Sustainable Farms Pathway

Full resources list

Session 1

- measuring equipment eg. trundle wheels
- calculators

Session 2

Per group:

- 2 litre drinks bottle
- 2 thermometers or temperatures
- water
- plasticine
- antacid tablets
- 100W+ desk lamp
- stopwatch

Session 3

Per group:

- plastic bottles and cups
- cotton or felt
- scissors
- craft knife
- seeds (e.g. spinach, lettuce, basil or parsley)
- growing medium (e.g. gravel, marbles, sand or shredded)
- fertiliser (water soluble or high potash feed)
- scissors and printed card-sort

Optional:

- Air pump (e.g. for fish tank)
- Internet access for research
- Sach's Culture Solution

Session 4

Per group:

- paper and pens
- cardboard
- split pins
- rubber bands
- drawing pins
- lolly sticks
- string
- scissors
- craft knives
- cutting boards

Optional access to additional tools:

- access to Tinker CAD

Session 5

Per group:

- Computer with access to the internet
- Micro:bits (note: this lesson uses V2 micro:bits, but if you don't have micro:bits or only have V1 then you can use the online simulator here https://makecode.microbit.org/

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Sustainable Farms - Session 1

Introduction to British Farming

Context:
Learners are introduced to the types of farms in our country, in particular arable and dairy farms, and where they are located. They apply a range of maths skills to develop understanding about land use and space. They use information presented in tables and graphs to find out more about farming in the United Kingdom. They begin to recognise the challenges farmers face and how engineers work with them to solve problems.

Engineering focus:
Learners will be working as an engineer by asking questions to understand more about farms by identifying problems. In particular this session draws on maths applications in context.

Learning time:
1.5 hours

Suggested age group:
11-14 years old

Curriculum links:
Mathematics - data handling
Learners will:
- To construct and interpret appropriate tables, charts and diagrams for ungrouped and grouped numerical data.
- To develop their mathematical knowledge, in part through solving problems and evaluating the outcomes, including multi-step problems.
- To develop their use of formal mathematical knowledge to interpret and solve problems.

Keywords
Arable
Horticulture
Dairy
Livestock
Sustainable
Climate
Sowing
Fertilising
Weeding
Harvesting
Irrigation
Ploughing
Compaction
Nutrients
Fertiliser

Resources:
- NFU Video:Introduction to Arable Farming
- NFU Video: Keeping Soil healthy
- Sustainable Farms Session 1 PPT
- Access to the internet for mapping exercise

Optional:
- Access to measuring equipment to estimate the area for the school grounds (eg. trundle wheel)

Suggested Activities

1

What do we know happens on farms in the United Kingdom? (5 minutes)
In groups of 3, ask the learners to generate ideas about things they think happen on farms. This is a quick-fire activity to generate lots of ideas. Ask them to prioritise the 4 things that they think happen most often (slide 2 can be used to inspire conversation.

Why are farms important to you? In the same groups allow learners some time to discuss why farming is important to them and their families. What aspects of their daily lives do they think have links to farming?

2

What does the data tell us about farming in the UK? (40 minutes)
Use Slides 3–12 to introduce learners to the two types of farming that are most common in the UK. The slides engage learners in using their maths skills to interpret and present data about different types of farms across the UK.

Involve the learners in interpreting the tables and pie charts provided, and then construct their own pie chart using the data they have been exploring. Work individually or in pairs to tackle the multi-step problem focused on exploring the area of land used to grow particular crops.

3

Optional: What is a hectare? (15 mins)
Teachers may encourage learners apply their maths skills linked to area to develop a better understanding of the term 'hectare'. By collaborating, learners estimate how many times their school grounds would fit into a hectare of land. Learners decide how they will estimate the area of their school grounds in metres squared, convert this to hectares and apply their understanding (Slides 13-14).

4

What farms are in our region of the UK? (30 mins)
Learners reflect on the number and reasons for particular types of farming in their local area (Slide 15-16). Learners can find out more about the processes involved in growing plants for food by watching the **NFU Video: Introducing Arable Farms**.
They collaborate to use Googlemaps to research local farms and develop understanding about the range of farm types in their area (arable, horticulture, dairy, sheep, pigs, poultry etc.). They present data following the instructions on slide 17, from which learners draw conclusions about why different certain types of farming occur in different parts of the country (slide 18), applying knowledge of terrain and weather.

What sort of problems do farmers, who grow plans for food, face? (10 mins)

5

A bespoke **NFU video: Keeping Soil Healthy** provides learners with insight into the problems that farmers face in keeping soil healthy. Through watching the video and listening to a real-world farmer describe the issues they face, learners identify multiple problems that regularly experienced on contemporary farms.

Encourage learners to consider how the problems relate to sustainability and climate change. Explore the links between the processes in farming that impact on greenhouse gases and climate? Debate the positive and negative impacts of farming and whether farming could be considered an optional human activity or not?

How do engineers help arable farmers to solve problems? (10 mins)

6

Bring the session to a close by recapping the problems that farmers find on their arable farms. Find out what problems learners can recall from the video, Slide 19 includes quotes from the video to revisit issues arising. Ask learners to work in pairs and use their quotes to support them in summarising the four problems they have identified:

- soil compaction
- pests eating seeds
- keeping nutrients in the soil
- carbon emissions have an effect on the environment, contributing to climate change.

Use the **infographic** on slide 20 to explain the relationship between farmers and agricultural engineers. Key things to note:

- Agricultural engineers that design and create innovations to make farming more efficient and sustainable.
- Agricultural engineers work through the Engineering Design Process: they **ask** questions to identify problems on the farm, **imagine & plan** solutions to those problems, **create** designs to solve the problem and then test and **improve** their designs.

Sustainable Farms - Session 1

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Learning time:
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Curriculum for Excellence links:

Third Level:
I can apply my knowledge and understanding of engineering disciplines and can develop/build solutions to given tasks. TCH 3-12a
I can work collaboratively, making appropriate use of technology, to source information presented in a range of ways, interpret what it conveys and discuss whether I believe the information to be robust, vague or misleading. MNU 3-20a
When analysing information or collecting data of my own, I can use my understanding of how bias may arise and how sample size can affect precision, to ensure that the data allows for fair conclusions to be drawn. MTH 3-20b
I can display data in a clear way using a suitable scale, by choosing appropriately from an extended range of tables, charts, diagrams and graphs, making effective use of technology. MTH 3-21a

Fourth Level:
I can solve problems through the application of engineering principles and can discuss the impact engineering has on the world around me. TCH 4-12a
I can evaluate and interpret raw and graphical data using a variety of methods, comment on relationships I observe within the data and communicate my findings to others. MNU 4-20a
I can select appropriately from a wide range of tables, charts, diagrams and graphs when displaying discrete, continuous or grouped data, clearly communicating the significant features of the data. MTH 4-21a

