Sound and music

Introduction

Why do we see lightning before we hear the thunder? How do we amplify sound and how do we reduce it? How is it we can hear at all? Sound is all around us every day and it is important for students to understand how and why we hear in order to manipulate their surrounding environment.

Key concepts of sound and music

The activities in this topic are designed to explore the following key concepts:

Early years

- We hear sound with our ears.
- Our sense of sound is very sharp.
- Sound travels through air.
- Sound travels through water and solid objects.
- We use two ears to judge where sounds come from.
- Sound bounces off surfaces (echoes).
- Sound is caused by vibrating objects.

Middle years

- Sound can vary in pitch (or frequency) and loudness.
- The pitch (or frequency) of sound is related to the speed of vibration of the sound source. The more vibrations per second, the higher the pitch.
- The loudness of sound is related to the size of vibration of the sound source: the larger the size of vibration, the louder the sound.
- Sound needs a material medium through which to travel.
- Sound travels faster through solids and liquids than through air.
- Sound is a travelling vibration that moves through a medium such as air, water or solid objects.
- Sound can bend around corners and spread out after passing through gaps.
- Objects have their own natural vibration pattern and can give a characteristic note when hit (or blown).
- Large or long objects vibrate more slowly, causing sounds of lower pitch (or frequency).

- Objects can be made to vibrate in sympathy with others that have the same pitch (or frequency).
- Sounding boards amplify sound, and are important in instruments.
- Vibrating strings form the basis of stringed instruments.
- Vibrating air is the basis of wind instruments.

Students' alternative conceptions of sound and music

Research into students' ideas about this topic has identified the following non-scientific conceptions:

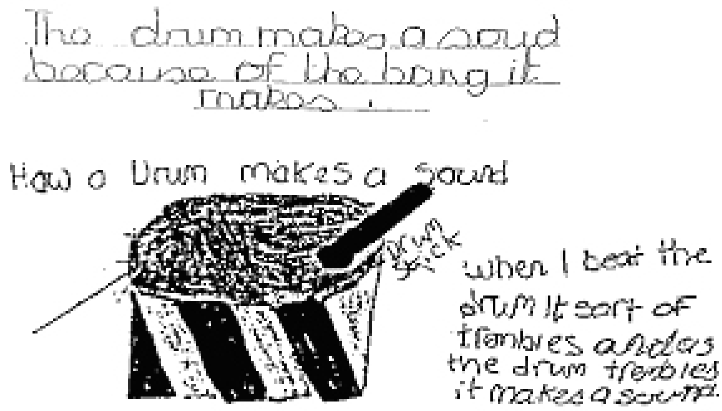
- Students find it difficult to express a mechanism for how sound travels.
- The loudness and pitch (or frequency) of sounds are confused with each other.
- You can hear and see a distant event at the same moment.
- Hitting an object harder changes its pitch.
- In a telephone, actual sounds, rather than electrical impulses, are carried through the wire.
- Sound moves faster in air than in solids (air is 'thinner' and forms less of a barrier).
- Sound moves between particles of matter (in empty space) rather than matter.
- Sound can travel through space.
- In wind instruments, the instrument itself vibrates, not the internal air column.
- The pitch of whistles or sirens on moving vehicles is changed by the driver as the vehicle passes.

Activities

Sound and the language of sound

This topic is about making children aware of the idea of sound and what makes sound. In order to do this we need to develop a language that allows them to discuss sound. It is this language development that is focused on when teaching this topic to Prep/Year 1 children. Accordingly, the following activities are suitable for Prep and Year 1 students.

Teaching note: It is useful to explore young children's perceptions of how sound is made to gain an understanding of their level of conceptual engagement. In order to do this it is instructive to get children to describe what is happening, supported by drawings. A question such as 'How does a drum make a sound?' can provide insights into students' thinking. Taken from a British research project, the following illustration of an activity where a drum is struck shows a variation in understanding.



ACTIVITY: 'WHAT IS SOUND?' PROBE

Key idea: Sound is caused by vibrating objects.

You will need:

- **a toy drum.**

Start off by banging a toy drum. What makes the drum sound? Write an explanation, using a drawing. Discuss with the class what is happening to the drum to make a sound.

ACTIVITY: PLACES WITH SOUNDS

Key idea: We hear sounds with our ears.

You will need:

- **pictures of locations where sound is prevalent.**

Display a number of pictures, for example, city street, airport, farmyard. Ask students to list the sounds they would hear from the pictures they see—roar of engines, screech of tyres, etc. Ask the students to choose a sound each, and, as a group, create a sound picture.

