*Physics > Big idea PSL: Sound, light and waves > Topic PSL2: How we see*

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| **Key concept (age 11-14)** |
| **PSL2.1: The ‘passive eye’ model of vision** |

**What’s the big idea?**

A big idea in physics is waves because it is the key to explaining how energy can be transferred from one object to another object by radiation, even when the objects are not touching. Waves carry information that can be detected by humans or manufactured detectors. Understanding waves helps us to communicate, explore the universe, and transfer energy to where we want it.

**How does this key concept develop understanding of the big idea?**

This key concept helps to develop the big idea by building on the concept that luminous objects are seen because light from them enters the eye, in order to help develop students’ understanding of how non-luminous objects are seen by the light that they scatter.

****The conceptual progression starts by checking understanding that light can enter an eye through its pupil. It then supports the development of the ‘passive eye’ model of vision when there is an obvious light source, in order to enable understanding of how non-luminous objects can be seen in diffuse light.

**Using the progression toolkit to support student learning**

Use diagnostic questions to identify quickly where your students are in their conceptual progression. Then decide how to best focus and sequence your teaching. Use further diagnostic questions and response activities to move student understanding forwards.

**Progression toolkit: The ‘passive eye’ model of vision**

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| **Learning focus** | Objects are seen when light reflects off them into our eyes. | | | | |
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| **As students’ conceptual understanding progresses they can:** | **C o n c e p t u a l p r o g r e s s I o n** | | | | |
| Describe the pupil in an eye as a hole that light can go through.  **P** | Explain how luminous objects can be seen when light from them enters the eye.  **P** | Illustrate how non-luminous objects can be seen when light reflects off them and enters the eye.  **P** | Explain how non-luminous objects can be seen when sunlight reflects off them and into our eyes. | Apply ideas of how non-luminous objects are seen to interpret new phenomena.  **B** |
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| **Diagnostic questions** | My eye | Seeing the light | In the dark | Seeing an explanation |  |
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| **Response**  **activities** |  |  | How do we see? | | Laser beam |
|  |  |  | Explaining seeing | Seeing theories |

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| Key: | | | |
| **P** | Prior understanding from earlier stages of learning | **B** | Bridge to later stages of learning |

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| **My eye** | **Seeing the light** | **In the dark** | **Seeing an explanation** | **How do we see?** |
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| Confidence grid | Predict, explain, observe, explain | Confidence grid | Explanation story | Talking heads |
| **Explaining seeing** | **Laser beam** | **Seeing theories** |  |  |
|  |  |  |  |  |
| Explanation story | Predict, explain, observe, explain | Analysing an explanation |  |  |

**What’s the science story?**

*The ‘passive eye’ model of vision*

We see an object when light from it enters our eye. We see a non-luminous object when light from a source strikes the object, and some of the scattered light from it enters our eye. A beam of light travelling between two objects is not directly visible. We only see the path of the beam when some of the light is scattered into our eye by particles (e.g. of dust, or water droplets) in its path.

**What does the research say?**

Optics instruction often takes for granted the essential fact that light must enter the eye for vision to take place. The need to convince the learner of this is seldom recognised (Galili and Hazan, 2000). This can be as simple as observing that the pupil in an eye is actually a hole that light can pass through (Gonzalez-Espada, 2003; Hardman and Riordan, 2014).

Many studies have explored children’s knowledge of optics and all have identified misunderstandings that are based on ‘common sense’ interpretations, which often suffice to explain everyday observations (Galili and Hazan, 2000). However children commonly use different ideas to explain different optical phenomena and rarely use one model consistently (Andersson and Karrqvist, 1981; Andersson and Karrqvist, 1983).

Guesne found that children often explain how they see luminous objects by describing light coming into their eyes, but then explain how they see non-luminous objects using an ‘active eye’ model, in which something goes out from their eyes (Guesne, 1985; Driver et al., 1994; Hardman and Riordan, 2014). To help students develop the scientific explanation that non-luminous object are seen because some of the light scattered off them enters the eye, it can help to remind students of how light reflects off a mirror before considering how objects reflect light from an obvious light source. Students can then be guided to apply this understanding to explain how we see non-luminous objects in more diffuse light (Allen, 2014; Driver et al., 1994).



*The progression in conceptions of vision encountered among 13- to 14-year-olds, towards that of a physicist (Guesne, 1985)*

Studies by Ramada and Driver (1989) and Andersson and Karrqvist (1983) found that just 31% of fifteen-year-olds (n=456 and n=166 respectively) described how a girl sees a book using the idea of light going from book to eye. Almost as many either used the non-explanation that ‘light helps us to see’ or gave no explanation at all. Anderson and Smith’s study (1986) showed that 6% of 10- to 11-year olds in their sample held the scientific view of vision, Boyes and Stanisstreet’s study (1991) showed this increases to 10% of 11- to 12-year-olds and 33% of over-14s.

Ramada and Driver (1989) also found that many students did not recognise that light is necessary for vision. This is perhaps because many students have never had the experience of total darkness in which they have been completely unable to see any object. In a study of 13-year-olds (n=47) it was found that 17% thought people could see in the dark and 65% though that cats could (Fetherstonhaugh and Treagust, 1992).

The progression toolkit for the ‘passive eye' model of vision begins by checking that students understand how the structure of the eye allows light to enter. By observing how a luminous object is seen, common misunderstandings are challenged and students are given the opportunity to construct a scientific understanding of vision. They are given the opportunity to consolidate their understanding by explaining how we see non-luminous objects when there is an obvious light source, before developing explanations for how non-luminous objects are seen in diffuse light. Two further activities challenge students to use these ideas to interpret new phenomena.

**Guidance notes**

Without a good understanding of how we see non-luminous objects it will be extremely difficult for students to understand ideas about colour. At this stage of their learning, for some students, it may be beneficial to spend more time on this key concept at the expense of the key concept: *Seeing in colour*.

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