Keywords
Arable
Horticulture
Dairy
Livestock
Sustainable
Climate
Sowing
Fertilising
Weeding
Harvesting
Irrigation
Ploughing
Compaction
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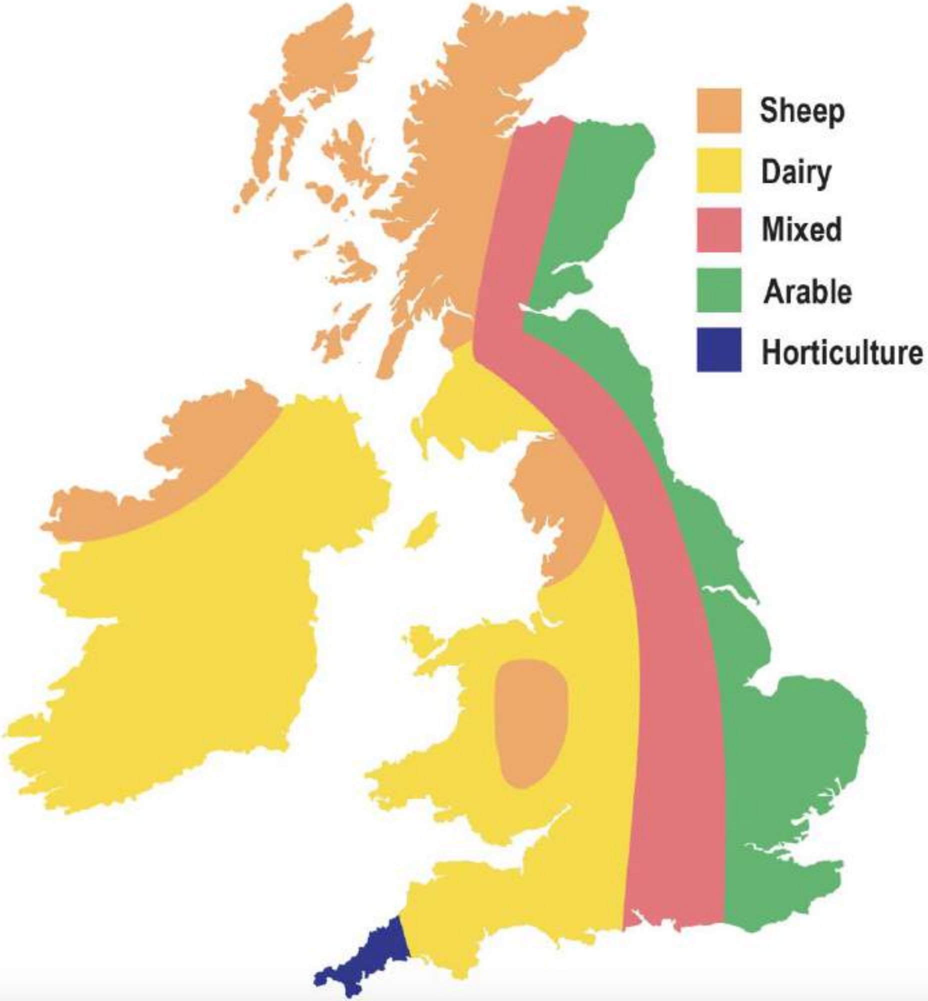
SUSTAINABLE FARMS

SESSION 1
Introduction to British farming



What variety of farms are there in the UK?

This map shows what **type of farming** takes place in different areas of the UK.

What do you think might happen on these different types of farms?

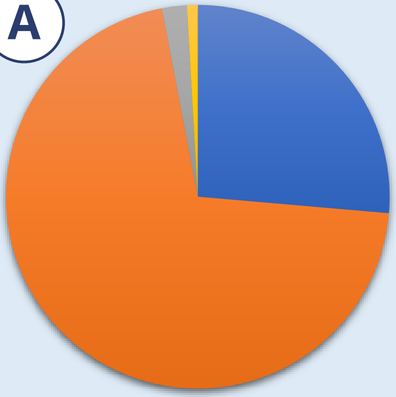
What does the data tell us about the types of farming in the UK and why?

Region	Farmland	Natural	Built on and green urban areas
England	72.9%	14.5%	12.6%
Northern Ireland	72.2%	23.0%	4.8%
Scotland	26.4%	70.6%	3.0%
Wales	59.3%	35.1%	5.6%

Which country has the most farmland?

What interesting things do you notice in this data?

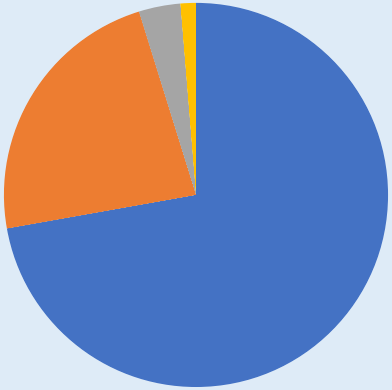
A



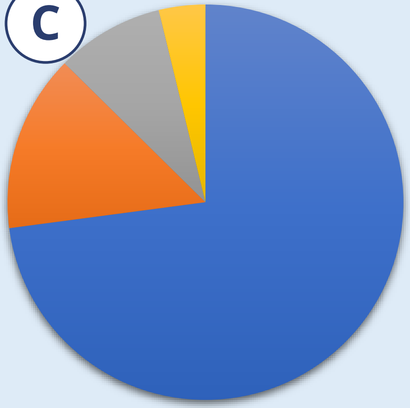
These pie charts do not include labels. They showing land use in England, Scotland, Wales and Northern Ireland.

Can you work out which pie chart represents which country?
Justify your answer.

B



C



Region	Farmland (%)	Natural (%)	Built on (%)	Green urban areas (%)
England	72.9	14.5	8.8	3.8
Northern Ireland	72.2	23.0	3.5	1.3
Scotland	26.4	70.6	2.1	0.9
Wales	59.3	35.1	4.2	1.4

D

Farmland
Natural
Built on
Green Urban

Can you represent the data in a pie chart to show land use across the UK?

Region	Farmland	Natural	Built on and green urban areas
England	72.9%	14.5%	12.6%
Northern Ireland	72.2%	23.0%	4.8%
Scotland	26.4%	70.6%	3.0%
Wales	59.3%	35.1%	5.6%

1. Calculate the UK total percentage of land used per category.
2. Use a ratio table to construct a pie chart.
3. Draw your pie chart with an appropriate title and key.

UK land use by nation - percentage of land used per category

Region	Farmland (%)	Natural (%)	Built on and green urban areas (%)	Total (%)
England	72.9	14.5	12.6	
Northern Ireland	72.2	23.0	4.8	
Scotland	26.4	70.6	3.0	
Wales	59.3	35.1	5.6	
UK Total				

UK land use by nation – percentage of land used per category

Region	Farmland (%)	Natural (%)	Built on and green urban areas (%)	Total (%)
England	72.9	14.5	12.6	100
Northern Ireland	72.2	23.0	4.8	100
Scotland	26.4	70.6	3.0	100
Wales	59.3	35.1	5.6	100
UK Total	230.8	143.2	26.0	400

How might this ratio table help you to construct a pie chart to represent the data?

% Land use	400	100	1	26	143	231
Angle size (°)	360°	90	0.9			

Which of these two representations, if any, do you find more helpful?

How else could you construct your pie chart?

Can you find out?

Background Information

The total area of agricultural holdings is about 23.07 million acres (9.34 million hectares), of which about **a third** is arable and most of the rest is grassland. During the growing season about half the arable area is cereal crops, and of the cereal crop area, more than 65% is wheat.

What approximate fraction of the total area of agricultural holdings is:

a. cereal crops
b. wheat

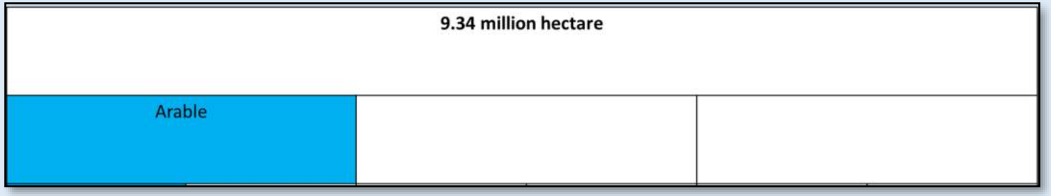
Step one: Break down the information

- The total area of agricultural holdings is about 9.34 million hectares
- Of which about **a third** is arable and most of the rest is grassland.
- During the growing season, about half the arable area is cereal crops
- Of the cereal crop area, more than 65% is wheat.

Step 2: Use a bar model to represent the problem

The total area of agricultural holdings is about 9.34 million hectares.

Of which about **a third** is arable and most of the rest is grassland.