ACTIVITY: LISTENING WALK

Key idea: We hear sounds with our ears.

Take the students on a listening walk. Groups then make a paste-up picture of the sources of the sounds heard. Each child then chooses a sound, then the class makes a sound picture as a paste-up picture.

ACTIVITY: WHAT SOUND IS THAT?

Key idea: We hear sounds with our ears.

You will need:

- **storybook: *The listening walk* by Paul Showers (1963, Adam & Charles Black, London)**
- **a recording of sound effects.**

Read *The listening walk* to the class. Then listen to a record or tape of sound effects. Ask the students to identify the sounds and guess how these sounds are made.

ACTIVITY: FROM WHICH DIRECTION IS THE SOUND COMING?

Key idea: We use two ears to judge where sounds come from.

You will need:

- **a blindfold.**

Conduct an activity with a blindfolded person identifying the direction from which clapping sounds appear to come. Try with one ear, then two ears. What is the advantage of having two ears?

To lessen the sound of movements made by the person making the clapping sound, have a group of students surround the student who is seated and blindfolded. The teacher can then point to specific students, who will clap their hands.

Explanatory note: We have what is called 'binaural hearing'. This means we hear with both ears. This helps us to determine the direction of the sound source. A source to the left of you will produce sound that reaches your left ear before it reaches your right ear. The brain interprets this time delay as a sound source to your left. Incidentally, you can't, using just your hearing, determine whether a sound is coming from directly in front of you or directly behind. Try your own experiment.

ACTIVITY: TAPPING BLIND

Key idea: We use two ears to judge where sounds come from.

You will need:

- **a blindfold**
- **a stick to be used as walking stick.**

Use a blindfold to make yourself totally dependent on sound to find how to get about. Take a stick and tap it in front of you as you walk slowly towards a wall. You need a solid floor to do this effectively.

Listen carefully to the sound of the tap as you approach the wall. You need a quiet room to do this effectively. You should find that you are able to tell when the stick is about to hit the wall.

How would you describe the change in sound as the stick approaches the wall? Can you suggest why the sound should change?

Explanatory note: As you get closer to the wall, the sound you produce at the floor reaches your ears in addition to the sound that is reflected off the wall. There is a slight delay between receiving the direct sound and the reflected sound, so each tap on the floor will sound a little longer. Theatres are designed to make sounds come to the audience as well as reflect off barriers. This has the effect of increasing the quality of the sounds made from the actors and/or musical instruments on stage.

ACTIVITY: EAR TRUMPET

Key ideas: Sounds bounce off surfaces. Reflected sound can add to direct sound to make a louder sound.

You will need:

- **a sheet of A4 paper.**

Fold a piece of paper into a trumpet shape, and use it as a funnel hearing aid.

How would you describe the difference it makes to sounds? Why do you think it makes a difference?

Explanatory note: The sound entering the funnel reflects a number of times and converges to the centre of the trumpet. In this way the intensity of the sound increases; it becomes louder.

ACTIVITY: SINGING IN A BUCKET

Key idea: Containers make good echo chambers.

You will need:

- **a metal bucket.**

Put your head in a bucket and sing (or talk if you're not confident about your singing voice).

In what way is the sound of your voice different?

Can you get the same effect by holding the bucket near your mouth?

How do you think the bucket affects the sound?

Explanatory note: Sound from your voice reflects off the insides of the bucket and adds to the sound from your voice. What you hear is a richer sound. The same effect is noticed when walking into a room with a hard floor and no furniture compared with walking into a room with furniture and carpets.

Types of sound

The following activities explore the sense of hearing. They also enable the language of sound to be investigated and developed. Although, as with most of the activities supplied, with adaptation they can be used for all age groups, the following are most suitable for Year 2 and above.

ACTIVITY: WORDS ABOUT SOUNDS

Key idea: Sound is caused by vibrating objects.

Write down a list of words that describe different types of sound and/or the methods of making them. Find a way of classifying these sounds under such headings as 'sounds made by people', 'sounds made by machines', etcetera.

ACTIVITY: SOUNDS!

Key idea: We hear sounds with our ears.

You will need:

- **a tray**
- **a stone**
- **a coin**
- **a drinking straw**
- **a marble**
- **a pencil**
- **a biro**
- **a rubber**
- **a piece of paper.**

Prop up one end of the tray. Look at the things you have collected. Blindfold your partner. Roll each object, one at a time, down the tray. The blindfolded person is to work out which object is being rolled.

ACTIVITY: DESCRIBING SOUND

Key idea: We hear sounds with our ears.

