PRIMARY + STEM

Teaching Resource

ACTIVITY: Ice cream

ACTIVITY OVERVIEW

What could be more delightful and delicious than making homemade ice cream in the pursuit of scientific understanding?

Understanding heat as an energy and the changes it brings about to familiar ingredients, like cream, is an engaging way to introduce students to the fundamentals of states of matter. These same understandings help explain Earth's weather, how wet clothes become dry, why puddles disappear, and, on a much broader scale, they enable a deeper understanding of contributing factors to global warming and climate change.

In making this frozen treat, students will experience how ice cream was made in the past (before there were household refrigerators and freezers), explore how to manipulate temperatures, and play around with native ingredients (if permitted).

SYNOPSIS

What could be more delightful and delicious than making homemade ice cream in the pursuit of scientific understanding?

Understanding heat as an energy and the changes it brings about to familiar ingredients, like cream, is an engaging way to introduce students to the fundamentals of states of matter. These same understandings help explain Earth's weather, how wet clothes become dry, why puddles disappear, and, on a much broader scale, they enable a deeper understanding of contributing factors to global warming and climate change.

In making this frozen treat, students will experience how ice cream was made in the past (before there were household refrigerators and freezers), explore how to manipulate temperatures, and play around with native ingredients (if permitted).

Foundation – Year 2

- Everyday materials can be physically changed or combined with other materials in a variety of ways for particular purposes (VCSSU045)
- Explore how food is selected and prepared for healthy eating. (VCDSTC016)

Year 3 – 4

- A change of state between solid and liquid can be caused by adding or removing heat. (VCSSU059)
- Natural and processed materials have a variety of physical properties that influence their use.(VCSSU060)
- Heat can be produced in many ways and can move from one object to another. A change in the temperature of an object is related to the gain or loss of heat by the object. (VCSSU063)
- Investigate food preparation techniques used in modern or traditional societies (VCDSTC026)

Year 5-6

- Solids, liquids, and gases, each behave in different ways and have observable properties that help classify them. (VCSSU076)
- Changes to materials can be reversible, including melting, freezing, evaporating, or irreversible, including burning and rusting. (VCSSU077)
- Investigate food preparation techniques used in modern or traditional societies (VCDSTC026)

ACTIVITY, MATERIALS AND INSTRUCTIONS

What is more inviting than making ice cream to introduce students to change of state and heat transfer concepts? Watch and feel kitchen staples transform into ice cream with a few simple ingredients – in the classroom!

Making ice cream this way is reminiscent of how ice cream was churned before refrigerators became a common household appliance. Experiment with ingredients to reflect flavours of different cultures.

*Note: This activity is not appropriate in the event of a dairy allergy in the class. Consider jelly-making to see the transformation from liquid to solid.

Materials for one pair of students

- ½ cup (125g) thickened cream (or a mixture of full-cream milk and cream)
- 1 tablespoon icing sugar
- ½ teaspoon vanilla essence
- 1 x large plastic resealable bag e.g. 27cmx33cm Hercules storage bag
- 1 x plastic resealable sandwich bag
- 1 x 4 cups ice cubes
- 1 x ½ cup table/cooking salt
- 1 x insulated lunch bag (alternative: tea towels)
- 1 spoon per child
- Measuring cups and spoons

Materials for 30 students

- 2L cream or (1L cream and 1L full-cream milk)
- 200g icing sugar
- 100ml vanilla essence
- 2 bags x 5kg ice
- 15 large plastic resealable bags
- 15 plastic resealable sandwich bags
- 2kg table/cooking salt
- 30 spoons
- Sufficient tea towels
- Sufficient measuring cups and spoons

Optional

- Thermometers
- Other flavouring ingredients: native bush foods, e.g. crushed lemon myrtle, quandong jam; prepared laksa/curry paste; pizza sauce, etc

*For a more savoury version, decrease the sugar and add salt to taste

Instructions

1. In the large-sized bag, add the ice cubes and salt.
The purpose of the salt is to produce temperatures that are well below 0°C so that ice cream can be made in a classroom setting without a freezer.

