Bringing back glass into the primary classroom – common misconceptions and background science

In this booklet, some common misconceptions that may become apparent when undertaking activities suggested in the 'Bringing back glass into the primary science classroom' resource are outlined.

Providing children with an opportunity to reflect on their own ideas is important. Understanding is shaped by experiences. Careful questioning that encourages children's talk and justification of their ideas, and providing further activities that challenge initial ideas, helps children to move forward in their understanding.

Some background science is included here to support educators. It is not intended to represent the knowledge and understanding required by the children.

As there is some overlap between activities in the concepts explored, the activities have been grouped into themes:

Heating and Cooling (Make Your Own Thermometer, Investigating Windows, Water Cycle in a Jar, Arctic Ice)

How does the home-made thermometer work?

When temperature increases, liquids expand. As the bottle used to create the thermometer is sealed, it is much easier for the liquid to push away the air from the open straw than to compress air trapped in the bottle. So the liquid expands up the glass straw. The hotter the temperature, the greater the expansion and the higher up the straw the liquid travels. Conversely, as the liquid cools, it contracts, takes up less space in the bottle and the level in the glass straw falls.

There is often confusion between the use of the terms heat and temperature.

Encourage children to use the term temperature when measuring how hot or cold something is. We typically use the Celsius scale for temperature (although some might have heard of other temperature scales, such as the Fahrenheit scale). Heat is a term that should be used when talking about energy – whenever there is a temperature difference, heat energy is transferred from the hotter to the cooler place. When heat energy is absorbed by an object, its internal energy increases.

Another common misconception is believing that 'heat' and 'cold' are different substances.

The connection of the terms hot and cold to temperature should be made clear. As temperature increases, an object becomes hotter. As temperature decreases, an object becomes colder.

Why is double glazing more effective at retaining heat than single glazing?

Double glazed windows have two panes of glass close together. There is a glass pane on the outside, a glass pane on the inside, and a small space between the glass panes known as an air gap or tight air pocket, which is now more commonly filled with argon, krypton or xenon gases as these are all very poor conductors of heat.

People often say, "Close the door – don't let the cold in!" This leads to a misconception that 'cold' can somehow 'move'.

Try to develop an understanding that a space becomes colder because heat energy always flows from a hotter to a colder area – the hotter area cools down and the colder area warms up.

Heat energy is transferred from hot spaces to cold spaces in different ways. Heat energy travels from particle to particle in a process called *conduction*, and this is the main way heat travels through solids such as glass**.** Materials that allow heat to travel through them easily are called good conductors. Those that are poor conductors (or reduce the rate of heat flow) are called *insulators*. Glass is an insulator. Heat transfer due to the movement of liquids and gases (e.g. air) is called *convection*. The trapped gas in between glass panels in double glazing cannot circulate, so this reduces heat flow by convection too, reducing the rate of heat loss from inside a building. The reduction in heat loss due to the trapped gas is the main reason that double glazing is more efficient than single glazing. With less heat able to leave the room through the windowpane, the room stays warmer.

Children often have the idea that covering objects with further materials provides heat. This is because of their experiences with putting on a coat or getting under a blanket.

The idea of reflecting *radiant* heat (sunlight) can be discussed with reference to their experiences of wearing black compared to white clothing when it is sunny. The idea of heat travelling (conducting) through materials can be compared to electricity travelling (conducting) through circuits.

How can the water cycle be recreated in a jar?

As it warms, water evaporates, turns into a gas, and rises (through the air). As the water vapour cools, the gas turns back into liquid water through a process known as *condensation* and collects as small droplets at the top of the jar (as clouds would form in the air). As more condensation occurs, the droplets increase in size and when the water droplets become heavy enough, the liquid water falls back to the bottom of the jar, just as rain would fall back to earth.
Evaporation is the process of changing the state of matter from the liquid phase into the gas phase.
Condensation is the process of changing the state of matter from the gas phase into the liquid phase.

Children may think that water only evaporates from oceans or lakes, when it can evaporate from plants, animals, puddles, and the ground, for example.