You will need:

- **a blindfold**
- **various objects that make sounds.**

Blindfold a partner, then use the objects to make three sounds in turn. Have your partner identify the sounds.

Write down two words describing one of the sounds. Have your partner identify the sound referred to.

ACTIVITY: LISTENING POSTS

Key ideas: We hear sounds with our ears. Sounds can vary in pitch and loudness.

You will need:

- **a blindfold**
- **various objects that make sounds.**

Sit blindfolded quietly in a room, or move outside and sit quietly for 2 minutes. Write down a description of any sounds you hear.

Sound and vibration

Sound can be made in many different ways and is always caused by vibration. The type of vibration results in the type of sound produced. The vibration activities mostly give tactile or visual evidence of vibrations associated with sound. They render visible the invisible. It is instructive to get students to describe what is happening, supported by drawings.

ACTIVITY: TUNING FORKS

Key idea: Sound is caused by vibrating objects.

You will need:

- **a tuning fork**
- **a ping-pong ball suspended with a length of thread**
- **a transistor radio**
- **a balloon**
- **a glass of water.**

Strike a tuning fork and have it touch a suspended ping-pong ball, or the surface of a glass of water. Write a description to explain your observations.

Hold your hand against the speaker of a transistor radio. Turn the volume up. What is vibrating?

Hold your head back and touch your throat lightly while saying ‘eeeeh’ with your teeth together. What is vibrating?

Hold a balloon against your nose, then speak. Feel the vibration with your hands. Have another person speak to the balloon. Describe the process by which the balloon is caused to vibrate.

ACTIVITY: DIFFERENT SOUNDS

Key idea: Sound is caused by vibrating objects.

You will need:

- **a wooden ruler**
- **a dinner fork**
- **an elastic band**
- **various containers**
- **a drum or tambourine**
- **uncooked rice**
- **bottles or jars containing water**
- **a comb.**

Make as many different sounds as possible with:

- **a wooden ruler**
- **a dinner fork**
- **an elastic band wrapped around various containers**
- **a drum or tambourine (put a sprinkling of rice on it)**
- **a series of bottles or jars containing water**
- **a comb and various surfaces around the room.**

Make a list of words to describe these sounds and the way they are made.

Explanatory note: For most of the objects the source of the sound is the object itself: it vibrates. However, in addition to the object, a column of air may also vibrate, as in the column of air within a container with an elastic band. Two types of sounds can be made with the bottles or jars: tapping on the side vibrates the glass and water; blowing across the top of the bottle or jar vibrates the air column within.

ACTIVITY: VIBRATING RULER

Key idea: Sound can vary in pitch (frequency) and loudness.

You will need:

- **a table**
- **a ruler.**

Place a ruler so it lies flat and protrudes over the edge of a table. Set the ruler vibrating by holding one end firmly against the table.

What is happening in the ruler to make the sound? What must be done to the ruler to obtain a louder sound? What is happening in the ruler to get a loud sound?

What must be done to obtain a higher pitched sound? What is happening in the ruler to obtain a higher pitch?

Explanatory note: The vibrating ruler is the sound source. The greater the amplitude of vibration, the louder the sound will be. The higher pitch is achieved where the ruler is shortened (the ruler extends a shorter distance over the edge of the table). In this situation the speed of vibration is greater. The greater the speed of the vibrating source, the higher the pitch of the sound.

Sound travels

Sound will travel through a range of materials, at different speeds. If you put your head against a railway line you can hear the train coming because the metal transmits sound very efficiently. Whales are able to communicate over large distances through sea water. The *String telephone* and *Utensil chimes* activities illustrate the passage of sound through strings. In *Utensil chimes* there is an added interest because the sound is nothing like the sound through air … it is deep and resonant and lasts quite a while. This is because the string transmits energy efficiently to your ear, and it also tends to favour the low-frequency components of the sound and suppress the jangling, high-frequency components.

With the *String telephone* activity in particular, it is instructive to ask students to describe how sound is transmitted from one person's mouth to the other person's ear.

The first activity, *Sounds in the distance*, is about the slow speed of sound travel. Sounds travel through the air at a high speed, but not as fast as light, which is why we see lightning before we hear the thunder during an electrical storm.

These activities are suitable for Year 3 and above.

ACTIVITY: SOUNDS IN THE DISTANCE

Key idea: Sound travels faster than light.

You will need:

- **a drum, tree or rubbish bin**
- **a stick.**

Have someone in the distance hit a drum, tree or rubbish bin with a stick. Is the sound heard at the same time as the striking is seen?

Write down what you think is happening and how you hear the sound.

