versions of the OzoMaps. Full-page versions for both maps that can be printed and used with Evo appear on the final two pages of this document.

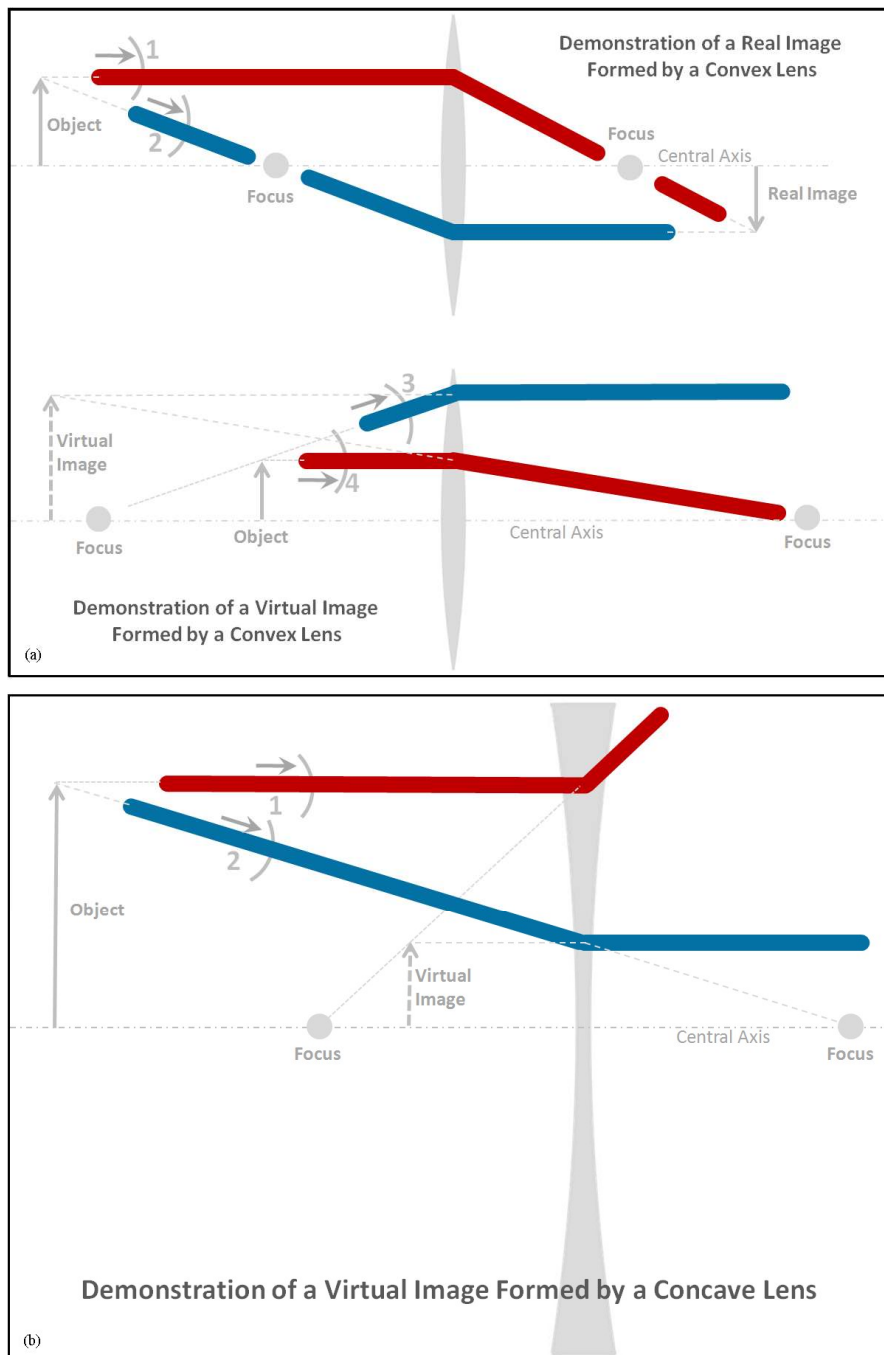


Figure 2

Figure 2(a) shows the OzoMap for demonstrating properties of a convex lens. The top half of the OzoMap shows the formation of a *real image* on the far right from an object on the far left. The incident ray labeled 1 is parallel to the central axis, and the convex lens refracts this ray through the focus on the right side of the lens. The incident ray labeled 2 comes in through the focus on the left and refracts parallel to the central axis. An example of this is how the lens of the human eye works. The lens forms a real image on the retina at the back of the eye that is upside-down. The brain then acts to make the image seem upright.