Provide plenty of opportunities for children to investigate and discuss these ideas – they could monitor the amount of water in a puddle over time.

A very common misconception is that steam (water vapour) can be seen, because people often talk about 'steam coming from a kettle'.

Similarly, it is a common misconception that clouds are formed from water as a gas, rather than formed from water droplets or ice.

Children may think that condensation occurs when air turns into a liquid, rather than the water vapour that is present in air that is condensing.

Water vapour, the gaseous form of water, is invisible. Water vapour may be produced at a range of temperatures, but when it is produced at or above 100^{o}C, it is often called steam. Misconceptions arise as steam cools and condenses in the surrounding air, turning into tiny water droplets that are visible. These are tricky concepts, as it is not easy for children to explore them practically (hence the common misconception) – explanations should be given where appropriate to the children and educators should take care to use the correct terms to reinforce ideas.

Teachers may find this article from Issue 6 of our Why&How Magazine helpful for exploring misconceptions related to understanding states of matter.

Why is melting Arctic ice a problem?

The Arctic is warming more than twice as fast as the rest of the planet. It is normal for some ice to *melt* during Arctic summers (with minimum ice levels in September) and then it reforms during Arctic winters. However, NASA has found that September Arctic sea ice is declining by 13% every decade. This is means we have less and less 'old' ice (older than one year) which is the thickest, most dazzling white and most *reflective* type of ice. In fact, whilst 'young' ice (less than a year old) *reflects* 30% of the sunlight (both *radiant heat* and *visible light*); 'old' ice *reflects* 80%. Unfortunately, this creates a positive feedback loop: global warming increases temperatures so more of the 'old' ice *melts*. Then as more 'old' ice *melts*, there is less *reflection* of the sunlight and temperature goes up further.

Glass is a *thermal insulator* and tiny hollow glass beads are highly *reflective*. When a thin layer of them is spread on the surface of the 'young' ice, the *reflectivity* increases from 30% to 45%, less ice melts in the summer and so it has more chance of becoming 'old' ice.

Living Things (Make a Model Lung, Feed the Birds, Plant Germination and Growth)

How does smoking affect the lungs?

Lungs are part of our respiratory system, and their function is to take in fresh air (during *inhalation*), extract the *oxygen* which our bodies need. The oxygen is then carried by the blood stream to cells throughout the body. Cells in our bodies need oxygen to react with glucose from our food to provide energy. The reaction produces water and another gas, carbon dioxide, that is transported back to the lungs through the blood stream and expelled (during *exhalation*). Other gases inhaled (such as those naturally present in the air) may be harmless or harmful to the lungs and the wider body systems.
The nicotine and other chemicals in tobacco can contribute to diseases and problems with the heart and lungs. The tar can form a sticky layer inside the lungs reducing their function and smoke can cause mucus to build up in the small airways in the lungs, making it more difficult for the smoker to breathe. Nicotine will also narrow blood vessels which, in turn, will reduce the number of red blood cells which carry oxygen to the heart.

Some pupils do not realise that what they inhale through their noses and mouths goes into their lungs.

Providing opportunities for children to see the structure of the respiratory system and to discuss how air and other substances can be inhaled the body will help them to understand that both good and bad substances may enter.

Should humans provide food for birds?

There is quite a lot of discussion around whether birds should only have food provided by humans in autumn and winter and left to forage naturally in spring and summer.

Sadly, with decreasing habitats in many areas, birds rely on the additional food provided by humans. The consensus is that feeding birds all year round provides them with much-needed nutrition and gives humans the opportunity to engage with nature in an easily accessible way. Ideally, food provided for birds should be put out regularly, to avoid birds expending too much energy flying to a site where food is no longer available and feeding stations should be cleaned to prevent the spread of diseases in the bird populations.