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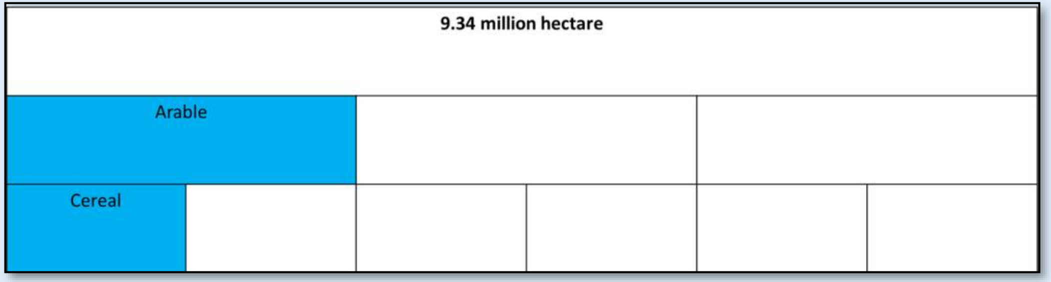
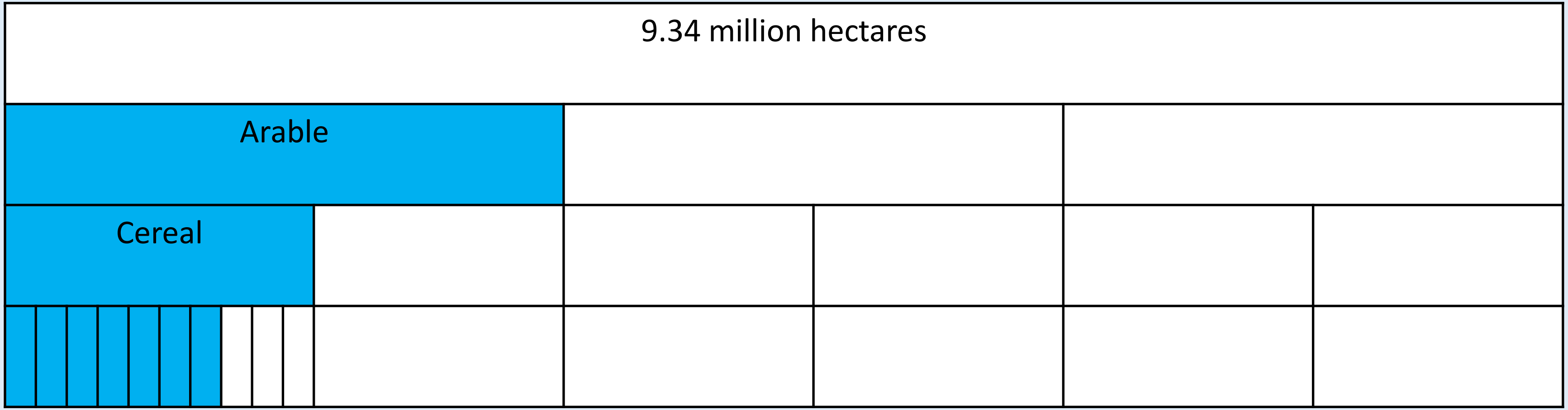


Bar model to support thinking

Of the cereal crop area, more than 65% is wheat.



Calculate:

- What fraction/percentage of the agricultural holdings is used for wheat?
- Approximately how much land is this? Show your answer in hectares and metres squared.

How does the size of a hectare relate to your school?

1 Hectare = $10,000m^2$

Time to investigate

How many m^2 fit into your school grounds?

How many of your school grounds would fit into a hectare?

What will you need to find out?
How will you find out?

Where does farming take place in the UK?

What do you notice about where different types of farming take place?

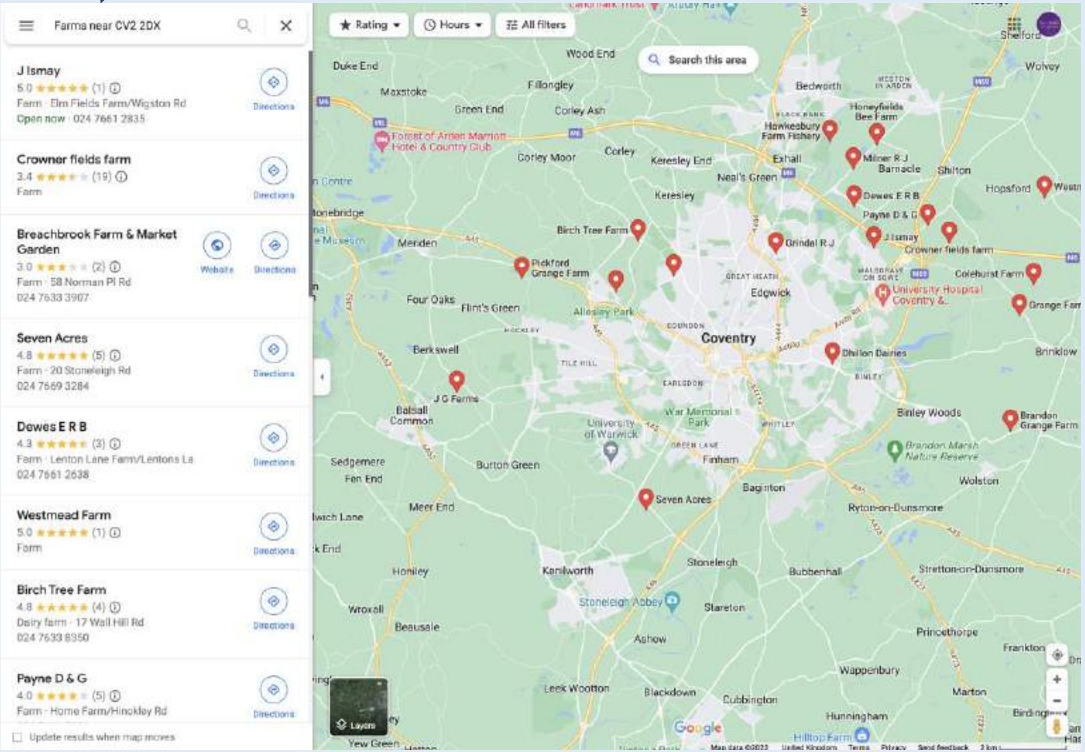
This is a **topographic map** of the UK. Colours show the **elevation** of the land - the height above the level of the sea.

Which region of the UK do you live in?

Have you noticed what type of farming takes place in this region?

What sort of farms are near you?

Search box



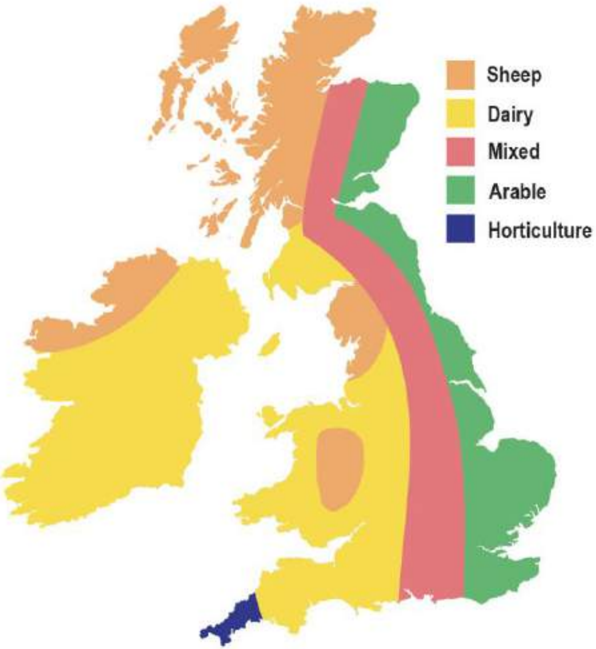
Visit https://maps.google.com

In the search box type: ‘Farms near [insert your town or city]’.

How many farms appear in your search?

Make a tally of the different types of farms near you.

Why are different farms in different places?



Our farming problems...

Can you engineer some solutions?

Squashing the soil in technical terms is called **compaction**. This can be very damaging for the soil because **it squashes earthworms which are very important for our soil health**. It also **prevents moisture and water entering the soil effectively**, which is vital for the growth of our crops.

After sowing we have real difficulty with **pests eating seeds**. Birds, small mammals and insects all eat seeds after they have been planted and this can lead to up to 35 out of every 100 seeds planted not turning into crops.

Keeping our soil healthy is a challenge. We test the soil so we can decide whether we need to add **extra nutrients**. This is to make it healthy and increase the yield so we get much more wheat per acre, or per area, of the field. The **fertiliser** which we add can also be a problem because **it is very expensive** and the production of fertilisers can contribute to **greenhouse gases**.

Carbon emissions are really important and we have to reduce them. **Ploughing can actually cause some carbon emissions**. This is because when we turn the soil and bring it to the surface, carbon within the soil reacts with the oxygen in the air. Microbes then turn this into carbon dioxide, a greenhouse gas.