2. In the sandwich bag, add the cream, icing sugar, and vanilla. Seal the bag securely and shake the bag gently to ensure the contents are mixed. The sugar and vanilla will dissolve in the cream.

3. Place the sandwich bag and its contents into the larger bag. Seal the larger bag securely.

Place these bags into an insulated lunch bag.

A tea towel/gloves may be used to hold onto the bag of ice and salt, instead of the insulated lunch bag. Temperatures as cold as –10°C or less may be reached, so it is best to minimize contact with skin while students are shaking the bag.

4. Shake the contents of the insulated lunch bag from time to time. Check the medium-sized bag and its contents every two minutes or so. Do this for between 5 - 10 minutes.

During this process, the water in the cream/milk turns into ice crystals, while the fat molecules arrange themselves in a network that can trap air within.

What is happening to the liquid cream? Does it feel colder than before? Is it less drippy? More solid-like? Is it ice cream yet?

While inspecting the contents of the sandwich bags, take the temperature of the ice bag every five minutes or so.

5. Remove the inner bag and rinse salt from the outside before opening. Taste the delicious frozen treat!

And critique it – what can be done to make it better?

- Is it too oily or too solid? Reduce the fat content.
- Is it still in liquid state? Keep it longer in the salt/ice bag and add more ice and salt.

HOW TO USE THIS ACTIVITY WITH YOUR STUDENTS

Foundation - Year 2

Even though students may not understand why changes of state occur, they are still able to appreciate the physical changes that take place when materials respond to a change in temperature e.g. melting and freezing. Emphasis should be drawn to the concepts of heat transfer, temperature changes, and change of state that students observe in the activity so that they can see the connections between them.

Extend this understanding by changing chocolate buttons into chocolate scribbles. Using chocolate buttons in sandwich bags, students can melt chocolate with the heat from their hands and make patterns with the liquid chocolate on a piece of parchment paper.

Years 3/4

Students are formally introduced to the topic of heat and change of states at this stage, and this activity presents many opportunities to extend student learning.

Students could practice reading the thermometer in this activity to measure the temperature of the various components in the activity.

Some approximate temperatures are: room temperature water (20-25°C); ice 0°C; ice and salt mixture (–10°C); cream (5°C); solid ice cream (–5°C).

Students could also extend their understanding of conductors and insulators by designing a container using recycled material to keep the ice cream solid for as long as possible, without putting it in the freezer.

Years 5/6

Turn this activity into an experiment to investigate the role of salt, as well as how the type of salt, or type of dairy product affects the product. Regardless of what the students are testing, they should make considerations for a fair test.

For example, this activity could be repeated without salt. Students identify what variable is different, i.e. salt, and what remains the same.

They make predictions and observe the effects of salt on the quality of the ice cream. They should observe that the ice cream mixture remains liquid-like without salt, because temperatures do not get below 0°C.

They could also investigate other variables, such as the amount of sugar, type of sweetener, type of dairy, etc.

DISCUSSION SECTION AND KEY THEMES

In this activity, the heat energy within the liquid cream mixture is transferred away, turning it into ice cream. As the liquid cream mixture loses its heat energy, its molecules transform from ones that can move around one another (in the liquid state) to having just enough energy to vibrate in fixed positions (in the solid state).

The key to making the entire system cold enough and to draw heat away from the cream mixture is the addition of salt to ice in the outer bag. This combination creates freezing temperatures well below 0°C, allowing ice cream to be made in the classroom.

Heat transfer

Heat is an energy, and it can move between objects. Heat always moves from hotter objects into colder ones. The bigger the difference in temperature, the faster heat flows.

Heat can be measured

Measuring temperature using a thermometer is one way of getting an indication of how much heat energy is in a material. However, heat energy and temperature are not the same things.

The heat an object contains is the amount of its thermal energy and is measured in Joules (J). Temperature, on the other hand, represents the average kinetic energy of the atoms and molecules in an object and is measured in °C (degrees Celsius).

