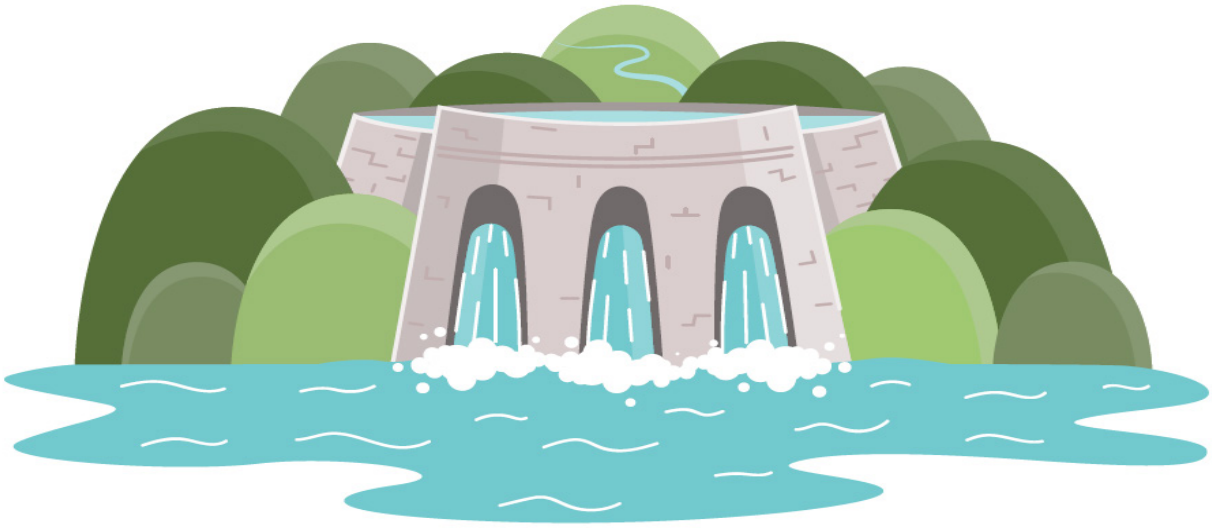
SEND Teacher Resource



Water
Investigating the Mpemba effect.

Water

Terrific Scientific Campaign

Investigation: Water

Hello! Welcome to the Water investigation from the Terrific Scientific campaign!

At BBC Terrific Scientific, we think it is vital to develop science learning in primary schools across the UK. By taking part in this activity, you will be developing your class's scientific thinking and investigative skills. These resources have been created for use with pupils with SEND.

At Key Stage 2 (Second Level in Scotland), **children need to:**

- **Develop** investigative skills.
- **Understand** when it is important to control variables.
- **Predict, observe and record** results.
- **Draw conclusions** (which may generate new questions).
- **Understand** the need to repeat activities.
- **Record** what they see and not what they want to see.

We have incorporated these principles into this exciting activity. We've made it suitable for primary classrooms by using readily available equipment and suggesting opportunities for support and differentiation within mixed-ability classrooms.

The BBC deems this activity safe if following some basic precautions. It is your responsibility as a School to carry out your own risk assessment and we recommend you consider the risks and mitigations we have described in this activity pack, as well as any risks which may be relevant to your specific class environment.

As well as these key working scientifically principles, we have made sure there are links to the science curriculum for each nation, as well as cross curricular opportunities for further learning. We think these are just as important, as they help to explain the relevance of Science and how it links to the world around us.

On our website you will find a supporting 'How to' film which shows teachers and teaching assistants how to set up and carry out the experiment. You will also find additional resources including a step-by-step lesson presentation, and an introductory film which sets the investigation into context for your students.

We orignially partnered with the University of Southampton for this investigation.

We hope this inspires you and your students to get scientific!

The Terrific Scientific Team.

Related links:

Find out more about Terrific Scientific and our other investigations on – bbc.co.uk/terrificscientific

Supported by: University of Southampton, Royal Society of Chemistry, Primary Science Quality Mark, Geological Society.

Contents

This pack will support you to investigate the Mpemba effect with your class, by gathering data to compare the freezing points of warm and cold water.

Learning intention

Children will investigate whether starting water temperature affects the time it takes for water to freeze.