Use the **Engineering Design Process** to find solutions to the farmers' problems.

Can you make things to make things better?

Agri engineers work through the **Engineering Design Process** to solve real-world problems that farmers have.

SUSTAINABLE FARMS

Sustainable Farms - Session 2

Can the right balance be found?

Context:
Learners explore the concept of sustainability in the context of farming, in particular arable farms. They learn about different processes on farms that either add or remove greenhouse gases from the atmosphere. Learners explore how agricultural engineers are finding solutions to support farmers to reduce processes that emit greenhouse gases and increase the activities that remove them. In doing so, the complexity of this problem is exposed, and pupils appreciate that 'finding the right balance' is the key to finding a solution.

Engineering focus:
Learners will be working as an engineer by asking questions to identify problems.

Learning time:
2 hours

Suggested age group:
11-14 years old

Keywords
greenhouse gas
carbon dioxide
atmosphere
nitrous oxide
methane
fertiliser
efficiency
emissions
biomass
cultivation
fossil fuels
renewable sources
intensive farming
transportation

Curriculum links:
Chemistry and Working Scientifically
Leaners will:

- Learn about the production of carbon dioxide by human activity and the impact this has on climate.
- Develop skills in working scientifically through investigation, data gathering, analysis and evaluation.

Resources:
Sustainable farms session 2 PPT
NFU and RGS Video - Farming and the Carbon Cycle
Card Sort Activity

Per group:

- 2x 2 litre drinks bottle
- 2 x thermometers or temperature sensors
- Water
- Plasticine
- 2-4 Antacid tablets
- Desk lamp (100W+ bulb)
- Stopwatch

Suggested Activities

1

What does sustainability mean to you?

Elicit the learners' understanding about ideas linked to sustainability. Display the range of words on Slide 2, and ask them to work in pairs to develop a concept-map. Use directional arrows and link phrases to describe their understandings.

Ask pairs to share their concept maps with the group, so they support each other in identifying useful prior knowledge. Ask learners to consider what they think we mean by **sustainable farming**.

2

Which crops have higher carbon emissions?

Ask learners to predict which of the crops of slide 3 have the highest carbon footprint - they could sort the produce into order on a post-it note. Reveal the mass of carbon dioxide gas released for every kg produced of each crop (slide 4) and ask learners to compare their predictions with the reality. What were they right about? What were they wrong about?

Explore learners thinking about why certain crops have larger carbon footprints and reveal where each of the crops were produced (Slide 5) and challenge misconceptions that it is all about distance. There are other factors such as artificial heating and lighting for growth and refrigeration that contribute as well.

3

Why does farming need to become more sustainable?

Engage the pupils in recalling their scientific knowledge and ideas about what greenhouse gases are. They are likely to be familiar with CO^2(Carbon Dioxide), NO_2(Nitrogen Dioxide) and CH^4 (Methane). Reinforce that the proportion of these gases in the atmosphere is closely connected to global warming resulting from human activity and discuss ideas about how increased greenhouse gases lead to temperature increases for the planet (Slide 6).

Ask them for a quick-fire response to estimate the % of greenhouse gas emissions -they think comes directly from farming and agriculture. Use Slide 7 to illustrate that nearly one tenth of the world's greenhouse gases are a result of farming. Given that farming is essential to feed our vast populations, it is not a negotiable. We have to have farming! So finding innovative technological solutions is the key to reducing emissions if progress towards net zero and carbon neutral farming is to happen.

Does carbon dioxide gas heat up differently to air?

Carry out a simple investigation to compare the effect of heating air and carbon dioxide with a radiant source of heat/light (slide 8).

- Partially fill both empty 2 litre bottles with water (approximately 1/3 full).
- Cover the top of one bottle with a ball of plasticine to trap the air inside, carefully push a thermometer through the plasticine (making a tight seal) so it is measuring the temperature of the air inside the bottle.
- Drop an antacid tablet in the other bottle and cover immediately with plasticine, again carefully push a thermometer through the plasticine (making a tight seal) so it is measuring the temperature of the carbon dioxide building up in this bottle.

4

- Turn on the high power lamp and make sure it is shining directly and evenly on both bottles.
- Observe and record the temperature of the gas in each bottle every 5 mins for the next hour. Findings should be recorded in a table and the analysed using a line graph.

Challenge learners to use their data to answer the following questions:

- What does this mean for the effect that carbon dioxide has on atmospheric temperature?
- How does this activity demonstrate the greenhouse effect that naturally occurs in Earth's atmosphere?

Alternatively you could carry out the Royal Society of Chemistry's -Modelling the greenhouse effect demonstrations

5

Farming and the carbon cycle

Support learners in connecting their findings from the enquiry with farming by watching the short animated film from the NFU and the Royal Geographical Society which explains how farming links to the carbon cycle.

6

How do we find a balance?

Use the Card Sort Activity (Slide 9), organising learners in groups of 3-4. The cards describe activities on farms which can be grouped into two piles: Activities that emit greenhouse gases and Activities that remove greenhouse gases from the atmosphere.

Review the learners' ideas using Slide 10. Explain that farms can be thought of as systems with different activities and processes working together -one activity knocking onto another, to create an overall impact. A key learning point is that even with new innovations to reduce greenhouse gas emissions, there will always be things that have to happen on farms that release greenhouse gases but there are things that we could do more of on farms to absorb them and keep the balance.

The job of the agricultural engineer is to work with farmers to reduce or capture greenhouse gases for a more sustainable farming future... the system is a complex system.

Activities causing greenhouse gas emissions	Activities reducing greenhouse gas emissions
Increasing numbers of livestock needed on farms to feed growing populations. Transportation of food crops from farms for processing and then on to the consumer. Fertilisers not taken up by crops are washed away into the waterways or broken down by microbes in the soil to to release nitrous oxide into the atmosphere. Artificial fertilisers are made under high pressure and at very high temperatures which require lots of energy that comes from burning fossil fuels. Manure decomposes releasing nitrous oxide and methane gases. Cows have a problem with incessant burping as they get rid of the methane produced in their four stomachs by digesting tough plant material. Breaking up the soil with a plough and other machinery exposes carbon in the soil to oxygen in the air which allows microbes to convert it into CO_2. Soil becomes compacted with heavy equipment driving across it, restricting plant growth and increasing waterlogging which leads to the production of nitrous oxide (N_2O) Hedgerows are removed to create larger fields for large scale intensive farming. Farm machinery and heating is mainly powered by the burning of fossil fuels.	Enhancing and increasing hedgerows Adding additives to the food for cattle and sheep to rescue methane (CH_4) emissions. Precision farming for crops to deliver nutrition and crop protection more efficiently. Loosening compacted soils to prevent soil compaction, reducing the need for cultivation and minimising N_2O emissions. Improve health of cattle and sheep to reduce methane emissions and boost growth rates. Introduce anaerobic digestion to convert animal manures, crops and crop by-products into renewable energy. Be more energy efficient to to reduce the use of fuels and electricity. Increasing woodland on farms. Biomass materials used in construction on farms. Reduce use of fossil fuels on farms and shift towards electricity from renewable sources (Solar/wind/bioenergy).

7

Working like agricultural engineers

Support learners in reflecting on how they have been working like agricultural engineers in the 'ask' stage of the Engineering Design Cycle - asking questions to better understand the impact of farming on the environment and the scientific ideas behind the impact farming practices have on carbon emissions (slide 11).

Be more energy efficient to to reduce the use of fuels and electricity.

Improve health of cattle and sheep to reduce methane emissions and boost growth rates.

Increasing woodland on farmland.

Introduce anaerobic digestion to convert animal manures, crops and crop by-products into renewable energy.

Biomass materials used in construction on farms.

Reduce the use of fossil fuels on farms and shift towards electricity from renewable sources (Solar/wind/bioenergy).

Adding additives to the food for cattle and sheep to rescue methane (CH_2) emissions.

Precision farming for crops to deliver nutrition and crop protection more efficiently.

Farm machinery and heating is mainly powered by the burning of fossil fuels.