Explanatory note: Sound travels at about 330 m per second in air; sound travels 1 km every 3 seconds. Light, on the other hand, travels at 300 000 kilometres per second. You can estimate how far away lightning occurs if you determine the time, in seconds, between seeing lightning and hearing thunder. Divide the time by three; the answer will give the number of kilometres to the location of the lightning and thunder.

ACTIVITY: INVESTIGATING DIFFERENT ASPECTS OF SOUND

Key idea: Sound bends around corners and spread out when passing through apertures. Sound reflects off objects.

You will need:

- **a loudspeaker.**

Design some experiments appropriate for investigating the following:

- **Does sound bend around corners? How much?**
- **How are loudspeakers designed?**

- **How effective is cupping your ears to hear soft sounds?**
- **Does sound reflect from some surfaces better than others?**

Explanatory note: Sound bends around corners very easily. You only need to have a door to a room slightly open for sound to travel through and spread out. Loudspeakers are designed so that the central part, called the ‘diaphragm’, can freely vibrate. Cupping your ear increases the loudness of the sound; it is the same explanation as given in the *Ear trumpet* activity. Sound reflects best off smooth surfaces.

ACTIVITY: STRING TELEPHONE

Teaching note: Young children have difficulty coordinating their holding and speaking and listening in this activity.

Key idea: Sound travels through solids. Cavities, or resonating chambers, can amplify sound.

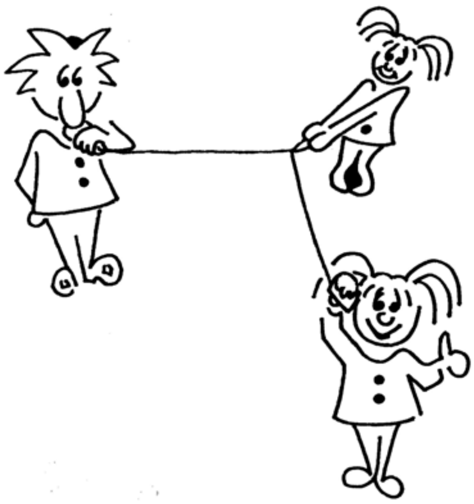
You will need:

- **two plastic cups**
- **string (5 m).**

Make a string telephone from two plastic cups and a length of string. Stretch the string telephone tight. One student talks into one can, while the student at the other end puts their ear to the other can.

How does the sound get from the speaker to the listener (describe the steps)?

Investigate the conditions for the sound to travel. Does the string need to be tight? Why/why not? Does it work when someone holds the string? Why/why not?



Hold the string between your thumbnail and forefinger and scrape along it. How does that sound? Can the sound be made to travel around a corner? (Try holding the string with a rubber band.)

What are two questions you could ask about the string telephone that could be answered by an investigation? Answer your questions.

Explanatory note: When you speak into the cup of the string telephone, the cup acts as an echo chamber to amplify the sound (the phenomenon is called ‘resonance’ and the cup acts as a resonating chamber). This amplified sound travels down the taut string as a vibration (sound is just a travelling vibration). The string needs to be taut for the vibrations to travel any appreciable distance. As the vibrations reach the second cup resonance occurs again. If the taut string rests against other objects the travelling vibrations pass into these objects. This leaves fewer vibrations to travel to the other cup and so the telephone will not work as well (or at all!).

ACTIVITY: UTENSIL CHIMES

Key idea: Sound travels through solid objects.

You will need:

- **forks and spoons**
- **string.**

Hang a series of forks and spoons from a string. Press the ends of the string against your ears. Have a friend jangle the forks and spoons together. A similar effect can be created by a coathanger dangling from a string. A fork tied to the string in the string telephone, and struck, also gives the same effect.

Explanatory note: You will hear the sounds of the jangling forks and spoons very well. This is because the vibrations are travelling along the string. Normally, sound travels to your ears through the air from the sound source. The sound spreads out in all directions from the source, so by the time it reaches your ear the sound is less intense. When the sound travels along the string it spreads out, so the intensity of the sound remains high.

ACTIVITY: SCRATCHING SECRETS

Key idea: Sound travels very efficiently through solids.

You will need:

- **a table**
- **a wooden ruler.**

Put your ear against a tabletop while someone scratches softly at the other end. Could this be used as the basis of a communication system?

Have a blindfolded friend sit at the other end of the table, resting his/her head on the table. One student holds up their fingers to indicate a number. Can you mentally concentrate on that number, and send it to your friend using telepathy?

You will be able to let your friend know the number, but not by telepathy! If you scratch very quietly under the table a number of times, your friend will be able to hear this and count, without the rest of the class hearing. Sound travels very efficiently through wood or metal.