Children will compare differences in freezing times of hot/warm water and cooled tap water to investigate what is commonly known as 'The Mpemba Effect'.

Children will discover and record the hardness of the water in their school.

Investigation:

We'd like you to investigate your tap water freezing times, by timing how long it takes cold water to freeze compared to hot water in your school's freezer.

Aims:

- To **understand** the difference between **hot** and **cold**.
- To learn and use **scientific vocabulary**.
- To **investigate** whether starting water temperature affects the time it takes for water to freeze.
- To **compare differences** in freezing times of hot/warm water and cooled tap water to investigate what is commonly known as 'The Mpemba Effect".
- To **participate** in a national experiment.
- To **see** what happens to water as it freezes, to **touch** water as it cools, to **hear** changes when we pour it as the water cools and turns to ice.

The activity will:

- **Enthuse children in Science,** underlining the principle that Science is accessible to all.
- **Demonstrate** helps us to understand the world around us.
- **Gather** evidence through practical activities, observations and controlled investigations.
- Allow children to see that their results can directly **contribute** to further scientific study.
- **Develop** student's investigative skills, as well as building conceptual understanding.
- Help children to **understand** that all results are valid, even if unexpected.

Notes:

Extra items may be needed if extension investigations are undertaken while the water is freezing. See 'teacher notes' for suggested extension activities.

Key vocabulary

Science, solid, liquid, water, ice, warm, cold, temperature, freezer, mini cup, thermometer, pour

Tip: Students may benefit from pre- learning of vocabulary prior to the investigation. You could then check children's understanding of vocabulary throughout using flash cards.

What will the children learn? (England, Scotland, Wales and Northern Ireland)

England

Working scientifically

- Planning different types of scientific enquiries to answer questions, including recognising and controlling variables where necessary.
- Taking measurements, using a range of scientific equipment, with increasing accuracy and precision, taking repeat readings when appropriate.
- Recording data and results of increasing complexity using scientific diagrams and labels, classification keys, tables, scatter graphs, bar and line graphs.
- Using test results to make predictions to set up further comparative and fair tests.
- Reporting and presenting findings from enquiries, including conclusions, causal relationships and explanations of and degree of trust in results, in oral and written forms such as displays and other presentations.
- Identifying scientific evidence that has been used to support or refute ideas or arguments.

Chemistry

- Observe that some materials change state then they are heated or cooled, and measure or research the temperature at which this happens in degrees celsius.

- Compare and group together everyday materials on the basis of their properties, including their hardness, solubility, transparency, conductivity (electrical and thermal), and response to magnets.

- Know that some materials will dissolve in liquid to form a solution. water changing state, relating to everyday experiences.

Scotland

- Sciences; experiences and outcomes.
- Sciences; planet earth; processes of the planet; water changing state, relating to everyday experiences.
- Sciences; materials; chemical changes; the properties of water.
- Sciences; topical science (discussing Mpemba's experiment).
- Sciences; materials; properties and uses of substances; Exploring properties and changes in substances,

Wales

- Skills; Enquiry, planning, developing, reflecting.

Northern Ireland

- The world around us: Science and technology; change over time from key questions.
- How do things change?
- What kind of changes happen?
- Can we stop unwanted changes?

Health and safety and control measures

Use of a thermometer

- To be used by staff, with (possibly) children reading the value.
- Prior to this, some work on reading thermometers/understanding negative and positive temperatures/finding the difference between a negative and a positive number could be done.

Important!

Only staff should have access to hot water.

Handling warm/hot water

- To minimise risk, only staff should have access. Staff should collect the hot water, transport it to the classroom, measure the temperature and pour it into marked mini cups. This should be done at the last possible minute to stop the water from cooling down, as this could affect the experimental outcome. We recommend you either heat tap water to 50°C, using the thermometer to measure the temperature or by using a wall water heater or kettle. If using a wall water heater or kettle, reduce the temperature of the hot water in the insulated cup/flask using cold water, using the thermometer to ensure that it does not drop below 50°C. We recommend having a fully stocked first aid kit available, which includes burn gel or a cold pack in case of accidental spillage.

Remember:

Have a cold pack readily available in case of accidental spillage.

