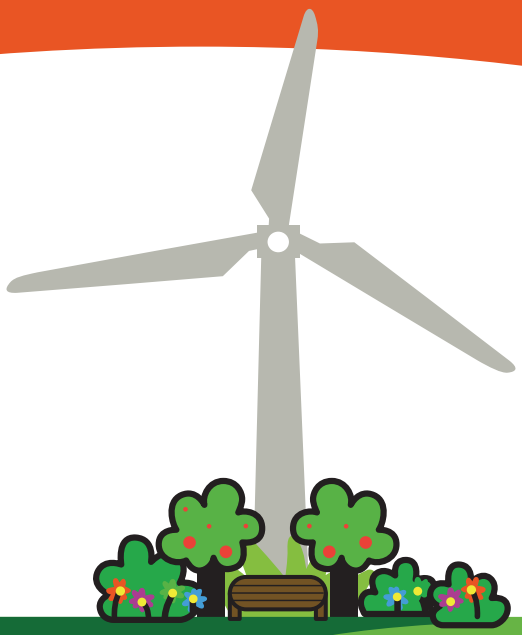
urban science



Sounds in the City

Students investigate how sounds affect the urban environment. They use sound mapping to assess the impact of sounds on daily life and discuss how sounds can be mitigated to improve the urban environment.

A curriculum linked learning module for students aged 13-15 to develop competences in working scientifically.

Learning challenge: Sounds in the City

The starting point of this module is that sounds (voices, sputters, noises, burrs) that surround us in a city might be disturbing or distracting, yet if we pay attention, they can be exciting and interesting, so it is worth examining them.

While students are mapping sounds, they learn about the scientific background of sounds and get acquainted with some data about how sounds affect people and their well-being.

This learning module can be used flexibly within the curriculum to support key knowledge about physics and develop working scientifically competences. The learning links with the Sustainable Development Goals and provides a broader context for student learning. It is suitable for adapting as a STEM activity or Eco Club.

The topic of sounds links with wave motion and an exploration of the different properties of sound waves and absorption properties of different materials.

www.urbanscience.eu

Co-funded by the Erasmus+ Programme of the European Union

To deliver this module we recommend:

- Start with one or both of the Stage 1 activities to generate interest and real-world context in the subject.
- A longer version of the sound mapping in Stage 1 will link effectively with Stage 3; you could jump from Stage 1 directly to Stage 3, returning to Stage 2 later if desired.
- Elicit current student understanding in Stage 2 and discuss students views and opinions.
- Stage 3 is the practical challenge where students gather data and make conclusions.
- In Stage 4 you will provide suggestions for sharing and presenting results.

Subject

Biology	Chemistry	Physics	Raising Attainment
		✓	✓

Programme of Study reference

• Physics (Key Stage 4)	**Wave motion** • Amplitude, wavelength, frequency, relating velocity to frequency and wavelength. • Velocities differing between media: absorption, reflection, refraction effects.	• Working scientifically	Students successfully completing this module will have had the opportunity to access these statements: 1d,1f,2b,2c,2d,2f,2g,3ai,3aiv,3av,3avi,3avii,4b Some will also have completed the following: 1c,3b,4a See Annex 1 for full statements.

Sustainable Development Goals

All Urban Science modules try to 'ensure inclusive and equitable quality education and promote lifelong learning opportunities for all' and in addition focus on education for sustainable development and global education - SDG 4.7. Support and resources here:

http://www.teachsdgs.org/

This module has strong links to SDG 3: Ensure healthy lives and promote well-being for all at all ages, SDG 9: Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation, and SDG 11: Make cities and human settlements inclusive, safe, resilient and sustainable. For example this project case study:

http://www.libelium.com/libelium-helps-to-reduce-noise-pollution-in-the-city-of-cuenca-ecuador/

shows clear links to noise pollution in cities and how it links to SDG 3, 11 and 12.

Activities Overview

Stage 1	Time (mins)	Resources needed
Sound Walk	30 mins	None required
Sound Map	15 mins	None required
Is / Is Not	20 mins	Student Sheet 1

Stage 2	Time (mins)	Resources needed
How Does May Neighbourhood Sound?	30 mins	None required
For and Against (and In Between)	20 mins	Student Sheet 2

Stage 3	Time (mins)	Resources needed
Introduction	15 mins	Bowl. Cling film. Hundreds and thousands sprinkles of the type used for cake decorations. Large spoon or drumstick. Metal baking tray, drum or similar to hit to make a loud noise.
Carrying out an Investigation	50 mins	Selection of different materials, a sound source (alarm clock, radio, etc), and a microphone connected to an oscilloscope or decibel meter (or suitable app).

