Prior knowledge

It's 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. Individual pupils in a class will vary in their experience and knowledge. Interacting with the audience during the show is the only way to be sure you're talking at the right level.

Watch out though, there are traps:

- If you ask "do you understand", everyone will likely nod because it's socially difficult to say 'no'. Ask questions to test their understanding, ask 'which bits are still confusing?', or 'do you have any questions?'.

- Bright kids who have learned extra content from their parents will be the first to put their hands up. Wait a while for others to catch up and take answers from as many different people as possible.

- 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.

- Younger children might become over-focussed on asking questions if these are allowed throughout a talk, and so it's better to clearly identify times where these are appropriate (ideally at the end of each section).

Try to ask questions that don't require prior STEM knowledge. It's better to test whether they can understand what you've told them (or challenge them to work something out from information that you have provided).

You may otherwise find yourself rewarding the most privileged children, who have been given the most prior opportunities to learn (eg by a supportive family). Meanwhile less-experienced children may feel stupid for not already knowing something that they've simply never encountered before. It's better to reward people for effortful thinking about the subject matter.

Try to 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. Or ask questions that rely upon non-STEM experience (eg sport, or arts).

What they do at school

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

- 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.

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

- 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

For GCSE science (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.*

For GCSE physics, also:

- The pressure law: decompression decreases temperature; increasing pressure increases temperature. This is necessary when talking about how the space fridge works.

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 it needs to be used sparingly and 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 …"). Be aware that people will need practice at recalling/interpreting (and preferably speaking) 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 some of you likely know this topic better than me, 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, and behaves much like visible light. Webb's MIRI instrument and the Flir C2 camera detect longer, mid/far-IR wavelengths.

- Mid-infrared is easily absorbed by skin and so 'feels warm'. This is what radiant heaters emit. Near-infrared does not feel warm in the same way (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 is colloquially associated with 'heat' 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

These resources are adapted from the Royal Astronomical Society's original AstroBoost project, which was funded by a STFC Spark Award. The project was managed and developed by Dr Jenny Shipway.