Access to and using the freezer

- As access to a freezer may be in restricted areas for students such as a staff room or kitchen, we propose staff collect the samples each time, rather than the students.
- It may be that only kitchen staff may be allowed to place water samples in the freezer.
- Touching frozen items when collecting the frozen samples also poses a risk. Wearing gloves to collect the cold containers will minimise the chance of ‘cold burns’ as well as reducing the risk of introducing bacteria to items in a freezer.

Transporting samples to / from the freezer

- Using clear plastic ‘takeaway’ trays will catch any spillages.
- Ideally they should be carried in an insulated box to maintain the temperature.

Additional Control Measures

The main experiment calls for water at 50°C, this should only be handled by staff. All water to be handled by pupils should be at a maximum of 43°C, in line with government guidelines for SEND schools.

We recommend: To minimise the risk of water spillage each group can be given a tray on which to carry out the investigation and paper towels to clear up any spillages.

Investigating the Mpemba Effect

Introduction

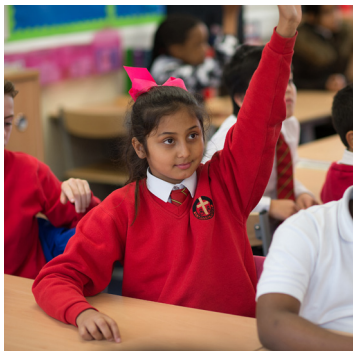
Some scientists have discovered that water doesn't always freeze how you would expect. Erasto Bartholomeo Mpemba was a young student of 11 or 12 years of age at school in Tanzania when he observed a phenomenon which today carries his name, all because he was in a rush to freeze hot cream. It had previously been observed by Francis Bacon, and even Aristotle, but the Mpemba Effect was first tested in detail in 1969 by Erasto Mpemba and Denis Osborne.

During our original investigation in February 2017 scientists at the University of Southampton were investigating the Mpemba Effect, to see if this discovery could be more widely applicable. To do so, they needed lots of people to repeat the same scientific investigation and we asked schools across the UK to send in their data. Although the study has now finished, you can still complete the investigation, conducting controlled comparative tests using your tap water

This resource has been tested in SEND classrooms and will support learning in the classroom for pupils with special educational needs and disabilities.

Ask:

If your class wanted to make ice cubes or ice lollies quickly, would it be better to use cold water or warm water? Which would freeze faster?



Resources

- 1 Litre of tap water, cooled overnight in a fridge.
- Container to hold cold water.
- Plastic measuring cylinder.
- 1 Litre of heated tap water 50°C (See 'teacher notes' for safe heating and transporting).
- Safe, suitable insulating container to hold hot water.
- Plastic shot glasses (to be referred to as mini cups) – two per student OR minimum of 50 in total.
- Small, clear plastic trays (take away food type) – enough for all measuring cups to fit in freezer, plus some to examine the results.
- Freezer access with enough space for small trays.
- Large trays to contain spillages – one per group.
- Insulating box to bring samples to and from the freezer.
- Timer.
- Markers – one per group.
- Thermometer.
- Paper towels to clear any spillages.
- Water hardness strips (these are avalible online inexpensively, we recommend strips that have 5 possible results)
- Gloves.

Expected duration

Approx. 2.5 hours.

NB: There will be time between the set up and conclusion when you could carry out other activities. It is possible the activity could over run depending on the efficiency of your freezer and the activities you conduct in the classroom during freezing and after you have collected your results. Please allow enough time for preparation and rehearsal also.

Additional equipment (if required)

- Two identical, empty 1 litre bottles. Fill one with cold water and chill overnight. Just before the lesson, fill the other with warm water (approx. 43°C). Wrap a piece of red paper round the warm bottle and some blue paper round the cold bottle (secure with sellotape). Use duct tape to seal the lids on if this will be an issue in your class. These will be used for handling.
- Have extra chilled water available for pupil-filling of cups.
- Ziplock bags for handling (size GL05 114x114mm ideal).
- Printed picture of a thermometer (see below). You may wish to laminate this.
- Use Interactive Whiteboard to demonstrate use of thermometer, remember to stress importance of reading thermometer when it is still in the liquid, as it will change once it has been removed.
- Laminated symbols for warm and cold (at least one of each per child).
- Items associated with “warm”: blankets, hot water bottles, furry thing red and orange items.
- Items associated with “cold”: metal bowls, spiky balls, cold water bottle, blue and yellow items.
- Use coloured shot glasses as your “minicups”. Pink/orange/red for warm and blue/green/yellow for cold.
- Thermometer Illustration sheet(provided)
- Hot and cold illustration sheet (provided)

Ask:

Does warm water freeze faster than cold water?