ACTIVITY: ROLE-PLAY: TRANSMISSION OF SOUND

Teaching note: This role-play model successfully explains the following:

- A disturbance can move along a material without the material moving with the disturbance; this is called a ‘wave’. Thus energy can transfer from a source to surrounding material, including eardrums. Sound may then be imagined to be a travelling disturbance; a soundwave.
- The particles in the material surrounding the vibrating source vibrate at the same frequency as the source. This incudes the eardrum; the eardrum vibrates at the same frequency as the sound source.
- Sound cannot travel through empty space. If we run our model with no people between the first and last person then a disturbance cannot be transmitted. We must assume in our model that the person representing the ruler can only move forward a short distance before moving backwards. An interesting observation can be made when watching space movies during scenes when spaceships get blown up in space and can be clearly heard.
- Sound travels faster in more dense materials such as water and wood. If we ‘run’ our ‘people in a row’ model over the same distance and compare a lot of people with just a few then it is quite noticeable that the disturbance

moves more quickly with a lot of people. When comparing air to water or wood, the particles in air are much further apart than they are in water or wood.

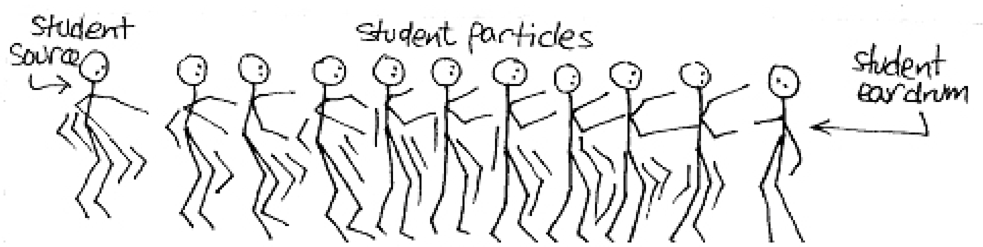
- As the disturbance can travel much more easily in dense materials, sound travels farther in dense materials.
- The disturbance that travels through the material is forwards and backwards to the direction of the disturbance, not sideways to it. This forwards-and-backwards motion of the particles in a material that produces a travelling disturbance is called a 'longitudinal wave'. Sound is classed as a longitudinal wave phenomenon. However, if the particles in the material move sideways to the travelling disturbance, as occurs in water waves, it is called a 'transverse wave'. We shall see later that light may be imagined as a transverse wave phenomenon.

The role-play model does not explain the following:

- The energy that is transferred in each collision is less than the previous collision as each particle collides with a number of particles. This means that sound only travels a certain distance. With the role-play model the students representing the air particles may give themselves extra energy (children will be children!) to sustain the travelling vibration.
- Be careful to note that in the model the air between people represents space between the actual air particles. Sound must be imagined to be a travelling disturbance caused by vibrations and collisions in the particles of the material in which the disturbance moves. Therefore sound should not be considered a separate entity that travels through a material. It is very much related to the particles' motion in the material.
- From the way we understand matter, the particles that make up matter are in constant motion, continually colliding into each other. The travelling disturbances we call sound are added collisions that occur constantly. The particles in a gas, such as air, are moving around faster than in a solid such as a piece of wood. This natural movement of particles inhibits the progress of a travelling vibration (soundwave), which is another reason why soundwaves travel further in solids such as wood than in gases such as air.
- Reflection of sound (although you may picture how it could be done).

Key idea: Sound is a travelling vibration through a medium.

To understand sound transmission, let us take the example of the vibrating ruler and someone some distance away hearing the sound. To represent the transmission of sound from the ruler to the ear, consider the following role-play model. In this model a person who moves forwards and backwards (vibrates) represents the sound source (in this case the ruler), another person represents the ear and is located some distance away from the person representing the ruler. To represent the air between the ruler the model requires a line of people. Each person represents a particle of air. The model is shown in the figure below.



To ‘run’ the model the first person (student source) moves forward, thus bumping the next person (student particle), who then bumps the person next to them (neighbouring student particles), and so on. You will then notice that a disturbance has moved along the entire row to the end person (student eardrum). Notice also that while the student particles only move a short distance, the disturbance passes all along the line of student particles. This travelling disturbance is what is termed a ‘soundwave’.

If we continue running the model, then the first person moves backwards and forwards (vibrating ruler). This sets up a vibratory motion in the neighbouring people (air particles) as they rebound from the person in front of them and the person behind them. This model then predicts that the particles in the air vibrate at the same frequency as the sound source, and the travelling disturbance (wave) through the air will result in the eardrum also vibrating at the same frequency as the sound source. A soundwave is just a travelling disturbance through a medium.