Stage 4	Time (mins)	Resources needed
Presenting Results and Peer Assessment	50 mins	Student Sheet 3

Health and Safety: please refer to the guidance provided on the Urban Science website before commencing the module.

www.urbanscience.eu/uk/learning-modules/health-and-safety/

STAGE 1 - Sounds in the City

Inquiry based learning stage

Stage 1 - Initiating and eliciting	✓	**Stage 2 - Defining and responding**	
Stage 3 - Doing and making		**Stage 4 - Communicating, presenting and evaluating**	

Learning objectives

1. Students are able to record and interpret simple data.
2. Students are able discuss different points of view.

Learning outcomes

1. Students record and map a range of different sound parameters.
2. Students distinguish different views on sounds which are wanted and unwanted.
3. Students discuss the potential impacts of sound on the urban environment.

Overview of lesson

In this lesson students are encouraged to explore the topic of sound by conducting a 'sound walk' and discussing how sounds can affect the urban environment.

Lesson structure

Introduction:

The key aim of the lesson is to introduce to students the idea that sounds in the city can affect people in different ways. There are two activities to choose from which develop students' skills in listening and recording sound, and then an activity to review their findings.

Main 1: Sound Walk

To introduce the topic of sound, students are invited to take a 15-minute walk and record sounds as they go. They can choose to record sounds using a smart phone or devise a scale of their choosing to record sounds as pleasant and unpleasant.

The 15-minute walk could be conducted through the school buildings and grounds. Alternatively, students could carry out the walk to/from home as a pre-task.

There are a range of sound mapping apps available e.g. MapMySound. These can be used to build up a sound map of the school and/or local community. This will provide a real-world context for the Stage 3 experiments.

Main 2: Sound Map

Before the activity starts, provide each student with a piece of paper and ask them to fold it in half. Open out the paper and draw a small ear in the centre, leaving the top and bottom halves blank.

Students spread out and sit down outside to listen to the world around them. It is best if the students close their eyes and listen for 4-5 minutes, then, remaining quiet, spend 5 minutes looking at what is going on around them as well as listening. During the latter period, the students can make notes on the paper of what they have heard. They can make a sound map by writing down sounds they have heard around their ear drawn on the top half of the paper. Nearby sounds are drawn close to the ear, distant sounds near the edge of the paper, and they can be arranged according to points of the compass. The lower half of the paper is used to draw pictures of what they have seen or to write words to describe what they seen and their feelings about the place.

Main 3: Is / Is Not

Students are invited to reflect on the sounds they have recorded, and consider if they are pleasant or unpleasant. Use Student Sheet 1 to record responses.

Ask students to share their responses. Can they identify patterns in the sounds they categorise as pleasant or unpleasant? For example, are pleasant sounds natural whereas unpleasant sounds mainly human-made? What impact do students think sound can have on the quality of urban environment?

Some other interesting questions to pose include:

- What would the world sound like without humans?
- What would the city sound like with no cars?
- Can we block out human sound?
- How would you explain to a friend the difference between the sound of a bird and an artificial sound?

This interesting article on acoustic ecology might be helpful:

https://www.thenatureofcities.com/2013/08/25/designing-the-urban-soundscape/

You can also explore sound maps of the UK:

http://www.extrium.co.uk/noiseviewer.html

An interesting soundscape from Stockholm, New York and Paris is a good way to elicit reactions from students about how sounds can affect emotions:

https://vimeo.com/15294298

Continued on page 6...

Lesson structure (Continued)

Plenary:

Teaching the concepts of sound can be challenging and students (and indeed teachers) often retain many misconceptions. We recommend a review of the basic science concepts via this site.

https://www.bbc.co.uk/bitesize/guides/zwjsgk7/revision/1.

The introduction to Stage 3 provides some diagnostic questions as a checker ahead of when they start to use their science knowledge in the Stage 3 activities. The Institute of Physics provides this great review of the science misconceptions when teaching this topic.

https://spark.iop.org/sounds-groups-particles-moving-and-fro

Student Sheet 1

Describe your environment:

List pleasant sounds:

List unpleasant sounds:

STAGE 2 - Sounds in the City

Inquiry based learning stage

Stage 1 - Initiating and eliciting		**Stage 2 - Defining and responding**	✓
Stage 3 - Doing and making		**Stage 4 - Communicating, presenting and evaluating**	

Learning objectives

1. Students are able to present data and evidence opinions.
2. Students are able to interpret data and justify results.
3. Students are able to present a range of arguments.