What evidence could they collect to answer it?

Is it a good plan?

Will the evidence collected answer the investigation question?

Teacher preparation

Main Investigation

We recommend:

To minimise the risk of water spillage each group can be given a tray on which to carry out the investigation and paper towels to clear up any spillages.

Prior to the lesson, measure 25ml using a measuring cylinder and pour this into a mini cup to see where it comes up to. A line should be drawn at this level on each mini cup. Divide your 50 cups into two piles of 25. If you are using coloured mini cups, put the red, pink and orange in one pile and the blue, green and yellow in the other. To help with randomization (see below), label your "warm" mini cups 'W1' to 'W25' and your "cold" mini cups 'C1' to 'C25'. If it is appropriate for your class, you could leave enough for the pupils to label one of each for themselves.

- We recommend you do a 'dummy run' before doing the investigation with children and note down how long it takes before ice begins to form. If it begins to form before 80 minutes, note down this time, and adjust your student worksheets and plan to start timing the investigation in the classroom from this time onwards.

- Freezing time can be influenced by how often the freezer is opened, the type of freezer (chest or upright) etc. By having a 'dummy run', you will have a guide as to when you need to start taking more frequent readings when the water begins to freeze. Knowing this approximate time also allows you to plan other related activities which can be carried out while the water samples are in the freezer (See additional activities).

- You might have noticed that items freeze more quickly in different parts of the freezer. Try to control for this by randomizing the way the cups are placed in the freezer, try not to clump all the warm and cool samples together.

- For the 'student worksheet', plastic shot glasses have been referred to as 'mini cups', and should be referred to as such for the duration

Watch the film:

Our 'introduction film' will be really useful for introducing the investigation to your students. On our website you will find an online lesson presentation including this film, learning objectives and the steps of the investigation to share with your class.

Note:

New theories are constantly being explored to try to explain what has been observed

- Plan how you will introduce the investigation question. Talk about what happened when liquids freeze (a reversible change from liquid to solid) and how this change occurs when the temperature is reduced. Talk about how we recognise that freezing has taken place. Tell the children about the young Erasto Mpemba trying to make ice cream in a hurry and putting warm cream in the freezer. Ask the children what they thought happened. **How long do they think it took the warm cream to freeze compared to if he had frozen cream that was cold?** You can tell them that Mpemba noticed that the warm cream froze faster than he expected. He wondered if all warm liquids freeze faster than cold ones and went on to test this. **How do you think he did that? Do you think the same thing happens with water? How could you test it?**

- This is a great example of science being counter-intuitive and therefore a really good opportunity to talk about how science works - careful observation of phenomena (the warm cream froze faster) leads to questions (do warm liquids freeze faster than cold?) which are then tested against evidence (freezing times of different temperature liquids).

- This is a comparative test, comparing two set of data: the time taken for water at two different starting temperatures to freeze. Children are investigating whether warm water freezes faster than cold water.

- As they are not collecting continuous data (water at a range of temperatures between cold and hot) they will NOT be able to draw a cause and effect conclusion i.e. the higher the temperature the less taken to freeze.

- Before starting, it may be useful to demonstrate how the students are expected to fill the mini cups by marking them at 25ml and carefully filling to this level.

Main Activity

1. Pass around the colour-coded bottles of warm and cold water. When handling the warm water bottle, use “warm” items such as blankets to convey the warmth. When handling the cold bottle, use cold metal items and spiky balls to convey the cool. Encourage pupils to identify if the bottle is warm or cold. Use symbols, speech and signs. Bottles can be touched on arms and legs of pupils if this is preferred.

2. Show pupils the picture of a thermometer and compare to the bottles of water. Ask them to help label the temperature of the two bottles onto the picture. You could use a thermometer to take the temperature of the bottles in class if this is appropriate in your setting.

