*Physics > Big idea PSL: Sound, light and waves > Topic PSL1: Sound and light*

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| **Key concept (age 11-14)** |
| **PSL1.1: Production and transmission of sound** |

**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 develops the big idea by building on the understanding that sounds are caused by vibrations, in order to help develop students’ understanding of how vibrating particles transfer energy through solids, liquids and gases, but not through a vacuum.

****The conceptual progression starts by checking understanding of how vibrations can be altered to produce different sounds. It then supports the development of a model, which explains how particles vibrate to transmit sound, in order to enable understanding of why sound becomes quieter with distance and how it is absorbed and reflected.

**How can you use 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: Production of sound**

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| **Learning focus** | Objects and materials can be made to vibrate to produce a sound that becomes louder as the size of vibration increases and higher pitched as the rate of vibration increases. | | | | |
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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** | | | | |
| Identify what vibrates to make sound.  **P** | Describe the effect of larger vibrations on a sound.  **P** | Describe the effect of faster or slower vibrations on a sound. | Explain how sound is produced by objects that do not appear to vibrate. | Explain how vibrations are passed on to the surrounding air. |
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| **Diagnostic questions** | Sound vibrations | Drum beat |  | Wood-rock | Into the air |
| High or loud? | |
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| **Response**  **activities** |  | Speaker vibration | | Touching note | Sound model |

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

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| **Sound vibrations** | **Drum beat** | **High or loud?** | **Wood-rock** | **Into the air** |
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| Confidence grid | Two-tier multiple choice | Focused cloze | Confidence grid | Simple multiple choice |
| **Speaker vibration** | **Touching note** | **Sound model** |  |  |
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| Predict, explain, observe, explain | Predict, explain, observe, explain | Critiquing a representation |  |  |

**Progression toolkit: Transmission of sound**

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| **Learning focus** | Sound needs a medium to travel through. It radiates out from a source in straight lines in all directions and when it strikes an object or new material it is transmitted, reflected, scattered or absorbed – or a combination of these. | | | | |
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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** | | | | |
| Identify which materials sound travels best in. | Describe how particles vibrate to transmit sound. | Explain why sound will not travel through empty space (vacuum). | Explain why sounds become quieter as the distance from the source increases. | Explain why sound is absorbed by soft surfaces and reflected or scattered by hard ones. |
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| **Diagnostic questions** | Sound moves | Candle sound | Balloon pop! | Long distance sound | Sshhh… curtains |
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| **Response**  **activities** | String ears | It’s quiet in space | |  | Noisy Road |

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

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| **Sound moves** | **Candle sound** | **Balloon pop!** | **Long distance sound** | **Sshhh… curtains** |
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| Two-tier multiple choice | Predict, explain, observe, explain | Predict, explain, observe, explain | Simple multiple choice | Confidence grid |
| **String ears** | **It’s quiet in space** | **Noisy Road** |  |  |
|  |  |  |  |  |
| Predict, explain, observe, explain | Simple multiple choice | Talking heads |  |  |

**What’s the science story?**

Some objects can affect others at a distance by emitting radiation which travels from one object (the source) to another (the receiver), through the material or the space (the medium) between them. Sound is an example of radiation.

Radiation travels out from a source in straight lines in all directions. When it strikes another object, it may go straight through (transmission), bounce off (scattering or reflection), or be stopped (absorption) – or a combination of these. The effects of radiation get steadily less the further it goes, because it is spread over an ever-increasing area, and because it may be gradually absorbed by the medium it is travelling through. When radiation is absorbed by an object, it has an effect on the object; this might be a chemical effect, an electrical effect or a heating effect.

Sound travels at a high speed. The speed of light, however, is very much higher, though it does travel at a finite speed.

Sound requires a medium (gas, liquid or solid) to travel through. It travels faster in liquids and solids than in gases.

The pitch of a sound depends on the frequency of vibration of the source (the number of vibrations per second). The loudness depends on the amplitude of the vibrations of the source (the maximum distance the source moves from its rest position when vibrating).

When sound hits a surface, some of it is usually reflected. This is the cause of echoes.

**What does the research say?**

Young children and some students may attribute the production of sound to the physical attributes of an object (for example, the tautness of a drum) or to the force used to make the sound (such as a hand hitting a drum), before developing an understanding that sound is caused by vibrations (Driver et al., 1994).

In a study of two-hundred-and-sixty 4-16 year old students Asoko, Leach and Scott (1991) found that students use of ‘vibrations’ to explain the source of sound increased with age, but this was also dependent on the context: 80% of students aged 11-16 used vibrations to explain sound when the vibrations were obvious (for example in a string); when air was vibrating in a horn this fell to 40%; and very few students used vibrations to explain the sound caused by knocking two small stones together. Tear (2011) suggests the students are encouraged to generalise their findings, when investigating sound, in order to explain new examples more readily.

The transmission of sound is difficult to understand. It is common for students to think of sound as a material substance that moves from one place to another (Barman, Barman and Miller, 1996). Even at degree level (Linder, 1992) found that some students thought of sound as a ‘lump’ of material travelling through a passive medium, similar to a surfer on a water wave.

In his study of twenty-eight 11-14 year olds Whittaker (2012) found that fewer than 30% used the idea of vibrations to correctly describe how sound travels through air. Half the students believed a gap around the door was necessary for sound to enter a room from the outside, which indicates a view of sound as a material substance. Only 20% were able to explain how sound vibrations can pass through the wall.

40% of students in the same study thought sound got quieter as it travelled further because it ‘faded and died out’ or ran out of ‘energy’. Less than half of this number gave the correct explanation which is that sound spreads out.

Caleon and Subramanian (2010) note that students may think that sound is slowed down by physical obstructions and a few students believe that sound can travel through empty space (vacuum). Most students can state that sound does not travel in a vacuum, but the majority cannot explain way using scientific ideas.

When sound is absorbed Asoko *et al.* (1991) found that students often described the absorbing surface as ‘trapping’ the sound and very few referred to vibrations in the absorbing material.

The progression toolkit for *production of sound* reminds students that sounds are made by vibrating objects and that bigger vibrations generate louder sounds. By observing vibrations the link is made between the speed of a vibration and the pitch of sound produced. This idea is developed by identifying less obvious vibrations that produce sound, in order to develop a model of how vibrations are passed on to the surrounding air.

In the progression toolkit for *transmission of sound* the model of transmitting sound by vibrating particles is developed further. Through investigation and observation students find out that sound travels best in a solid, and they use the model of vibrating particles to explain why. They consolidate their understanding of this model by applying it to explain why sound does not travel in a vacuum, why sounds become quieter with distance from the source, and how surfaces absorb and reflect sound. These phenomena also introduce students to some of the properties that sound shares with light and other forms of radiation.

**Guidance notes**

As an introduction to sound, students often look at a range of different vibrating objects and musical instruments to investigate how to make sounds louder/softer or higher/lower. This would be a very useful experience for students to have had and to reflect on whilst considering the science ideas covered by this key concept.

Sound is not a ‘type of energy’ but a way of transferring energy: sound transfers energy from the energy store(s) of a vibrating object or material to the energy store(s) of new objects or materials by radiation. Sound is transient and there is no meaningful way to calculate the amount of energy it contains until it is detected. It is more useful to describe the mechanisms and processes of how sound transfers energy. This can be done with increasingly greater sophistication as students’ understanding develops.

A summary of the BEST approach to teaching energy can be found on the Best Evidence Science Teaching home page which is on the STEM Learning website (Fairhurst, 2018).

**References**

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