**Seeing the bottom**

Alice jumps into a rock pool.

It’s a lot deeper than it looked from the edge!

Alice’s friends are talking about what she did.

They are talking about why the water looked shallow.

**Katie:** Light from the bottom bends as it moves through the water.

**Lucy:** The image of the bottom changes direction as it leaves the water.

**Niamh:** Light from the rocks changes direction as it moves into the air.

**Megan:** The water magnifies the rocks on the bottom.

**To answer**

1. Who is right about why the pool looks shallow?
   * *Explain your answer*
2. Who is wrong about why the pool looks shallow?
   * *What would you say to help them understand?*
3. How can a diagram show what happens more clearly?

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*Physics > Big idea PSL: Sound, light and waves > Topic PSL3: Making images > Key concept PSL3.2: Refraction and lenses*

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| **Response activity** |
| **Seeing the bottom** |

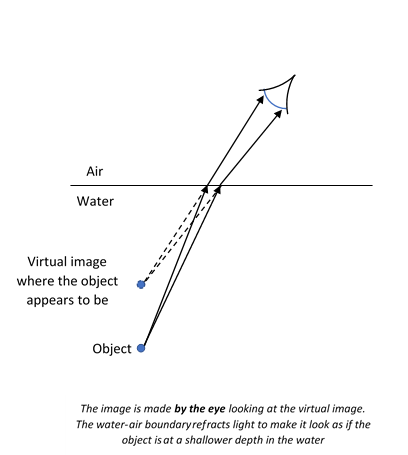
**Overview**

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| Learning focus: | All light from each point of an object that passes through a converging lens is bent (refracted) to a corresponding point in a sharp image. |
| Observable learning outcome: | Explain why water can appear shallower than it really is. |
| Activity type: | Talking heads |
| Key words: | Refract, refraction, apparent depth |

This activity can help develop students’ understanding by addressing the sticking-points revealed by the following diagnostic question:

* Diagnostic question: How deep?

**What does the research say?**

A common strategy for teaching students about refraction is to demonstrate examples of refraction phenomena and to explain the observations using ray diagrams that show how light is bent by glass blocks. In this approach students may use a ray box to explore how light travels through a parallel sided glass block to understand the nature of refraction. They change the angles of incidence to establish: a change of direction only occurs at an interface; light travelling perpendicular to the interface is not refracted; and light bends towards the ‘normal’ when entering more dense medium and vice versa (Tear, 2011).

In order to understand how ray diagrams explain refraction: students first need to understand that light is emitted in all directions from each point on the source (Rice and Feher, 1987; Dedes and Kanstantinos, 2007; Galili and Hazan, 2000; Andreou and Raftopoulos, 2011); and the idea that rays *represent* the direction light travels in (Andreou and Raftopoulos, 2011).

A *virtual image* formed by refraction is not really an image – it is not a *real* image. As with observing reflections in a plane mirror, it is important to recognise that the observer is an inherent part of the optical system (Galili and Hazan, 2000; Andreou and Raftopoulos, 2011) and that the real image which we observe is formed on the retina of the eye. As with plane mirrors, it is helpful to use dashed, ruled lines to work out where each ray of light appears to come from; it is here that the object is seen to be because the image formed on the retina is exactly the same as if the object *were* here. The ray diagram shown here is used ‘to find where the object appears to be’.

**Ways to use this activity**

This task is intended for discussion in pairs or small groups. It can be done as a pencil and paper exercise or projected onto a screen.

Students should read the statements and follow the instructions on either the worksheet or the PowerPoint. Listening in to the conversations of each group will often give you insights into how your students are thinking. Each member of a group should be able to report back to the class.

Feedback from each group can be used, with careful teacher questioning, to bring out a clear description or explanation of the science.

*Differentiation*

The quality of the discussions can be improved with a careful selection of groups; or by allocating specific roles to students in the each group. For example, you may choose to select a student with strong prior knowledge as the scribe, and forbid them from contributing any of their own answers. They may question the others and only write down what they have been told. This strategy encourages contributions from more members of each group.

NB in any class, small group discussions typically improve over time and a persistence with this strategy is often very successful in the medium to long term.

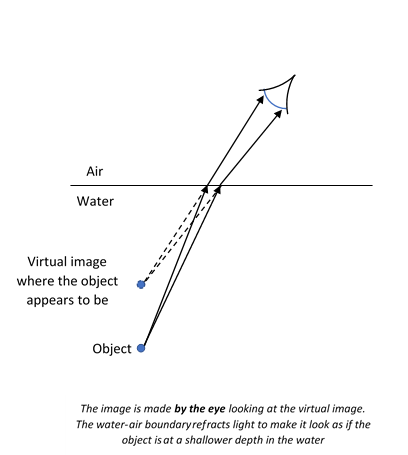
**Expected answers**

Niamh is the only one who is right. Light from the bottom bends at the surface. Tracing rays of light back from the eye in straight lines, shows that rays from a point on the bottom meet at a shallower depth than the real origin of the light rays.

Katie describes the light being bent as it passes through water, which is uniform in all directions. There is no mechanism *within* the water to make light bend consistently in one direction.

Lucy is thinking of an image as a physical replication of an object which can travel through the water and turn as a whole. This misunderstanding cannot explain why the image should appear to be at a particular depth, whereas the light ray idea can.

Megan has used the idea that things look bigger when they are nearer to attribute a property to the water. There is no mechanism within the water that can explain how the bottom can be magnified. Observation shows that things seen in the pool do not look smaller if removed from the pool.

A diagram shows how light rays move from the bottom of the pool to Alice’s eyes. These can be traced back using a ruler to show where they would have crossed if they had not been bent on leaving the pool. This shows exactly where the object appears to be.

**Acknowledgments**

Developed by Peter Fairhurst (UYSEG).

Images: Peter Fairhurst (UYSEG).

**References**

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