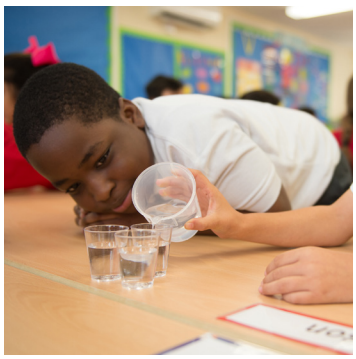
- Prior to the lesson, it may be useful to measure 25ml using a measuring cylinder and pour this into a mini cup to see where it comes up to. A line should be drawn at this level, and this would then be the level children are advised to fill their cups up to.

3. Mini cups marked ‘W’ should then be given to staff to collect in clear plastic trays which have been labelled A, B, C, D. The mini cups should be arranged in number order in the trays, with cups W1-8 (or how many fit) in tray A, with the next batch in tray B, and so on. This will make sample collection much easier.

4. Staff should bring the cold and warm water to the class in suitable containers. The temperature of each should be taken by staff and noted down.

Film:

Please make sure you have viewed the ‘How to’ film for this investigation available on our website – t



Testing water hardness:

While the water is freezing, the water hardness strips can be used to test the tap water. Results should be noted.

Find full instructions in the Water: Classroom presentation resource on our website.

Also, see 'additional activities', where we also offer ideas of activities to do while you wait for the water to freeze.

5. All students should be given a beaker of cooled tap water. Try to avoid pupils dipping their fingers into the water as this may introduce contaminants which affect results. Assist pupils as necessary to fill mini cups to the level indicated (approx. 25ml). You could use plastic pipettes to get the level right if mini cups are over-filled. Try to work quickly so that the water does not warm up too much. Collect the mini cups into a separate clear plastic tray.

6. Staff (plus students if possible) should collect all 'C' filled cups into labelled trays (E, F, G, H) ready to go into the freezer. Place them in number order into the trays, with cups C1-8 (or how many fit) in tray E, with the next batch in tray F, and so on. This will make sample collection much easier.

7. Staff should then measure warm water into 'W' mini cups and place in separate trays.

- It is important for the investigation that the water does not cool down, so this should be done at the last possible moment, after all the 'C' cups are collected.

8. Staff should take all samples and place them in the freezer. **Care should be taken not to "clump" together all the warm water and cool water in the same part of the freezer, try to spread them around as evenly as possible.** The starting time should be written down so time taken to freeze can be calculated later.

9. Label two takeaway trays with 'W' and 'C' and two bags with 'W' and 'C', this is ready for the recording phase.

10. You will have about 80 minutes until the first measurement. During this time, you could test the water hardess (see callout). If you think this might confuse your students you could try one of the additional activities listed below and complete the water hardness test as a separate activity.

Discussion:

You should discuss why it is important to collect multiple results for each temperature and to calculate the mean freezing time, as well as the importance of accurate measurement (of time, amount of water, and starting temperature) as well as making accurate comparisons of observations of freezing.

11. After **80 minutes** (or less, depending on your 'dummy run'), it will be time to start **sampling**. Staff should collect 4 mini cups from the freezer (2 'C', 2 'W') and bring these to the classroom in an insulated box. Depending on your class, you may wish to wait until there is a layer of ice 2mm thick in the mini cups before starting the measurements. This is thick enough to make good sounds when poured.

12. Work quickly. Ask pupils to pour one of each into the labelled tray and one of each into the labelled ziplock bags. Seal the bag with as little air in as possible. Can they HEAR a difference as it is poured into the tray? Listen out for the different sounds of hard ice, or runny liquid water. Encourage pupils to look at the samples. How much the water has frozen should be recorded in the class results table.

- How much has frozen will range from none to completely. The method of measuring and recoding should be decided by the students and teacher before the sample is frozen. Talk about how you will know that the water is completely frozen. We suggest you use a scale from 1-5 where 1 is liquid water and 5 is solid ice, although you could agree another method with your class.

- At each observation time (10 minute intervals) you will have a value for two samples of each temperature to add in to the class results sheet. By working as a class, you will only complete the top two lines of each section of the main results table.

13. The scale you choose is not key data, so we recommend you choose the most appropriate scale for your class. It can be used as an opportunity for learning about observation, measurement, estimating and recording. However, the key data which must be recorded unambiguously is the time at which the **water has frozen completely.**

- Mini cups and plastic trays should be recycled once the result has been recorded.

