MIRRORS

Differentiating real and virtual images

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Differentiating real and virtual images

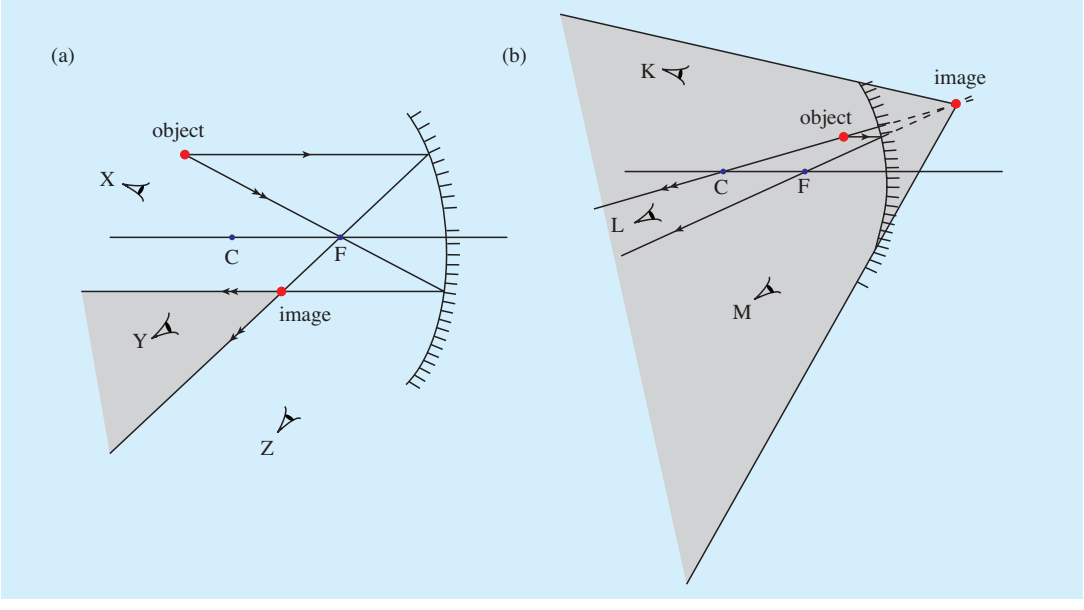

Figure 1. *Images in a concave mirror: (a) real image, (b) virtual image.*

Plane and convex mirrors create only virtual images while concave mirrors can create both virtual and real images. A virtual image is one that cannot be obtained on a screen and can only be seen when looking directly at the optical device. The image is formed by the convergence of the rays' extensions after reflection or refraction, not by the convergence of the rays themselves. In contrast, a real image occurs where rays do in fact converge. This image can be seen on a screen or when standing in an appropriate position in front of an optical device (as seen in figure 1(a), while an observer standing at point Y in the field of vision can see this image, observers standing outside the field of vision at points X and Z cannot). A virtual image, however, can generally be seen by all observers positioned in front of the mirror. For example, in figure 1(b), all of the observers positioned at points K, L and M can see the virtual image. From this we can conclude that a virtual image has a larger field of vision than a real image.

Students generally have the misconception that 'a real image cannot be seen without a screen' or that 'you can only see a real image if you position a screen at the place where the image has formed' (these two ideas are generally discussed in textbooks) [1]. Because of this, students state their belief that every image they see in a mirror is a virtual image. When they look at a concave mirror with a focal length of 10 cm and see a small and inverted image from a distance of 100 cm, they identify these images as virtual images. When the students are asked why they think these are virtual images, some of their answers are 'we see the image directly,' 'it is visible without a screen,' or 'it's a virtual image because it's behind the mirror.' As can be seen from these responses, the students do not realize that it is also possible to see a real image when they look into a mirror.

Some of the images seen when looking into a concave mirror are virtual and some are real. It is important to make use of suitable demonstrations to teach students how to differentiate between which images are virtual and which are real. Such demonstrations will provide the opportunity to make a more comprehensive analysis of the images seen in mirrors and lenses and create a foundation for creating the correct conceptions in students' minds. This in fact was the starting point of the current study.