Loosening compacted soils to prevent soil compaction, reducing the need for cultivation and minimising N_2O emissions.

Increasing numbers of livestock needed on farms to feed growing populations.

Fertilisers not taken up by crops are washed away into the waterways or broken down by microbes in the soil to to release nitrous oxide into the atmosphere.

Transportation of food crops from farms for processing and then on to the consumer.

Manure decomposes releasing nitrous oxide and methane gases.

Breaking up the soil with a plough exposes carbon in the soil to oxygen in the air which allows microbes to convert it into CO_2.

Hedgerows are removed to create larger fields for large scale intensive farming.

Soil becomes compacted by heavy equipment, this restricts plant growth and increases waterlogging which leads to the production of Nitrous oxide (N_2O).

Enhancing and increasing hedgerows.

Artificial fertilisers are made under high pressure and at very high temperatures which requires lots of energy that comes from burning fossil fuels.

Cows have a problem with incessant burping as they get rid of the methane produced in their stomachs from digesting tough plant material.

Sustainable Farms - Session 2

Can the right balance be found?

Context:
Learners explore the concept of sustainability in the context of farming, in particular arable farms. They learn about different processes on farms that either add or remove greenhouse gases from the atmosphere. Learners explore how agricultural engineers are finding solutions to support farmers to reduce processes that emit greenhouse gases and increase the activities that remove them. In doing so, the complexity of this problem is exposed, and pupils appreciate that 'finding the right balance' is the key to finding a solution.

Engineering focus:
Learners will be working as an engineer by asking questions to identify problems.

Learning time:
2 hours

Suggested age group:
11-14 years old

Curriculum for excellence links:
Third Level:
I can apply my knowledge and understanding of engineering disciplines and can develop/build solutions to given tasks. TCH 3-12a
I can explain some of the processes which contribute to climate change and discuss the possible impact of atmospheric change on the survival of living things. SCN 3-05b
Inquiry and investigative skills (see Sciences Benchmarks for further details):
Plans and designs scientific investigations and enquiries
Carries out practical activities in a variety of learning environments
Analyses, interprets and evaluates scientific findings
Presents scientific findings
Fourth Level:
I can solve problems through the application of engineering principles and can discuss the impact engineering has on the world around me. TCH 4-12a
Through exploring the carbon cycle, I can describe the processes involved in maintaining the balance of gases in the air, considering causes and implications of changes in the balance. SCN 4-05b
Inquiry and investigative skills (see Sciences Benchmarks for further details):
Plans and designs scientific investigations and enquiries
Carries out practical activities in a variety of learning environments
Analyses, interprets and evaluates scientific findings. Presents scientific findings.

Keywords
greenhouse gas
carbon dioxide
atmosphere
nitrous oxide
methane
fertiliser
efficiency
emissions
biomass
cultivation
fossil fuels
renewable sources
intensive farming
transportation

Resources:
Sustainable farms session 2 PPT
NFU and RGS Video - Farming and the Carbon Cycle
Card Sort Activity

Per group:
- 2x 2 litre drinks bottle
- 2 x thermometers or temperature sensors
- Water
- Plasticine
- 2-4 Antacid tablets
- Desk lamp (100W+ bulb)
- Stopwatch

Suggested Activities

1

What does sustainability mean to you?
Elicit the learners' understanding about ideas linked to sustainability. Display the range of words on Slide 2, and ask them to work in pairs to develop a concept-map. Use directional arrows and link phrases to describe their understandings.
Ask pairs to share their concept maps with the group, so they support each other in identifying useful prior knowledge. Ask learners to consider what they think we mean by **sustainable farming**.

2

Which crops have higher carbon emissions?
Ask learners to predict which of the crops of slide 3 have the highest carbon footprint - they could sort the produce into order on a post-it note. Reveal the mass of carbon dioxide gas released for every kg produced of each crop (slide 4) and ask learners to compare their predictions with the reality. What were they right about? What were they wrong about?
Explore learners thinking about why certain crops have larger carbon footprints and reveal where each of the crops were produced (Slide 5) and challenge misconceptions that it is all about distance. There are other factors such as artificial heating and lighting for growth and refrigeration that contribute as well.

3

Why does farming need to become more sustainable?
Engage the pupils in recalling their scientific knowledge and ideas about what greenhouse gases are. They are likely to be familiar with CO_2 (Carbon Dioxide), N_2O (Nitrogen Dioxide) and CH_4 (Methane). Reinforce that the proportion of these gases in the atmosphere is closely connected to global warming resulting from human activity and discuss ideas about how increased greenhouse gases lead to temperature increases for the planet (Slide 6).

Ask them for a quick-fire response to estimate the % of greenhouse gas emissions -they think comes directly from farming and agriculture. Use Slide 7 to illustrate that nearly one tenth of the world's greenhouse gases are a result of farming. Given that farming is essential to feed our vast populations, it is not a negotiable. We have to have farming! So finding innovative technological solutions is the key to reducing emissions if progress towards net zero and carbon neutral farming is to happen.

Does carbon dioxide gas heat up differently to air?

Carry out a simple investigation to compare the effect of heating air and carbon dioxide with a radiant source of heat/light (slide 8).

- Partially fill both empty 2 litre bottles with water (approximately 1/3 full).
- Cover the top of one bottle with a ball of plasticine to trap the air inside, carefully push a thermometer through the plasticine (making a tight seal) so it is measuring the temperature of the air inside the bottle.
- Drop an antacid tablet in the other bottle and cover immediately with plasticine, again carefully push a thermometer through the plasticine (making a tight seal) so it is measuring the temperature of the carbon dioxide building up in this bottle.

4

- Turn on the high power lamp and make sure it is shining directly and evenly on both bottles.
- Observe and record the temperature of the gas in each bottle every 5 mins for the next hour. Findings should be recorded in a table and the analysed using a line graph.

Challenge learners to use their data to answer the following questions:

- What does this mean for the effect that carbon dioxide has on atmospheric temperature?
- How does this activity demonstrate the greenhouse effect that naturally occurs in Earth's atmosphere?

Alternatively you could carry out the Royal Society of Chemistry's -Modelling the greenhouse effect demonstrations

5

Farming and the carbon cycle

Support learners in connecting their findings from the enquiry with farming by watching the short animated film from the NFU and the Royal Geographical Society which explains how farming links to the carbon cycle.

How do we find a balance?

6

Use the Card Sort Activity (Slide 9), organising learners in groups of 3-4. The cards describe activities on farms which can be grouped into two piles: Activities that emit greenhouse gases and Activities that remove greenhouse gases from the atmosphere.

Review the learners' ideas using Slide 10. Explain that farms can be thought of as systems with different activities and processes working together -one activity knocking onto another, to create an overall impact. A key learning point is that even with new innovations to reduce greenhouse gas emissions, there will always be things that have to happen on farms that release greenhouse gases but there are things that we could do more of on farms to absorb them and keep the balance.

The job of the agricultural engineer is to work with farmers to reduce or capture greenhouse gases for a more sustainable farming future... the system is a complex system.

Activities causing greenhouse gas emissions	Activities reducing greenhouse gas emissions
Increasing numbers of livestock needed on farms to feed growing populations. Transportation of food crops from farms for processing and then on to the consumer. Fertilisers not taken up by crops are washed away into the waterways or broken down by microbes in the soil to to release nitrous oxide into the atmosphere. Artificial fertilisers are made under high pressure and at very high temperatures which require lots of energy that comes from burning fossil fuels. Manure decomposes releasing nitrous oxide and methane gases. Cows have a problem with incessant burping as they get rid of the methane produced in their four stomachs by digesting tough plant material. Breaking up the soil with a plough and other machinery exposes carbon in the soil to oxygen in the air which allows microbes to convert it into CO_2. Soil becomes compacted with heavy equipment driving across it, restricting plant growth and increasing waterlogging which leads to the production of nitrous oxide (N_2O) Hedgerows are removed to create larger fields for large scale intensive farming. Farm machinery and heating is mainly powered by the burning of fossil fuels.	Enhancing and increasing hedgerows Adding additives to the food for cattle and sheep to rescue methane (CH_4) emissions. Precision farming for crops to deliver nutrition and crop protection more efficiently. Loosening compacted soils to prevent soil compaction, reducing the need for cultivation and minimising N_2O emissions. Improve health of cattle and sheep to reduce methane emissions and boost growth rates. Introduce anaerobic digestion to convert animal manures, crops and crop by-products into renewable energy. Be more energy efficient to to reduce the use of fuels and electricity. Increasing woodland on farms. Biomass materials used in construction on farms. Reduce use of fossil fuels on farms and shift towards electricity from renewable sources (Solar/wind/bioenergy).