15. Once the recordings are made, encourage pupils to explore the samples. How does the water feel? Is there any ice? Is there more ice in 'W' or 'C' samples? Use the ziplock bags of samples to improve handling by all pupils. Try to ensure all pupils explore how cold the water has become. Can they feel a difference between the 'W' and 'C' samples? Use the thermometer picture to show where warm and cold are on the scale (we started at about 50°C and 7°C). Introduce the idea that at 0°C the ice will freeze and become solid (hard). Show where 0°C is on the thermometer and ask if pupils think the warm or cold water will get to freezing point first. You can also use warm and cold associated items to help embed the temperature difference.

16. This song might appeal to your class, it is to the tune of "If you're happy and you know it":

Is it water, or is it ice?
Can you SEE?
Is it water, or is it ice?
Can you TOUCH?
Is it water, or is it ice?
Does it feel really nice?
Is it water or is it ice, can you tell?

17. Every 10 minutes, a member of staff should select 4 further samples (2 'C', 2 'W') from the freezer for the class to observe and record in the same way. Remember to work quickly to minimise ice-melt. In our trial, we ran another activity at the same time as the recording phase. Some pupils really enjoyed the "reveal" of pouring the cups out – try to draw other pupils into the process by using the song and doing a drum roll sound effect before you pour. Has it changed? Is it stuck in the cup? Can we break the surface with a pencil or is it completely frozen solid? Support pupils to label the activity trays/bags with laminated symbols for the keywords: **solid**, **liquid**, **ice**, **water**, **warm**, **cold**

18. This process should be repeated until the remaining 'C' and 'W' samples are completely frozen. The time taken to reach this should be recorded as the end of the investigation.

19. The key pieces of data to record are:
    - **the time taken for cool water sample to become completely frozen**
    - **the time taken for warm water sample to become completely frozen**
    - **the hardness of the water (if you have done this activity)**

20. Remember that the children are comparing two data sets: warm and cold starting temperatures, and can **only conclude what the results show:** that warmed water freezes more quickly, more slowly or at the same time as chilled water. They cannot draw a conclusion that the higher the starting temperature the faster or slower water freezes.

21. While the water is freezing, children will measure the hardness of their tap water (see Additional Activities). This offers links to other big ideas such as dissolving and solutions. It also offers a talking point of why water hardness differs across the UK.

Recording results

Children can record their own individual group results in the tables on worksheets. The majority class results need to be collated into a class results table which you could fill in with your class on a smart board, or flip chart. We have provided an example class results table you can use if you wish which can be customised for the number of groups in your class.

Some pupils will enjoy completing parts of the pupil sheet with assistance.

Remember:

The class results table must show the length of time taken for each sample to freeze, which froze first (cool or warm) plus the water hardness result.

Teacher notes

It is important to emphasise to the children that science is a process of gathering evidence to support or refute ideas about observed phenomena and sometimes these theories change and so the scientific thinking changes.

It is important to stress that whatever the results are, they need to be recorded and not dismissed. Young children may be expecting a certain result and may be disappointed if they complete the experiment and the results are different to those they predicted. They may feel like they haven't done it correctly and the results are wrong, but this is not the case.

The result will lead to interesting discussions and should be evaluated in terms of how well they answer the question. It may be that the experiment needs to be repeated with greater accuracy, but as Mpemba found out, it is also possible that strange results can lead to further investigations and new understanding.

NB: Boiling water does alter the hardness of the water. Water has temporary and permanent hardness, and boiling removes the temporary hardness, which is deposited as scale on the kettle. For this reason we suggest heating the water and testing with a thermometer at intervals until you reach 50°C. Using this method will mean that the cool and warm water have a similar hardness.

Important!

Online safety is paramount, and a useful guide can be found here: **bbc.co.uk/cbbc/topics/stay-safe**

Discussion of results

Depending on your result, different conclusions can be formed by your class. Here, we provide possible talking points for you and your children to consider.

- What happened when we cooled the water? Use warm and cold associated items to remind pupils of the activity.
- Revisit the original question; has the investigation given you an answer?
- Did you find a difference in the freezing times?
- Was it easy to agree a score?
- Work together to put these ideas together and write a summary. This could start with **"I used to think that ... But now I know that ... Because..."**

Additional activities

These activities could be undertaken during the investigation while the water samples are freezing, or as standalone activities on freezing, dissolving and changes of state.