The bottom half of the OzoMap in Figure 2(a) shows the formation of a virtual image from a convex lens, when the object is between the lens and the focal point. The incident ray labeled 3, appearing to be coming from the focus to the left of the lens, is refracted parallel to the central axis. The dotted gray line extends the refracted ray to the location of the virtual image. The incident ray labeled 4, arriving parallel to the central axis, refracts and converges at the focal point to the right of the lens. The dotted gray line extends the refracted ray to the location of the image. The arrowhead of the image is at the intersection of the two refracted rays' extensions. The most common example of this is found in the behavior of a magnifying glass. When the object is *between the focus and the lens*, the image formed is *virtual* and *larger* than the object.

Figure 2(b) shows the formation of a virtual image from a concave lens. The incident ray labeled 1 originates at the arrowhead of the object and is parallel to the central axis. The lens diffracts and diverges the ray such that it appears to be coming from the focus on the left, as shown by the dotted line extension. The incident ray labeled 2 coming from the arrowhead of the object and heading for the focus on the right, refracts parallel to the central axis. A dotted line extension is then drawn backwards from the refracted ray. The arrowhead of the image is at the intersection of the two refracted rays' extensions. In the case of a concave lens, the image is virtual for all object positions, is smaller than the object, is upright, and lies closer to the lens than the object. One of the most common practical uses for concave lenses is to correct vision that is nearsighted. The nearsighted eyeball is too long, causing far-away images to form somewhat short of the retina. A properly fitted concave lens diverges the rays just enough to correct this problem.