During his voyage around the world on HMS Beagle, the famous scientist Charles Darwin noticed that on each of the Galapagos Islands the finches had different shaped beaks. The beak shape is an important *adaptation* enabling a bird to eat specific types of food. Animal adaptations can be thought of as any body shape, process or behaviour that allows an organism to survive in its environment. Animal populations naturally change over time in response to changes in the environment. Those better equipped to survive any environmental change, due to their own favourable adaptations, are more likely to reproduce and pass their genes and these adaptations to their offspring, the next generation – this is the process of *natural selection*. Birds have different shaped beaks depending on what they eat and available food sources. Birds may get their food from many different sources, e.g. mud, water, fruits, seeds, wood, or they may catch it in the air. The different shapes of beaks allow access to various food supplies.

Teachers may find this article from Issue 3 of our Why&How Magazine helpful for exploring concepts related to understanding evolution.

What conditions are needed for plant germination and growth?

Seeds needs water and warmth to *germinate*. Some seeds also need some light to germinate. Covering a jar may increase the warmth surrounding seedlings to aid germination, but for most seeds, the colour or transparency of the container will not affect the germination process.
During germination, a seed's stored energy provides nutrients for growth, until the first primitive leaves are formed, at which point it will begin to produce its own food, through a process called *photosynthesis*. This mainly happens in the green leaves of the plant.

After germination, seedlings will grow best with good sunlight, water and air, so the leaves can make their own food. If a glass jar is used to cover seedlings (rather like a greenhouse), its transparency enables plenty of light to reach the plant and it will also trap heat, making it very suitable for growing seeds. Of course, heat can cause evaporation and dry the soil, which would not be good for the plant. If a covering glass jar is opaque, no light will pass through it, so the leaves will yellow and eventually the plant will die. If a glass jar is translucent, some light will pass through. The seedlings may be long and leggy as they search for the light and may become yellow if they don't have enough light for photosynthesis.

A common misconception is that light is always needed for germination.

Many seeds germinate best in total darkness. However, there are some that need light and will remain dormant until they have sufficient light to trigger germination. These include poppies, petunias and busy lizzies.

Light and Sound (Glitter Discovery Jar, Mirror Images, Make Your Own Microscope, Making Music)

How do light sources and reflective surfaces differ?

Light sources are those materials or devices that produce visible light (this could be *natural* or *artificial*). When light strikes a surface, the light may be reflected, absorbed by the material or may be able to pass through it.
All materials *reflect* light – this is why we can see them. A 'mirror reflection' is only produced when the surface is smooth. 'Bumpy' surfaces reflect light in all directions so an image cannot form (as it would in a mirror), but some of the light that is reflected travels to the eye and the object can be seen.

A common misconception is that reflective surfaces (such as mirrors, shiny, or brightly coloured materials) emit light. It is also common to think of only shiny surfaces or water as being reflective.

Children rarely experience true darkness, so are often able to see objects that don't emit light when they believe it is dark. It is important to provide opportunities for children to discover that only light sources emit light.

Another common misconception is that opaque, coloured surfaces 'give out colour or darkness'.

Coloured surfaces *absorb* some of the spectrum and reflect others. A white surface reflects all colours whilst a black surface absorbs all colours of the spectrum.

Why do we see shadows from the glitter jar?

A shadow is formed whenever an *opaque* object is placed in the path of a ray of light, the light cannot pass through the object and only rays at the edges of the object can pass, outlining the shadow.
A s the objects in the glitter discovery jar move around in the water, the torch light is blocked by opaque and, to a lesser degree, *translucent* materials, leading to the creation of shadows. Increasing the light available, by introducing a torch, makes shinier objects even brighter, so they are more visible in the liquid, and this increases the contrast so that shadows become more apparent.

A common misconception is that vision is an active human process, 'I am looking at something, which is why I can see it', or that eyes give out a form of light to enable us to see.

Children need to know that that we see things because light travels in straight lines from light sources to objects and then (is reflected) to our eyes.

When making a microscope, we can ensure that our pupils understand the path of the light: from the light source, light travels in a straight line to the foil, where it is reflected in a straight line to the sample. The light is reflected from the sample and travels towards the water lens in parallel lines. The water droplet is a rounded convex shape which causes the light to be refracted so that the light rays converge (come together). By changing the direction that the light is travelling, the lens can 'trick' our eye and allow us to see enlarged images.