Working like agricultural engineers

7

Support learners in reflecting on how they have been working like agricultural engineers in the 'ask' stage of the Engineering Design Cycle - asking questions to better understand the impact of farming on the environment and the scientific ideas behind the impact farming practices have on carbon emissions (slide 11).

Be more energy efficient to to reduce the use of fuels and electricity.

Improve health of cattle and sheep to reduce methane emissions and boost growth rates.

Increasing woodland on farmland.

Introduce anaerobic digestion to convert animal manures, crops and crop by-products into renewable energy.

Biomass materials used in construction on farms.

Reduce the use of fossil fuels on farms and shift towards electricity from renewable sources (Solar/wind/bioenergy).

Adding additives to the food for cattle and sheep to rescue methane (CH_4) emissions.

Precision farming for crops to deliver nutrition and crop protection more efficiently.

Farm machinery and heating is mainly powered by the burning of fossil fuels.

Loosening compacted soils to prevent soil compaction, reducing the need for cultivation and minimising N_2O emissions.

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Cows have a problem with incessant burping as they get rid of the methane produced in their stomachs from digesting tough plant material.

SUSTAINABLE FARMS

SESSION 2

Can the right balance be found?

What does sustainability mean to you?

climate change	organic	carbon footprint
preservation	net-zero	energy efficient
reuse	organic	zero-waste
recycle	eco-friendly	carbon offsets
reduce	conservation	circular economy
biodegradable	deforestation	renewable energy

Which crop has the largest carbon footprint?

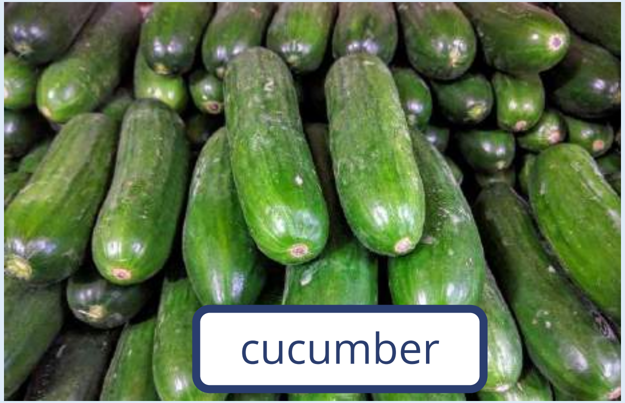
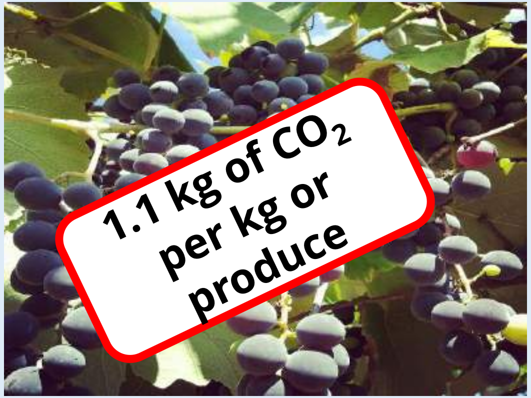


Image credits: Steve Hopson/Spirtu/thmsvrbrggn/Maksym Kozlenko/trehaeuser/Muffet

Compare the mass of CO_2 release for each kg of produce.



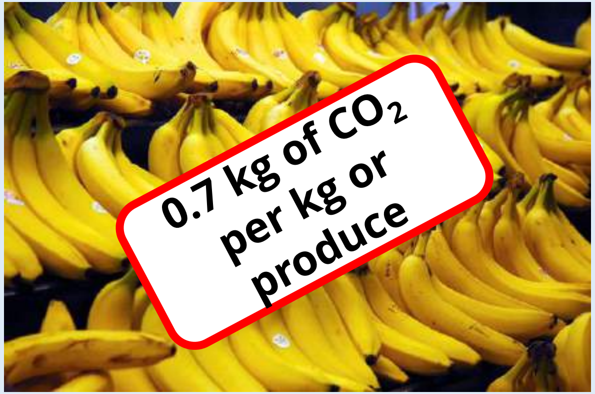
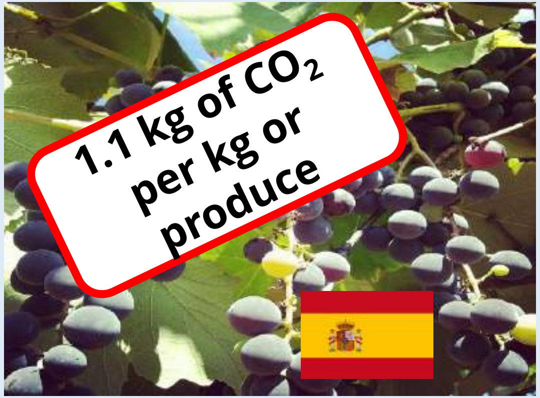
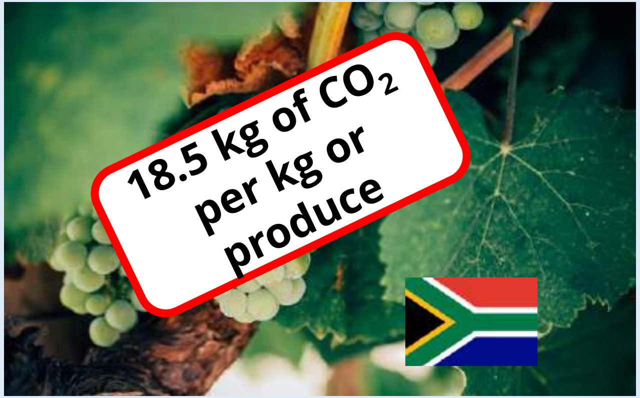


Image credits: Steve Hopson/Spirtu/thmsvrbrggn/Maksym Kozlenko/trehaeuser/Muffet

Why do you think some crops have higher carbon emissions?