Role-play the transmission of sound. How does your model change when comparing sound travel in wood versus air? What about sound travel through space? What does this model predict about the speed of sound in air compared to the speed in wood?

ACTIVITY: VISUALISING SOUNDWAVES

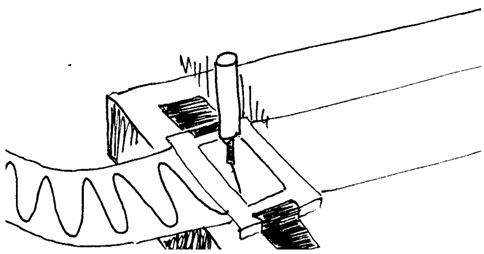
Teaching note: With this activity, students can connect the vibration of the sound source with the representation often given for sound in voice recognition images seen on television programs.

Key idea: Soundwaves are travelling vibrations through a medium.

You will need:

- **a long strip of the paper used in cash registers**
- **a texta**
- **cardboard**
- **a bench**
- **sticky tape.**

Make a cardboard sleeve that the strip of paper can move through freely. The top of the sleeve should have a rectangular window. Attach the sleeve to a bench.



The strip of paper should be fed through the sleeve at a constant rate. At the same time, someone vibrates a texta, drawing on the paper through the window. A wave pattern is then observed on the paper that has been fed through the sleeve. Look at the patterns for large vibrations (these model loud sounds) and high/low frequencies with the pen (these model high-/low-frequency sounds).

After completing a few patterns, predict the shape of the patterns formed. Connect each pattern to the type of sound it represents: soft or loud sound and/or high/low frequency.

ACTIVITY: HOW FAR CAN SOUND TRAVEL THROUGH SOLIDS?

Key idea: Sound travels very well through solids and liquids.

You will need:

- **a fence or railing that has a continuous length of wood or metal**
- **a tuning fork.**

Have one person place the base of a tuning fork at one end of a piece of metal (the top of a metal or wooden fence or railing). Move some metres away and hold your ear close to the fence. What do you notice? Why? You don't need a tuning fork for this activity; you could tap with a ruler. If you have access to a long piece of metal (*not* a railway line), determine the maximum distance from the sound source for which the sound can still be heard.

Sound in our lives

Teaching note: Sound plays a very important role in our day-to-day lives. Some sounds are used to indicate danger or to grab our attention. This activity explores students' perceptions of these everyday sounds and is suitable for all year levels, but probably works best for middle years students.

ACTIVITY: LISTING SOUNDS

Key idea: Sounds vary in pitch, or frequency, and loudness.

Construct a list of sounds we come across in our day-to-day lives, listed under such headings as:

- **sounds for communication**
- **sounds for pleasure**
- **sounds that qualify as 'noise pollution'**
- **sounds indicating danger, etcetera**
- **organisations or institutions that need to have a policy on noise.**

Musical instruments and sound

Making music is an excellent vehicle for introducing and refining ideas about sound. These activities mainly concern the control of pitch, and vibration, but understandings about resonance and sound intensity are also promoted. Although musical instruments are useful for teaching sound at any level, these activities relate properties of instruments to pitch and are therefore suitable for middle years students. The activities involving mathematics are more suited to the upper levels.

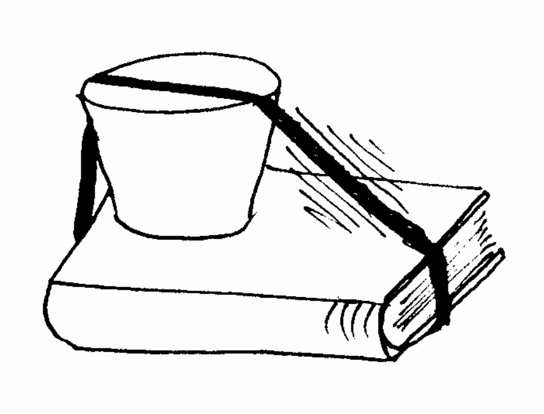
ACTIVITY:
ELASTIC-BAND GUITAR

Key idea: Sounding boards amplify sound, and are important in instruments; vibrating strings form the basis of stringed instruments—the greater the tension in the string, the higher the pitch.

You will need:

- **an elastic band**
- **a hardcover book**
- **a plastic cup.**

Stretch the elastic band around the book and cup. Pluck the band in various places. Can you get three different notes with this instrument?



