Learning

Prior knowledge

It's pretty much impossible to guess what people already know. This is true even for schools, who may be about to start a topic, or have just completed it. Interacting with the audience during the show is the best way to check you're at the right level.

Watch out though:

- If you ask "do you understand", they will likely nod because it's socially difficult to say 'no'.
- Bright kids who learned things at home will be especially keen to put their hands up.
- Children who are struggling are less likely to contribute. Remember you will always have a wide range of prior knowledge / abilities. These children especially will appreciate simple statements / repetition / recapping and contextualisation of concepts.

It's nice to ask questions that don't require prior knowledge. It's better to test whether they can understand what you've told them or can work things out from information that you have provided, rather than testing what they knew already. Else you are rewarding children for being bright and/or well-educated (which may reflect their family background), rather than for making the effort of learning.

Include some questions that anyone could answer (eg what is the brightest part of the image? What in the room do you think will look hot?). This helps include and give confidence to those who may otherwise be struggling with the content.

What they do at school

<u>By the end of KS2 (yr6, 11yr), mostly in the final year of this period, they should have learned:</u>

- Light is energy.
- Light appears to travel in straight lines.
- Shadows: what they are / why they make the shapes they do
- Light sources (eg the Sun) as compared to things that *reflect* light (eg the Moon)
- We see things because they give out / reflect light into our eye
- Light can be split into different *rainbow* colours of the *spectrum* using a *prism*.
- Light can *reflect* and *refract.*
- *Gravity* keeps the Earth in orbit around the Sun. More-massive things have more gravity.

<u>By the end of KS3 (yr 9, 14yr), they should have also learned:</u>

- Light travels really fast and can travel through a vacuum.
- *Luminous* things *emit* light.
- *Transparent* materials *transmit* light (*transmission*).
- *Translucent* things partly transmit light. *Opaque* things do not transmit light.
- Light can transfer energy from source to absorber (eg in eye/camera)
- Light is a wave. *Wavelength, frequency*.
- Use of ray model to show how mirrors, *convex lenses*, eyes work.
- *Heat* = the total amount of thermal energy in an object (kinetic energy of jiggling molecules)
- *Temperature* = a measure of the average kinetic energy in an object's molecules

By GCSE (yr11, 16yr) they should also have learned:

- *The speed of light.*
- *Electromagnetic waves/spectrum - Gamma rays, X-rays, ultraviolet, visible light (colours), infrared, microwaves, radio waves and properties/uses of these.*

There is no problem with introducing concepts beyond what they may be currently doing in school. This can be a good opportunity to recap / reinforce concepts and jargon that is at their level. But do try to avoid introducing overly advanced jargon if you can avoid it.

Vocabulary

Jargon is *really* useful. But needs to be used with care.

Cognitive research has shown that working memory allows only a limited number of items to be considered at one time. Condensing a complex idea into a single word allows it to count as one item.

Think clearly about which jargon words you want to use during the presentation. They should be words that will be necessary/useful to use during this presentation, and which you will be actively using.

Each word should be clearly introduced in context, and then used a good few times. The first few times, remind people what it means (eg "So the wavelength – or colour – is related to …"). People will need practice at remembering/interpreting (and preferably using) a word before it becomes defined in their brain in a way that allows them to use it as a single item in their working memory.

Physics of light, and heat transfer

There are many excellent places online to learn about the basics of electromagnetic radiation and heat transfer. Also I know some of you already know this topic, so I won't try to explain everything from scratch here. But here are some things to watch out for …

- Infrared includes a WIDE range of wavelengths. Many everyday uses of infrared (eg CCTV IR spotlights, TV remote controls) use wavelengths only just beyond the visible spectrum, aka shortwave-IR or near-IR. Near-IR can be seen using a mobile phone camera or hacked webcam. Webb's MIRI instrument and the Flir C2 camera detect longer, mid/far-IR wavelengths.
- Mid-infrared *feels* warm on skin – this is what radiant heaters emit. Near-infrared does not feel warm in the same way as it's not so easily absorbed by skin (it behaves more like visible light).
- *Heat* is a defined amount of energy, while *temperature* is a measure of the average energy per molecule in an object. A large, cool object may have more heat than a small, hot one.
- Mid-infrared is not the same as 'heat'. Heat is the kinetic energy of jiggling molecules, while infrared is energy in the form of electromagnetic radiation.
- The reason why mid-infrared *feels* warm is that (i) everyday objects like our bodies are really good at absorbing/emitting mid-infrared and (ii) there's a lot of it around. (We absorb UV very well too, but there's a lot less of it in our environment.) So: mid-infrared is a form of energy which is significant for our *experience* of everyday heat *transfer*.
- Your skin does not directly detect mid-infrared in the way that your eyes directly detect visible light. Water in your body absorbs infrared, warming your skin. Your skin then detects the increase in temperature.
- If you stand behind glass you won't get any mid/far IR. But you'll still feel warmed by absorption of other (mostly shorter) wavelengths. About half the energy of sunlight is in the infrared.

- Snakes have tiny “heat pits”, with temperature sensors inside. If they receive IR from one side, it heats the other side of the pit, giving them some directional sense. This type of structure is similar to that found in the early evolution of eyes, but these are NOT eyes because the IR is not directly absorbed by a light-reactive molecule. Also, the resolution is terrible! Generally, IR eyes aren’t a thing because there’d be too much interference from your own body heat.

A trick to encourage questions

Sneaky trick: instead of asking “do you have any questions”, try asking “what questions do you have?”. Or, even more sneaky, “what questions do you think other people in the group might have?”.

AstroBoost Project

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