Learning outcomes

1. Students prepare sound maps.
2. Students discuss their results and reflect on their own views about sound.
3. Students reflect on results from different points of view.

Overview of lesson

In this lesson students think more deeply about how sound affects their community and how they feel about it.

During the lesson, it can be helpful to review student's current knowledge about the properties of sound waves. This will be essential in Stage 3 when students consider ways to reduce the impact of unpleasant sounds in urban areas.

Sounds in the City - understanding the situation

Lesson structure

Introduction

How aware are students of the sounds in their neighbourhood? We often tune out sounds which might be unpleasant or simply background noise.

https://www.bbc.com/future/article/20120508-why-your-brain-loves-to-tune-out

This lesson 'opens' ears to sounds in daily life.

Main 1: How does may neighbourhood sound?

Using data from the 15-minute sound walk in Stage 1, ask students to create a sound map of their community. They should identify where there are areas of high sound levels and low sound levels. They could also indicate where more natural sounds are to be found, and indicate areas on their map where action should be taken to reduce sound levels.

The map can be used as a starting point for mitigation investigations in Stage 3.

Main 2: For and Against (and in between)

Not everyone agrees that less sound is good. Vibrant cities are often loud with people enjoying the attractions of city life; noise is not a black and white issue.

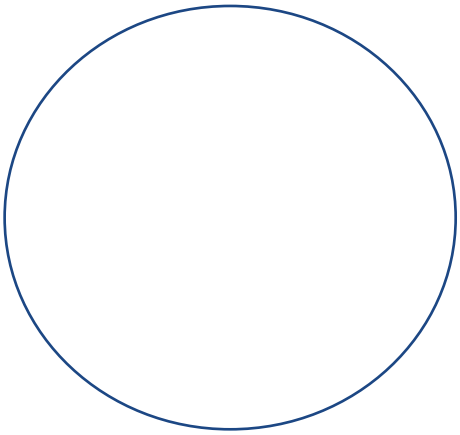
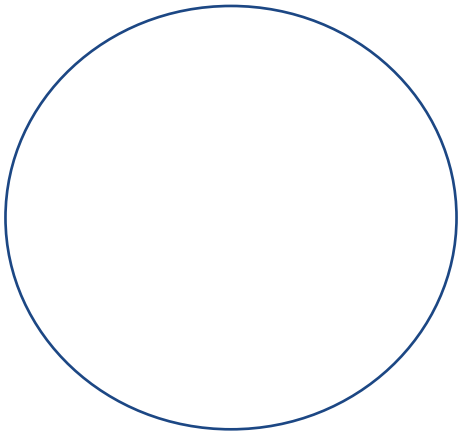
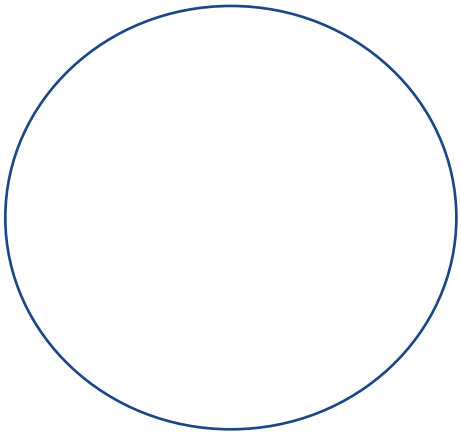
Ask students to map out all the different arguments for reducing noise levels in cities and for increasing them. They might wish to consider the impacts on jobs, economy, well-being, transport, etc. Use Student Sheet 2 to record opinions.

Plenary

This activity provides a good review for students in terms of their key science knowledge.

https://spark.iop.org/questions-check-understanding-sound.

Student Sheet 2 - For and Against (and In Between)