Running the OzoBlockly Programs

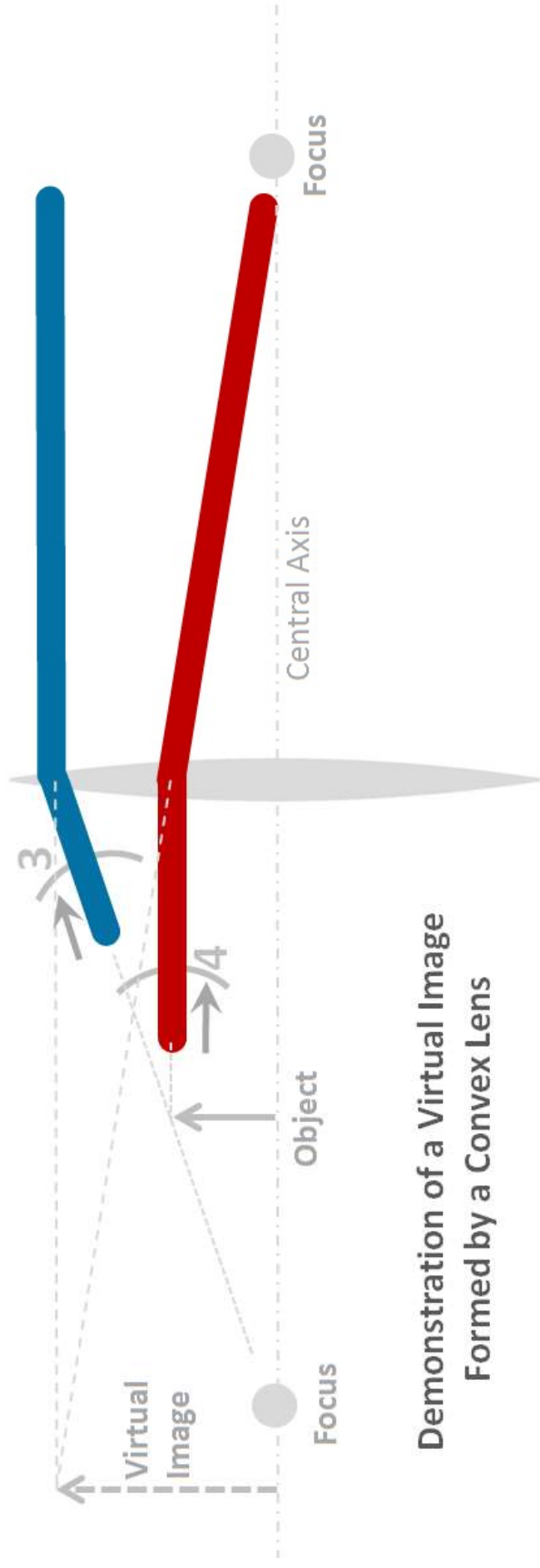
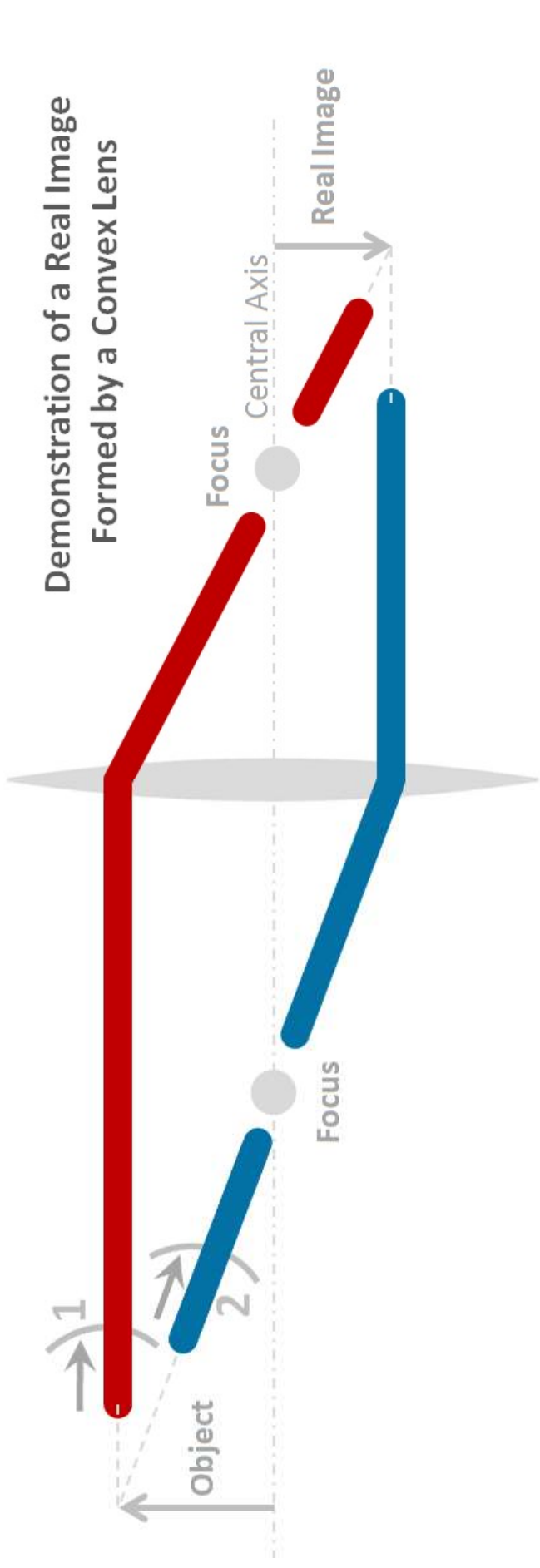
1. There are two OzoBlockly programs accompanying this classroom application. Load the OzoBlockly program *ConvexLens.ozocode* (share code is **q2yqu3**) when using the convex lens OzoMap. Load the program *ConcaveLens.ozocode* (share code is **a6zpaw**) when using the concave lens OzoMap.
2. Place Evo at the location labeled with the number 1, facing the direction shown by the gray arrow and with his leading edge on the curved gray line.
3. Start the program that has been loaded into Evo. He will display a red LED and follow the red pair of incident/refracted rays.
4. Evo will stop at the end of the red refracted ray and display a white light for seven seconds. This should give you time to lift and move Evo to location 2. He will display a blue LED and follow the blue pair of incident/reflected rays
5. Evo will stop at the end of the blue refracted ray and display a white light, again giving you seven seconds to lift and move Evo to the next numbered location.

6. Evo will stop after traversing the last pair of numbered incident/refracted ray pairs, display a white LED momentarily, and then turn off automatically.