Teachers may find this article from Issue 1 of our Why&How Magazine helpful for exploring misconceptions related to understanding light.

What is the difference between the volume and pitch of a sound?

Sounds are caused by *vibrations*. When a vibration is created, its energy travels outwards from the source in all directions. The energy is passed on through surrounding solids, liquids and gases (e.g. the air). We hear sounds because the air in our ear causes the eardrum to vibrate. Hitting a glass tumbler causes it to vibrate, along with the water inside and this makes a sound that we can hear. An empty glass, or glass with a small amount of water, has more air in and around it, so the glass vibrates quickly which makes a high-pitched sound. When the glass has more water in it, the glass vibrates more slowly, and the sounds produced are at a lower pitch. The longer the column of water vibrating, the lower the pitch produced.

Children often confuse volume and pitch.

Try to encourage the use of the terms 'high' and 'low' when referring to pitch, which is due to the frequency of the sound wave (i.e. how quickly the object vibrates). 'Loud' and 'soft'/'quiet' are terms relating to volume, which is a measure of the amount of energy of a sound, or the size of the vibration.

They make think that by hitting a jar harder, that it will change the pitch.

They should be shown that this just makes the noise louder. When investigating, encourage the children to try to strike the glass with the same amount of force so they are not changing the volume.

Teachers may find this article from Issue 11 of our Why&How Magazine helpful for exploring misconceptions related to understanding sound.

Materials (Soil Profiling, Fire fighters)

Are soil and compost the same?

Compost is a made from rotted organic matter. Soil is the thin layer of material covering the earth's surface and is formed from the weathering of rocks. It is made up of mineral particles, organic materials, air, water and living organisms. Different soils have different properties depending on their composition. There are lots of different types of soil – sand, clay, silt, chalk and many more.

Organic material is broken down by microorganisms and other creatures in the soil. The broken-down material becomes nutrients for plants. Soil is important for all life on Earth.

Sandy soil is coarse textured, pale coloured and has large *particles*. These create lots of small air gaps. Water drains through them easily so it usually feels dry.
Silt soil is smaller than sand particles but larger than clay particles. Silt particles are slippery when wet and powdery when dry. If the soil feels smooth like talcum powder, it is silty. Silty soils are dense and do not drain well. They are more fertile than either sandy or clay soils.
Clay soil is usually sticky and has small particles. They contain very few air gaps and water does not drain through it easily.
Chalky soil is a light brown soil. Water drains through it quickly.

It is often thought that soil and compost are the same thing. Children may think that all soils are the same.

Providing opportunity to explore different types of soil and compost will help develop children's appreciation for these materials and their importance in supporting life.

How is fire created and extinguished?

All fires require 3 things: a source of heat, a fuel (flammable material) and a source of oxygen. If any of these is taken away, the flame will be extinguished.

Children often believe that the only way to put out a fire is to cool it down, or to pour water on it.

It is important for children to understand that it is not always safe to put water on a fire, for example if caused by an electrical fault, or if oil is present. Where possible, arrange for local firefighters to talk to the children about fire safety and ensure they understand that they should never attempt to put start or put out a fire themselves.

In this demonstration, the oxygen in the air is displaced by carbon dioxide, extinguishing a flame.

When an acid such as vinegar mixes with an alkali/base such as bicarbonate of soda, a chemical reaction occurs, and new materials are created. In this reaction, a salt called sodium acetate is made and this dissolves in the water also present in the vinegar, more water is produced, and the gas carbon dioxide is also produced and bubbles up through the liquid. Carbon dioxide is heavier than air and so remains close to the bottom of the jug, above the liquid. When the jug is tipped, the carbon dioxide is poured out and sinks further, smothering the flame. As it does not support combustion, carbon dioxide can be used in fire extinguishers.

To create heat resistant glass, certain chemicals can be specifically used in its production, such as soda lime or silica, and glass may also be tempered to increase its strength.