A swimming pool at 36°C has a lower temperature than a cup of hot coffee at 85°C, but because a swimming pool contains more water, it stores a lot more heat energy than a cup of coffee.

Melting point/Freezing point

The melting point is the temperature at which a pure substance like water changes from a solid to a liquid state. The freezing point refers to the temperature when pure liquid water turns into ice.

For pure water, the melting point and freezing point refer to the same temperature of 0°C. At this temperature, both melting and freezing are happening at the same time, but one process is favoured over the other. This explains what is happening when ice cubes stick together in a drink. They stick together because while some of the ice is melting, some of the ice is also refreezing. Eventually, though, the melting process is favoured and all the ice melts.

When heat is continually added to the solid ice e.g. in a classroom setting, melting is favoured and the temperature stays at 0°C until it all melts into liquid water. When heat is continually drawn away from the liquid water, e.g. in the freezer, freezing is favoured. The water will then stay at 0°C until it all turns into ice.

States of Matter

If something - e.g. air, cream, salt, etc.,- is made up of atoms and molecules, and takes up space, it is matter. Matter can exist in different forms, also known as states of matter. There are currently more than a dozen recognised categories, but primary school students are only expected to learn about the first three - solids, liquids, and gases.

Depending on how much energy they possess, the same atoms and molecules may exist in different states, with each state showing very different properties. Because the atoms and molecules themselves do not change into something else while they change states, this process is considered a reversible, physical change.

Changes of state

Heat is a form of energy. When a substance is heated, this energy is transformed into kinetic (movement) energy in its atoms and molecules. The more energy the atoms and molecules receive, the faster they move. If the substance receives enough energy, the atoms and molecules can move so fast that they are able to break the bonds that keep them in position. When this occurs, the substance changes its state from one to another - e.g. solid to liquid, or liquid to gas. The reverse is true if the substance loses heat.

Since the critical difference in these three states of matter is the amount of energy, then it means that, by altering the amount of energy, we can change one state into another. And because there is no alteration to the nature of the atoms or molecules, changes of state are physical, reversible changes.

Variables that affect when matter changes states:

1. Temperature: As explained in the previous section.
2. Concentration: Adding salt or other solutes to a liquid makes the melting/freezing point decrease but increases the boiling point of liquids.
3. Pressure: Increased pressure on ice makes it melt without a change in temperature. This explains how an ice-skater can glide on ice.

Altering the freezing point of water (Freezing point depression)

Ice in pure water will melt or freeze at 0°C. However, mixtures will always melt or freeze at lower temperatures than pure substances.

When impurities, such as salt (or sugar), are added to water, the resulting solution that is full of sodium and chloride particles (from salt), makes it difficult for water molecules to organise themselves into orderly patterns that are characteristic of ice. At 0°C, this solution cannot refreeze as easily and remains a liquid. It takes much lower temperatures before it can turn into solid ice.

This helps to explain how ice, at room temperature, rapidly melts when salt (or sugar) is added to it, followed by a drop in temperature in the ice.

At room temperature, two processes take place simultaneously – some ice melts, while some water refreezes resulting in a thin layer of water on the outside of the ice.

Salt dissolves in this layer of water. While this does not disrupt the melting process, it does make it harder for the melted water to refreeze into ice.

Because ice melts faster than water refreezing in this instance, heat is continually drawn from the mixture for melting to occur. This causes a drop in temperature in the mixture. The temperature drops to the new freezing/melting point of the saltwater mixture.

QUESTIONS AND ANSWERS

Is ice cream made when coldness enters the cream to make it cold?

No. Ice cream is made when heat leaves the cream mixture and turns it into something that has less heat. Heat always moves in the direction of where there is more heat to where there is less heat. In this activity, the ice-and-salt bag draws the heat out of the cream mixture.

Can we make ice cream without adding salt to the ice bag in this activity?

No. The temperature of the bag of plain ice would not get cold enough for the cream mixture to turn into ice cream. When salt is added to the ice, it makes the ice colder, creating temperatures well below 0°C, which allows for ice cream to be made in the classroom.