For	Against	In Between
		
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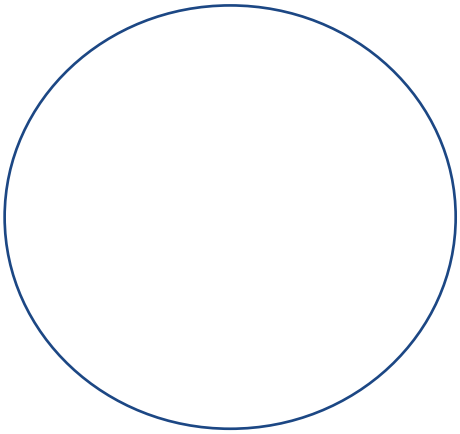	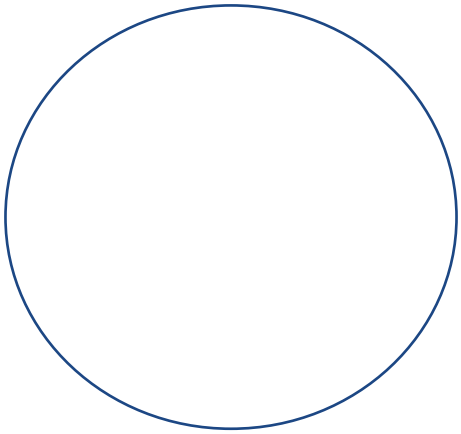	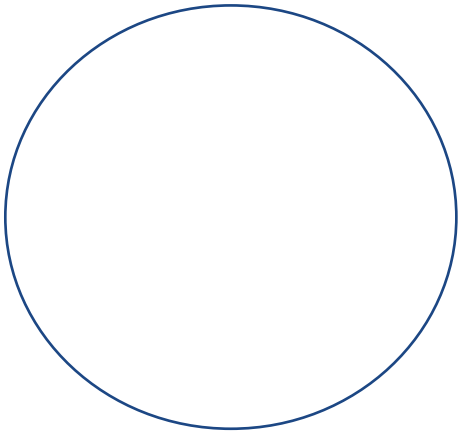

My view is...

STAGE 3 - Sounds in the City

Inquiry based learning stage

Stage 1 - Initiating and eliciting		**Stage 2 - Defining and responding**	
Stage 3 - Doing and making	✓	**Stage 4 - Communicating, presenting and evaluating**	

Learning objectives

1. Students are able to plan and carry out an investigation.
2. Students understand the absorption, reflection and refraction properties of different materials.
3. Students can recognise and consider limitations in their method.
4. Students can apply their scientific knowledge to a local context.

Learning outcomes

1. Students plan and carry out an investigation to test the suitability of materials to absorb or insulate sound.
2. Students identify the absorption, reflection and refraction properties of different materials.
3. Students consider whether a particular material is the best material for a job when other variables of equal importance are considered.

Overview of lesson

In this lesson students design an investigation to explore how unwanted sounds can be reduced. They use a real-world context (see Stage 2) to focus their investigations and provide recommendations for presenting in Stage 4.

Lesson structure

Introduction

Now that students have explored sounds in the urban environment and the impact they can have on well-being, they are challenged to consider how unwanted sounds can be reduced.

This 'sprinkles' demonstration is a good way to firm up on student knowledge of the key concepts. The plenary at the end of Stage 2 allows students to address their misconceptions.

- What is sound?
- What is noise?
- How do we hear?

1. Sprinkles demo: https://spark.iop.org/dancing-sprinkles
2. Students peer mark their results from the plenary at the end of Stage 2.
3. Key misconceptions could be put onto a topic 'messy wall'.

Main: Carrying out an Investigation

This activity introduces how unwanted sounds can be shielded through reflection of sound and absorption of sound. There are different options for reducing unwanted sound; of course, the sound could be stopped or prevented in some way but many sounds are an inevitable result of modern living. Two ways to reduce unwanted sound are using a reflector or an absorber.

Ask students design a simple way of testing the ability of different materials to absorb or reflect sound. They will need to rank the materials in order. To produce accurate results students will need to:

- compare the amplitude or frequency of the source signal before and after the insulation is applied.
- identify problems encountered and consider the limitations of the method of testing.
- build the simple testing equipment and test each material, recording the results. They will also need to identify other variables, beside the insulation properties of the material itself, that the engineers will need to test for (e.g. how heavy the material is, cost, and how easy it is to work with).

https://spark.iop.org/sound-unwanted

For students to carry out their experiments, they will need access to a variety of different materials, a sound source (alarm clock, radio, etc), and a microphone connected to an oscilloscope or decibel meter (or suitable app). Students will need to carefully consider how they control external sounds which might affect their results.

It will motivate the students to provide a real-world context for their experiments. Students could select the context themselves (see Stage 2). Some suggestions are:

- A music shop is located next to a busy road and the owners want to ensure customers can listen to music without interference from traffic. What recommendations can you make them?
- A 5-story block of flats is located 50 metres from a busy main road. What recommendations do you have to reduce unwanted sounds for the residents?
- A new football stadium is being constructed on the edge of housing. What recommendations can you make to reduce noise both inside the stadium disturbing residents and reduce noise from spectators traveling to the stadium?

Plenary

Ask students to present their results by creating a table to record their findings. Based on the results, ask students to make recommendations for reducing unwanted sounds.