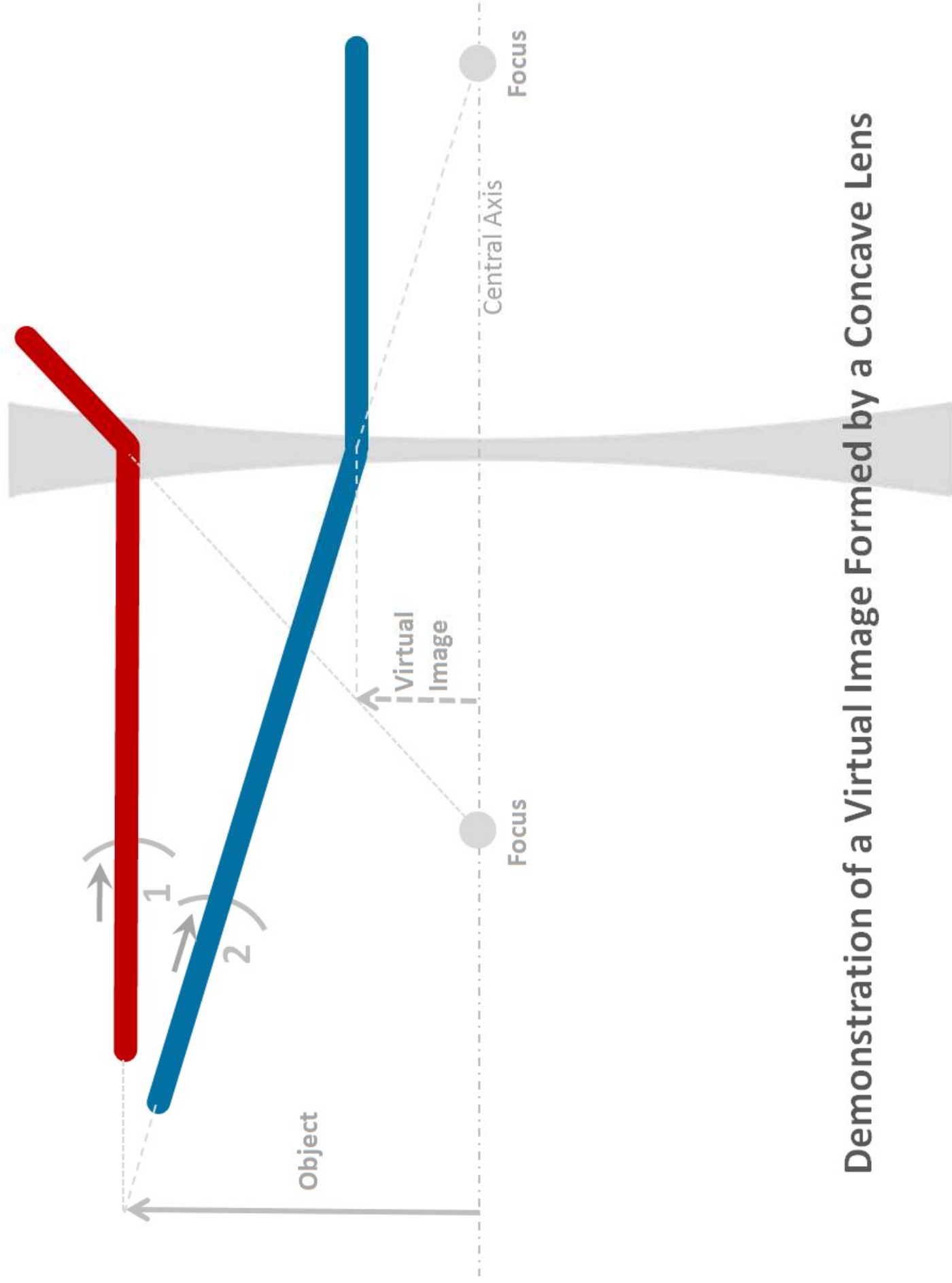
Student Activity

After the students have worked with their Ozobot Evos, and they understand the behavior of both convex and concave thin lenses, ask them to do some WWW research to find real world applications of convex and concave lenses in addition to those mentioned earlier in this document.

Demonstration of a Real Image
Formed by a Convex Lens



Demonstration of a Virtual Image
Formed by a Convex Lens



Demonstration of a Virtual Image Formed by a Concave Lens