What is the freezing point or melting point of water?

This refers to the temperature at which water turns from solid to liquid (melting point), or liquid to solid (freezing point). For pure water, this temperature is 0°C.

Why is salt put over icy roads in winter?

This practice is done to keep roads safe during winter (although we do not see this often in Australia!). When salt is put over icy roads, it turns into a salty solution and causes falling snow and rain to melt upon impact, rather than turn into ice. It also prevents melted ice from refreezing.

The sodium and chloride particles (from the salt) make it more difficult for the water molecules to organise themselves into solid ice.

This method works well to prevent slippery roads up to a certain temperature. However, under extremely frigid conditions, applying sand over the ice to increase friction is more effective than using salt.

How does salt make the bag of ice and salt colder?

Since the air around the ice is warmer than the ice itself, the ice melts, creating a thin layer of water on the ice. Salt dissolves in this layer of water. Salty water needs colder temperatures to freeze because the dissolved salts make it harder for water molecules to crystallise into ice. It won't freeze at 0°C, which leads to a lot of the ice melting. Every time water molecules melt from solid to liquid, heat energy is absorbed from around them. This keeps the temperature low.

This melting process of the ice is particularly important for making the ice cream really cold, really fast. As the ice melts, it draws in heat to itself and makes the things around it much colder - including the cream mixture. With the addition of salt to ice, the temperatures can reach temperatures of at least –10C°!

Why does ice cream need to be churned?

Ice crystals form when a mixture of cream, sugar, and flavourings turns into ice cream. The constant churning of the mixture prevents big ice crystals from forming, while introducing air into the ice cream. This produces a lighter and smoother textured ice cream.

How does the type of dairy product, e.g. thickened cream, full-cream milk, low-fat milk, affect the texture of ice cream that is produced?

It depends on the quantity of fat in the ingredient. Thickened cream has a high fat content, while low-fat milk contains minimal amounts of fat. A certain amount of fat is required for smooth, light-textured ice cream that holds its shape at room temperature.

Why does melted, then re-frozen, ice cream never taste as good as the original?

Bleurgh... re-frozen ice cream IS unappetizing. This is because re-frozen ice cream contains ice crystals that are much bigger, and this changes the texture permanently. It will no longer be as smooth.

Why is there fat in ice cream?

Fat, in the form of butterfat (found in cream), is a major ingredient in ice cream. The melting point of ice is 0°C, and the melting point of butterfat is around 32°C. This means that, once the ice cream is served, the ice will start to melt at room temperature. Butterfat, however, does not melt until it is in our mouths. Just like how a block of butter retains its shape when left out at room temperature, the butterfat in ice cream will help it retain its shape, even as ice melts.

Fat is also essential for lightness in texture. When the ice cream mixture is whipped, the fat molecules form a lattice structure, which traps air bubbles within it. Too little fat will produce ice cream that isn't light enough, with a coarse icy texture, and a watery mouthfeel. Too much fat, on the other hand, will produce hard ice cream with a greasy mouthfeel.

What is the difference between sorbet, gelato, and ice cream?

The difference lies in their fat content. Sorbet is made of fruits and sugar, containing neither fat nor dairy products. Gelato generally contains less fat than ice cream and is often not churned as much, resulting in a denser texture than ice cream. They are all delicious!

OUTSIDE OR SUPPLEMENTARY READING

Articles

How was ice-cream made before refrigerators were invented? | Notes and Queries | guardian.co.uk (theguardian.com)

Four Factors for Perfecting Ice Cream | Institute of Culinary Education
This site provides more comprehensive information for those interested in the science of ice cream-making.

Salt on Ice - Scientific American

Make Ice Cream | STEM Activity (sciencebuddies.org)

TOPIC WORDS

- Heat
- States of matter
- Change
- Temperature
- Solid
- Liquid
- Melting
- Freezing
- Salt
- Cream
- Ice
- Water
- Fat
- Sugar
- Crystals