We showed the students the pictures displayed in figure 2, taken from the physics textbook by Serway

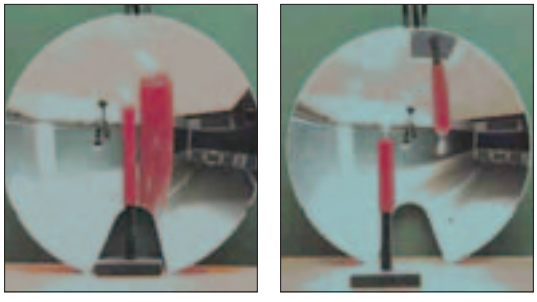

Figure 2. *Using a concave mirror. Left: virtual image; right: real image [2].*

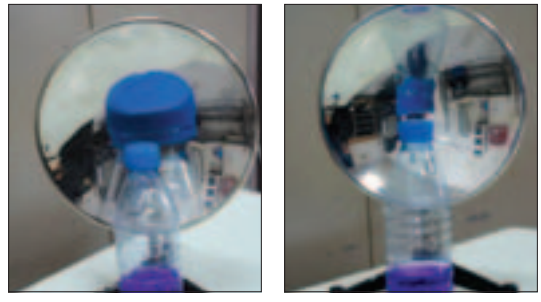

Figure 3. *Looking into a concave mirror. Top left: virtual image; top right and bottom left: real images. (Photographs taken for this study.)*

and Jewett [2], about the formation of images in a concave mirror. The students identified the images in both pictures as virtual images. The explanations they offered for their perception included statements such as 'the image can be seen without the use of a screen,' or 'both images are behind the mirror.'

To demonstrate that their explanations were wrong, the students were exposed to a situation similar to the one shown in figure 3. We first captured an image as seen in figure 3(a) (object between the focal point and a concave mirror surface, image flat and virtual) and then asked the students what kind of image this was. All of the students replied that it was a virtual image. Subsequently, as in figure 3(b), we arranged the object (the water bottle) so that the image would fall exactly on the object (object in the centre of a concave mirror, image is at centre, inverted and real) and then asked the students whether this was a virtual or a real image.

A good percentage of the students started making statements such as 'we can see the image but it's not behind the mirror.' They continued with, 'could it possibly not be virtual? But if it is, how can it be seen like this?' Some students tried positioning their fingers horizontally in place of the water bottle, joining their fingers with the image reflected in front of the mirror without actually touching it. After experiencing this, most of the students made statements such as 'this image must be a real image because it's in front of the mirror.' The students were asked to portray what they had seen in the demonstrations in a drawing. After a general discussion, most students then said 'it seems that a real image can appear without a screen and the inverted images we saw in the concave mirror were actually in front of the mirror.' Following this, as in figure 3(c), an image of the classroom was captured in the concave mirror and the students were asked what kind of image this was. After a short discussion, most students were able to differentiate the image, saying 'it looked like it was behind the mirror but it's actually in front of it and it's a real image.'

Similar studies were conducted by Graham [3], Corni [1], and Balta and Eryılmaz [4]. Graham used the real image formed in his camera to convince students that the real image was formed in front of a concave mirror. Corni obtained a real image with a concave lens and without a screen and Balta and Eryılmaz used a spoon (concave mirror) to show that the inverted image or real image formed inside the spoon, when looked at closely, is actually formed in front of the spoon. The researchers demonstrated this phenomenon using both photographs and drawings. It can be said that such studies are very useful for teachers. However, the results of the three studies described here also indicate that students are highly likely to have the following ideas: 'if the image appears when someone looks at the mirror, it's virtual,' 'the image appeared without the use of a screen so therefore it's virtual,' or 'the image is behind the mirror so therefore it is virtual.' In the situation above, only a small water bottle and a concave mirror were used to capture a moment where object and real image appeared together (because the object and the image were in the central focus of the concave mirror) in order to help students perceive that a real image could be

formed in front of a concave mirror without using a screen. Teachers may make use of these activities in their classes to help students correct their misconceptions. The study was carried out with science teacher candidates and can easily be implemented in elementary and high school classrooms.

Acknowledgements

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