Here's a challenge! Without changing the position of the cup, but by adjusting the elastic band, can you make the longest section of the band give the highest note? Can you make it play the lowest note? Which section sounds the loudest? Can you think of a reason why?

Explanatory note: The *Elastic-band guitar* activity involves the following ideas:

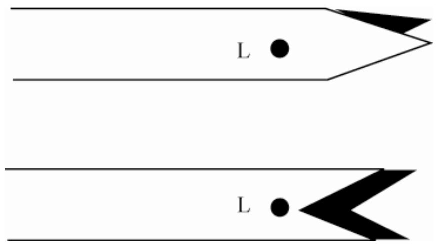
- The tighter the string/elastic, the higher the note (and faster the vibration). This is the principle on which guitars or violins are tuned.
- The longer the string, the lower the note, because of slower vibrations.
- The thicker the string/elastic, the lower the note (again because of slower vibrations).
- The loudness of the sound is enhanced by a sounding box, in this case the cup itself picks up the vibration and amplifies it out through the open mouth; a phenomenon called 'resonance'.

ACTIVITY:
STRAW OBOE

Key idea: Vibrating air is the basis of wind instruments.

You will need:

- **a drinking straw**
- **scissors.**



Cut the end of a drinking straw into a V section. If you press your lips against the part marked '*L*', and blow, you should, with a bit of practice, be able to make the straw sound a musical note.

What do you think is causing the sound? Cut pieces off the end of the drinking straw as you blow! How does the sound change? Use your straw to make a very high whistle. You can join a number of straws together to make one long straw. How do you think it will sound?

If you have a wider straw to fit over your first straw, you can slide it up and down to change the length. What instrument works like this?

Explanatory note: The straw oboe works rather like a reed instrument, with the V section vibrating to cause the sound. The sound is picked up by the air inside the straw, which vibrates and causes a note that depends on the length of the straw. The shorter the straw, the higher the note. The oboe can be quite tricky to play, but you can feel the vibration against your lips once it is sounding. You can join two or three straws together to make a long and very low-sounding oboe.

ACTIVITY: MUSICAL BOTTLES

Teaching note: With older students it would be a useful exercise to extend this activity into mathematics.

Key idea: Vibrating air is the basis of wind instruments.

You will need:

- **a row of identical glass bottles.**

Line up a row of identical glass bottles. Blow across the top of each. Do they sound the same? Tap each with a fork or metal key. Why does tapping and blowing cause different sounds? What is causing the sound in each case?

If you fill the bottles to different levels with water, and line them up in order of water height, then tapping them will show that the fullest bottle has the lowest pitch. But if you blow across the necks you will find that the order is reversed.

It is possible to tune the bottles to give a series of scale notes. The following amounts (in mL) will give the C-D-E-G notes (not concert pitch!) that will play 'Mary had a little lamb'.

	C	D	E	G
For a 1 L milk bottle:				
For tapping	520	430	360	Empty
For blowing	Empty	140	290	500
For a 750 mL tonic or soda water bottle:				
For tapping	535	400	300	Empty
For blowing	Empty	120	205	390

Explanatory note: The musical bottles work differently depending on whether you tap or blow the bottles. What you should find is:

- the bottle with the smallest amount of air should give the highest note when you blow
- the bottle with the smallest amount of water should give the highest note when you tap.

When you blow, the air inside the bottle vibrates and the smaller the amount, the faster the vibrations. When you tap, the bottle with water in it vibrates, and the water acts to slow down the vibration, causing the opposite pattern. With a good ear and a bit of persistence, you can coax the bottles into tune either for blowing or tapping, but not both at once.

ACTIVITY: PAN PIPES

Teaching note: This activity is suitable for middle years students.

Key idea: Vibrating air is the basis of wind instruments.

You will need:

- **seven or eight drinking straws**
- **scissors**
- **masking tape**
- **cardboard.**

Pan pipes can be made with a series of drinking straws of different lengths taped together. Cut the straws into different lengths and, using the masking tape, attach them to the cardboard in descending order.

Play the pipes by blowing across the tops of the tubes, which are tuned by carefully adjusting their lengths. The shorter the length, the higher the note.

The ratio of the lengths determines the relative pitch of the notes. If two lengths are in simple ratios such as 1:2 (an octave), 2:3 (a musical fifth) or 3:4 (a fourth), the pipes will sound pleasing when played together.

The table below shows the relative lengths necessary to make a major scale.