The BBC deems the following activities suitable and safe for primary school children. It is your responsibility as a school to carry out your own risk assessment if you decide to carry out any of these extension activities, taking into account any risks, which may be relevant to your specific class environment.

Online map:

While the water is freezing, children will measure the hardness of their tap water. This offers links to other big ideas such as dissolving and solutions. It also offers a talking point of why water hardness differs across the UK, which is one of the key data points that we have plotted on our map of the UK.

Measuring water hardness

Follow the instructions included with the water hardness strips. Before you start, show the pupils the sticks and talk about what colour the indicator patch is. Now perform the test together. Encourage pupils to match the colours to decide on your score. The score tells us how “hard” the water is. Hard water has more minerals dissolved in it. If you have “hard” water, it takes more soap to get bubbles in the bath and shower. It also means you get scale in your kettle. You can take a look in the staff room kettle to see if your result matches up (ensure it is completely cool and empty before taking it into the classroom).

Investigating dissolved

minerals in water

Notes:

The Geological Society and The Royal Society of Chemistry have produced a series of additional resources around water and water hardness which you can find by following the link from our website **bbc.co.uk/terrificscientific.**

An example which can be given of a solid dissolved in water is sugar.

- Give each pupil a cup of water. Use dark or transparent cups so they can clearly see the sugar before it is dissolved. Use small torches or place on a lightbox if this helps.
- Ask students to add a spoonful of sugar at a time and stir each time until it looks like it disappears.
- Explaining that it actually dissolves to form a solution is a good starting point.
- By adding increasing amounts of sugar, children can count the number of teaspoons of sugar it takes for a cup of water to be saturated. They will be able to see this happen as the sugar will still be present at the bottom of the cup.
- This can begin a discussion on other substances that can be dissolved in drinking water. As well as their tap water, they could investigate different drinks by reading the labels and seeing what else is dissolved in them.
- This is a good comparative investigation and can be linked to healthy living.

What happens when we cool water?

Talking to the students about the usefulness of insulation for this investigation and in real life can be tricky, but comparing the differences in materials may be a good way of showing this.

- Create “ice beds” in large bowls. You can use either ice cubes or freeze 3-5cm depth of water in the bowls in advance. Give each pupil a ziplock bag (size GL05 114 x 114mm is ideal) filled with warm (43°C) water and a bag of cold/chilled water. Make sure the bags are labelled. You could also use symbols or a small amount of red and blue coloured glitter or shredded paper inside the bag to show warm and cold.

- Encourage pupils to feel the water in each bag (gently so it doesn’t get popped!). You could also place the samples of warm and cold water on pupil’s hands or knees. Use warm and cold associated items to help pupils identify the difference. Then place these bags onto an ice bed to cool. After a minute, feel them again. Have they changed?

- What happens to the water when it sits on top of the ice? Does it get hotter or colder? Why? What is happening to the ice? Which one is hottest after 10 minutes? Can you tell?

- This is similar to what is happening with the mini cups in the freezer. The ice bed takes the energy from the warm water, just as the freezer does. This means the water in the bags cools down. The same is happening with the cold water, but it may be less noticeable because there is a smaller temperature difference.

- The ice bed will start to melt due to the warmth from the water bags, the classroom and pupils’ hands. In the freezer, the heat energy is constantly removed so it stays cold, eventually freezing

- Support pupils to place laminated symbols for water and ice next to the thermometer picture. Can they “label” the ice bed activity with the words: solid, liquid, water, ice, warm, cold, freezingclassroom and pupils’ hands. In the freezer, the heat energy is constantly removed so it stays cold, eventually freezing

The Geological Society

Discussion:

Ask children to think about what they have just observed and suggest why salt is added to their playground and roads in winter.

Picking up ice with string

Challenge your class to pick up an ice cube from a full glass of water without getting their fingers wet and only using a piece of string provided.

- After a minute or two, demonstrate how to do this. Place an ice cube in a glass of water and wait for it to settle and float.
- Lay the string across the top of the ice cube and sprinkle some fine salt onto and around the string in contact with the ice cube and wait a few seconds.
- Carefully lift the string. If you cannot lift it, try adding more salt and trying again.
- This works because the salt lowers the freezing point of the water. The ice melted slightly but refroze around the string.