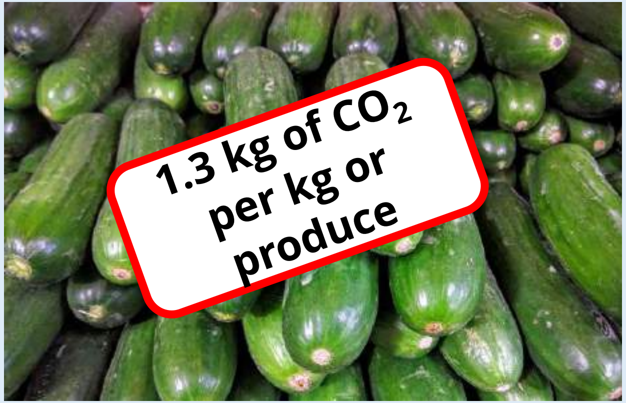
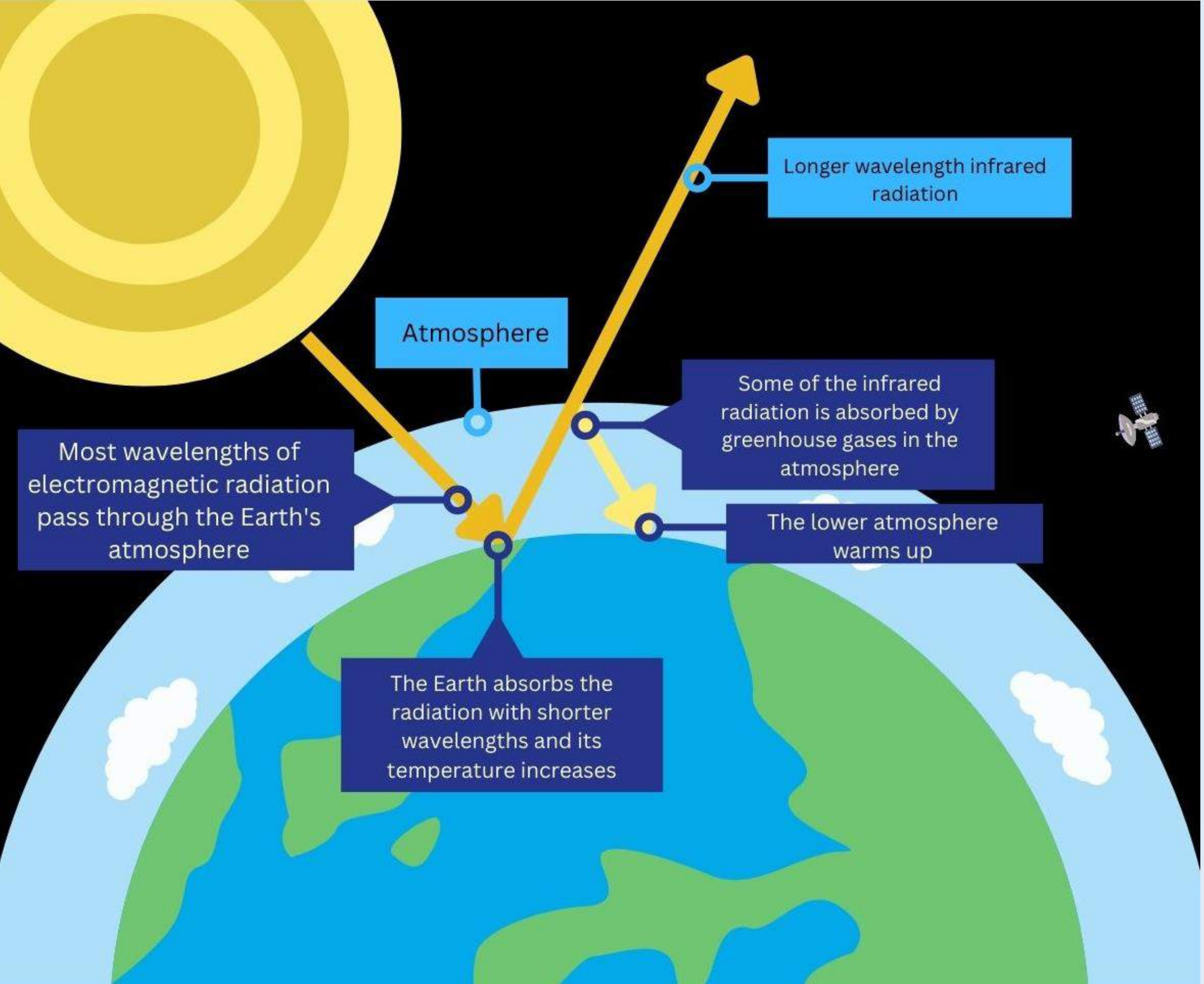
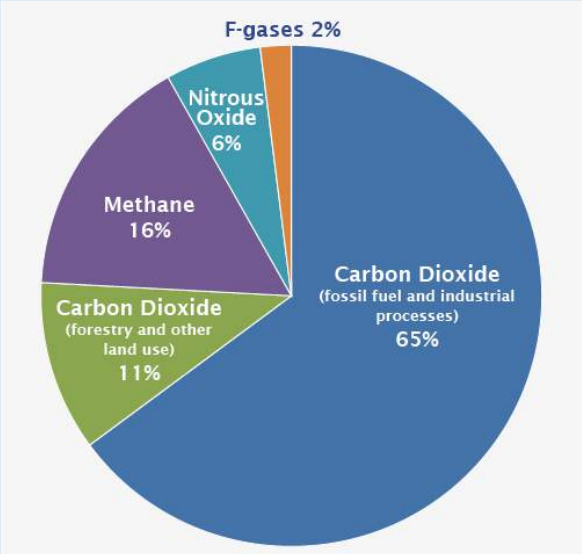


Image credits: Steve Hopson/Spirtu/thmsvrbrggn/Maksym Kozlenko/trehaeuser/Muffet



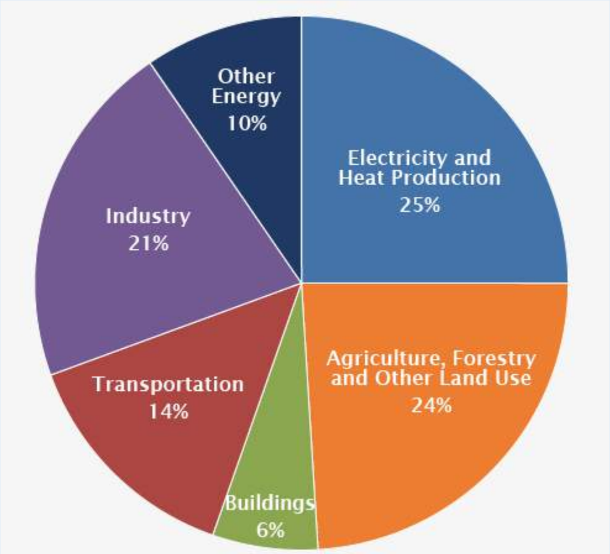
What do you already know about the impact of carbon emissions on our planet?

What are the greenhouse gases and where do they come from?



Global greenhouse gas emissions by gas.

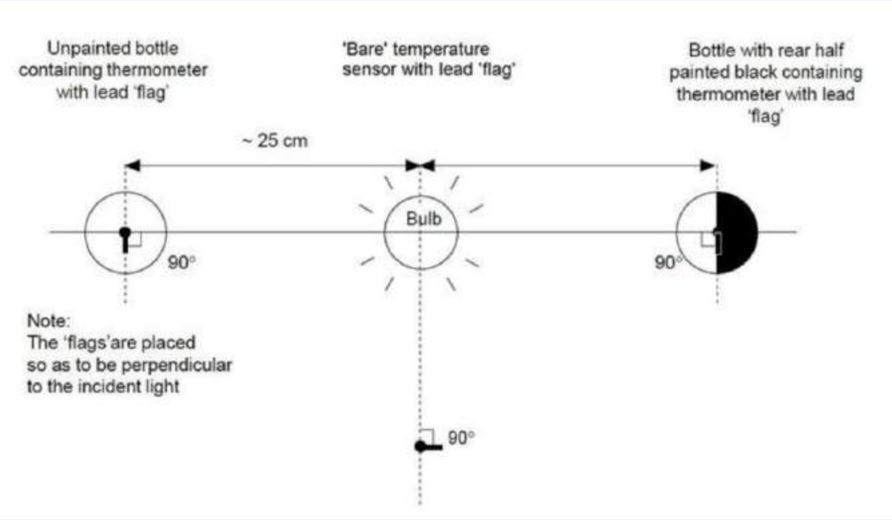
The Intergovernmental Panel on Climate Change Special Report on Climate Change and Land (2019) estimates agriculture is directly responsible for **up to 8.5% of all greenhouse gas emissions.**

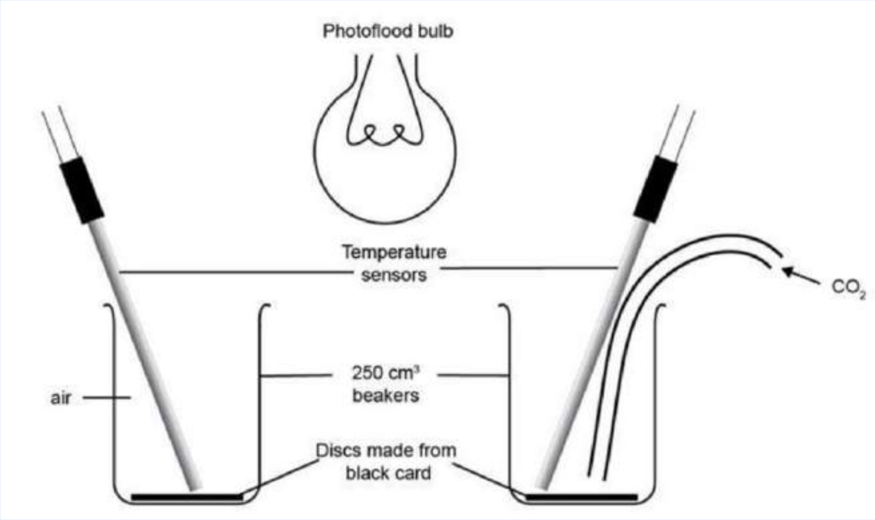


Global greenhouse gas emissions from different sectors.