Interval	**Relative length**	**Fraction of straw length**
Unison	1.0	Whole straw
Major tone	0.89	$^8/_9$
Major third	0.80	$^4/_5$
Fourth	0.75	$^3/_4$
Fifth	0.67	$^2/_3$
Major sixth	0.60	$^3/_5$
Major seventh	0.53	$^8/_{15}$
Octave	0.50	$^1/_2$

Measure the length of your longest straw. Use a calculator and the table above to find the lengths needed for your other seven straws. For a simpler set of pipes, use the first four straws only, or straws in a ratio 1.0:0.8:0.67:0.5. Cut these and tape them together, using short straw lengths between them to act as spacers.

Try placing a small plug of plasticine in the ends of the straws to lower the notes by an octave.

ACTIVITY: SOUNDING BOARDS

Key idea: Sounding boards amplify sound, and are important in instruments.

What you need:

- **a rubber hammer**
- **a desk**
- **a tuning fork.**

Hit a tuning fork with a rubber hammer (or strike it against something firm but soft). Listen to the note it makes. How long does it take for the fork to stop sounding?

Hit the tuning fork again, but then place the base of the fork against a desk. What is the difference in the sound? What do you think causes the difference?

Does the type of surface the fork is held against make a difference? Why do you think this is?

Explanatory note: When sounds of certain frequencies enter sounding boards, the reflections that occur inside the boards occur so that the incoming sounds add to the reflected sounds to produce a louder sound. The phenomenon is called ‘resonance’ and the sounding board is called a ‘resonating chamber’.

ACTIVITY: SINGING WINE GLASS

Key idea: Objects have their own natural vibration pattern and can give a characteristic note when hit (or blown).

What you need:

- **a wine glass**
- **a saucer**
- **vinegar**
- **water.**

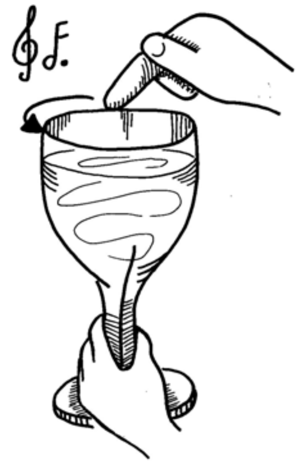
Pour a small amount of vinegar or water into a saucer. Dip your finger into the vinegar and rub it in a continuous circular motion around the rim of a wine glass, holding the glass at the base with your other hand.

The glass should give a high, ringing sound if you have the correct finger pressure and speed.

Why do you think the glass makes a sound?

Is the note it gives off the same as when the glass is tapped? Pour a small amount of water into the glass, Do you think it will give a higher or lower note? Try it.

Explain why you think the glass gives a different note when it has water in it.



Explanatory note: In the *Singing glass* activity, the glass is set into vibration by the action of the rubbing finger. With some alcohol or even water on the finger, rubbing the glass around the edge causes a constant grab/release action which sets the glass into vibration with a clear ringing tone. If you do this under the table at a restaurant people will find it hard to identify where this penetrating sound is coming from, which is just as well, because they'll throw you out if they discover you!

Different glasses give different notes depending on their thickness and size. Holding the glass by the base allows a free vibration. A glass with more wine in it will give a lower sound because the vibration is slowed.

ACTIVITY: SYMPATHY TUBE

Key idea: The tube acts like a sounding board, which amplifies sound.

You will need:

- **a large measuring cylinder or bucket**
- **plastic pipe 3 cm in diameter and 30–40 cm long**
- **water**
- **tuning forks.**

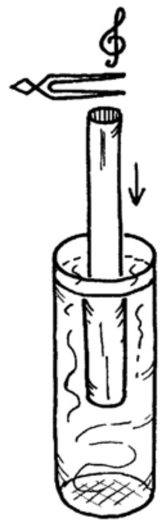
Hold a plastic pipe with its end in the water in a measuring cylinder (or bucket).

Strike a tuning fork and hold it above the end of the pipe. Listen carefully as you lower the pipe into the water, keeping the tuning fork just above the end.

At a certain point, you should hear the pipe sound 'in sympathy' with the tuning fork. When you find this position, blow across the top of the pipe. How does the note compare with the tuning fork note?

Try different tuning forks.

Is there a link between the tuning fork note and the length of the pipe for which the sound occurs?



Explanatory note: The *Sympathy tube* activity involves matching the natural frequency of the tube to resonate, or vibrate in sympathy with the tuning fork. The vibrating tuning fork sets the air in motion, and this will be amplified in the tube at a particular length. In fact, there will be more than one length that will resonate, since for each length there is more than one natural pitch. This is why a bugle can sound more than one note. A player can select which note resonates by adjusting their lip vibrations.