Take the discussion further to link with broader sustainability issues. How might unwanted sounds affect the mental well-being of urban residents? Are there any sounds which will enhance well-being?

STAGE 4 - Sounds in the City

Inquiry based learning stage

Stage 1 - Initiating and eliciting		Stage 2 - Defining and responding	
Stage 3 - Doing and making		Stage 4 - Communicating, presenting and evaluating	✓

Learning objectives

1. Students are able to communicate their results.
2. Students can apply a range of communication techniques.

Learning outcomes

1. Students select an appropriate communication technique.
2. Students present their results using their chosen technique.
3. Students critique the work of others.

Overview of lesson

In this lesson students think about how to communicate their results. They consider a range of options and then select the most appropriate. After communicating their own results, they listen to and provide constructive feedback to other groups.

Lesson structure

Introduction

Now that students have developed their results, they need to provide feedback. If you have used a real-world context, consider who the results need to be presented to and develop feedback suitable for the target group; this could be a resident's group, architects or town planners.

You can link the sharing of results to future careers using this website:

www.acoustics.salford.ac.uk/schools/

Main

Students consider how to present their results. This is a generic list of ways students can consider.

- **Poster** - create a poster communicating your results and making recommendations for the café; the poster could include a picture of the café based on your recommendations.
- **Film** - create a 5-minute film communicating to the café owners how you carried out your research and the results; you could include interviews with potential customers.
- **Presentation** - deliver a 5-minute presentation for the café owners.
- **Report** - write a report laying out your recommendations and evidence.
- **Other** - add your own suggestion.

Student Sheet 3 offers feedback sheets to use during presentations.

Plenary

Ask students to share their reviews of each presentation. Groups can review their work and consider ways to improve it in the future.

Student Sheet 3 - Review form

Review plans

This activity can be used to analyse or appraise anything in a structured way.

Student name: .....

Topic: .....

Strengths

Weaknesses

Enablers

Barriers

Opportunities

Threats

Annex 1 - Key Stage 4 Working Scientifically Statements

Through the content across all three disciplines, students should be taught so that they develop understanding and first-hand experience of:

1. **The development of scientific thinking**
    a. the ways in which scientific methods and theories develop over time.
    b. using a variety of concepts and models to develop scientific explanations and understanding.
    c. appreciating the power and limitations of science and considering ethical issues which may arise.
    d. explaining everyday and technological applications of science; evaluating associated personal, social, economic and environmental implications; and making decisions based on the evaluation of evidence and arguments.
    e. evaluating risks both in practical science and the wider societal context, including perception of risk.
    f. recognising the importance of peer review of results and of communication of results to a range of audiences.

2. **Experimental skills and strategies**
    a. using scientific theories and explanations to develop hypotheses.
    b. planning experiments to make observations, test hypotheses or explore phenomena.
    c. applying a knowledge of a range of techniques, apparatus, and materials to select those appropriate both for fieldwork and for experiments.
    d. carrying out experiments appropriately, having due regard to the correct manipulation of apparatus, the accuracy of measurements and health and safety considerations.
    e. recognising when to apply a knowledge of sampling techniques to ensure any samples collected are representative.
    f. making and recording observations and measurements using a range of apparatus and methods.
    g. evaluating methods and suggesting possible improvements and further investigations.

3. **Analysis and evaluation**
    a. applying the cycle of collecting, presenting and analysing data, including:
        i. presenting observations and other data using appropriate methods.
        ii. translating data from one form to another.
        iii. carrying out and representing mathematical and statistical analysis.
        iv. representing distributions of results and making estimations of uncertainty.
        v. interpreting observations and other data, including identifying patterns and trends, making inferences and drawing conclusions.
        vi. presenting reasoned explanations, including relating data to hypotheses.
        vii. being objective, evaluating data in terms of accuracy, precision, repeatability and reproducibility and identifying potential sources of random and systematic error.
    b. communicating the scientific rationale for investigations, including the methods used, the findings and reasoned conclusions, using paper-based and electronic reports and presentations.

4. **Vocabulary, units, symbols and nomenclature**
    a. developing their use of scientific vocabulary and nomenclature.
    b. recognising the importance of scientific quantities and understanding how they are determined.
    c. using SI units and IUPAC chemical nomenclature unless inappropriate.
    d. using prefixes and powers of ten for orders of magnitude (e.g. tera, giga, mega, kilo, centi, milli, micro and nano).
    e. interconverting units.
    f. using an appropriate number of significant figures in calculations.