Salting icy roads and pavements lowers the freezing point of water that forms ice, which leads to melting and prevents falling snow or rain from being able to freeze.

Discussion:

Ask children to think about what they have just observed and suggest why salt is added to their playground and roads in winter.

Story-time

Mpemba story excerpt from his 1969 paper, "Cool?"

My name is Erasto B Mpemba, and I am going to tell you about my discovery, which was due to misusing a refrigerator. All of you know that it is advisable not to put hot things in a refrigerator, for you somehow shock it; and it will not last long.

In 1963, when I was in form 3 in Magamba Secondary School, Tanzania, I used to make ice-cream. The boys at the school do this by boiling milk, mixing it with sugar and putting it into the freezing chamber in the refrigerator, after it has first cooled nearly to room temperature. A lot of boys make it and there is a rush to get space in the refrigerator.

One day after buying milk from the local women, I started boiling it. Another boy, who had bought some milk for making ice-cream, ran to the refrigerator when he saw me boiling up milk and quickly mixed his milk with sugar and poured it into the ice-tray without boiling it; so that he may not miss his chance.

Knowing that if I waited for the boiled milk to cool before placing it in the refrigerator I would lose the last available ice-tray, I decided to risk ruin to the refrigerator on that day by putting hot milk into it. The other boy and I went back an hour and a half later and found that my tray of milk had frozen into ice-cream while his was still only a thick liquid, not yet frozen.

I asked my physics teacher why it happened like that, with the milk that was hot freezing first, and the answer he gave me was that "You were confused, that cannot happen".
Then I believed his answer.

After learning about the story of Mpemba, there are ways in which it can be linked to English, Drama and even History by writing an account of Mpemba and his discovery.

- What surprises the children about Mpemba's discovery? As you explore this event further you could ask them, do you think the hot water freezing faster was what he expected? Why? Why not? Children could discuss this in pairs.

- Children could draw a story board, with speech bubbles to be filled in of what they imagine Mpemba told his friends and teacher about his findings with the hot cream.

- Alternatively, they could write a diary of Mpemba's day, including details of his environment, the reaction of the people around him and how he felt when his friends and teachers weren't convinced.

Glossary

Accurate	A 'best guess' of what might happen in an investigation based on the scientific knowledge you already have.
Condensation	The process when a gas changes into a liquid when temperature is lowered to a certain point.
Comparative test	The accuracy of a measurement depends on the quality of the measuring apparatus and the skill of the scientists taking the measurement. In this investigation it will be difficult to measure the starting temperatures accurately, the temperature of the freezer and the exact freezing point.
Dissolve	The process when some solids mix with liquids to form a solution. The solid can no longer be seen but it has not disappeared.
Evaporation	The process when a liquid changes into a gas below its boiling point.
Freezing	The process when a liquid becomes a solid when temperature is lowered to a certain point.
Hard Water	Water with a large amount of dissolved minerals.
Insulation	The reduction of heat transfer between an object and its surroundings. Usually used to keep something warm or keep something cold.
Mpemba Effect	A phenomenon where, in some circumstances, water that is initially hot freezes faster than water that is initially cold.
Reliable	Data is reliable if it can be replicated. In this case children across the country will be carrying out the same investigation. The reliability of the data form each class will be improved by each class taking repeated measurements.
Saturation	The point at which no more of a solid can dissolve in a liquid.
Soft Water	Water with a low amount of dissolved minerals.
Solution	A mixture formed of a liquid and dissolved solid.
Thermometer	A device for measuring temperature.
Valid	Data is only valid if the measurements that have been made are affected by a single independent variable. In this case it will be difficult to control the starting temperatures and the temperature of the freezer. It will be possible to control the amount of water.

References

Science advancement happens by reading and understanding previous findings and adding to them.

Mpemba Story Excerpt

Erasto Mpemba and Denis Osborne, 'Cool?' Physics Education, 1969 (May, Vol 4) pp. 172-175 Accessed through the Royal Society of Chemistry: **http://www.rsc.org/learn-chemistry/resource/download/res00001018/cmp00001662/pdf**