Image credits: Environmental Protection Agency

Why are carbon emissions a problem for the environment?

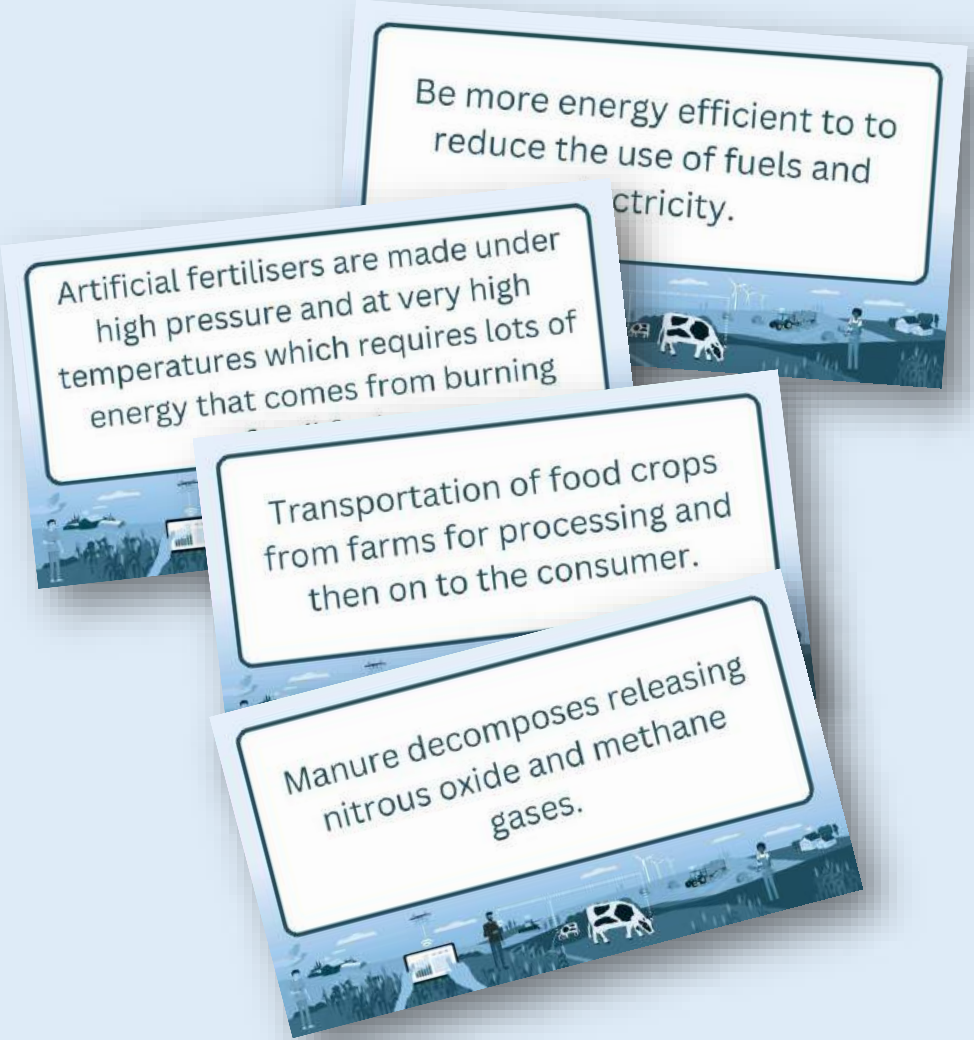




Experiment 1

Experiment 2

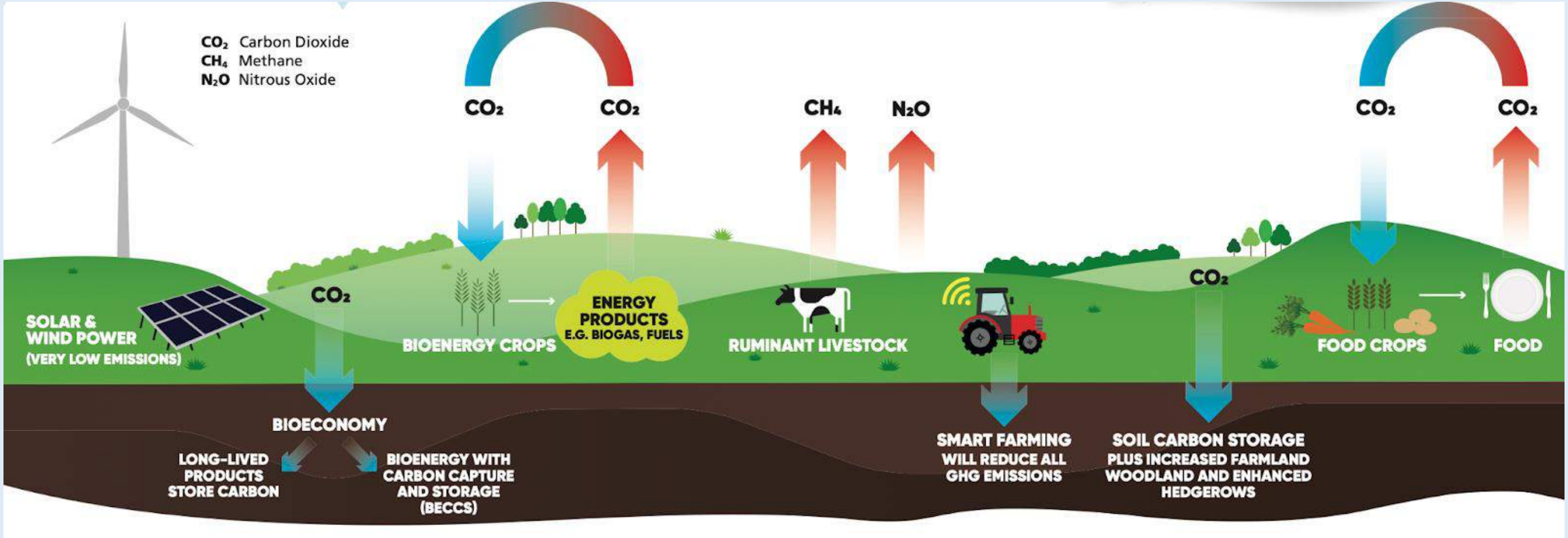
Image credits: Royal Society of Chemistry



Finding a balance

Work collaboratively to sort the cards into activities on farmland that **release greenhouse gases** into the atmosphere and activities that **remove greenhouse gases** from the atmosphere.

Finding a balance in the farming environment



AGRICULTURE

10% of UK Greenhouse Gas Emissions

Circular balanced flows of greenhouse gases

Image credits: NFU

Today we have been working like agricultural engineers by a**sking questions** to better understand the problems farmers face in reducing the impact of their farms on the environment.

SUSTAINABLE FARMS

Sustainable Farms - Session 3

How can more sustainable growing techniques innovate how we grow plants for food?

Learning time:
2 hours

Suggested age group:
11-14 years old

Context:
In this session learners will be introduced to contemporary farming methods for growing plants for food and learn what is meant by a 'hydroponics system', its advantages and disadvantages. Learners will think about the key components within a hydroponic system and consider how they interact. They will apply their science knowledge to this real-life application. Learners will then be challenged to work in teams and use recycled materials to create a simple hydroponic farm to successfully grow the seedlings and evaluate their prototype.

Engineering focus:
Learners will be working as an engineer by systems thinking thinking, creating and adapting in their creative problem solving.

Keywords
hydroponics
vertical farm
aquaponics
sustainable
systems thinking
reservoir
growing chamber
growing medium
nutrient solution
delivery system
wick system
drip system
ebb and flow system
nutrient film system

Curriculum links: Design Technology
Learners will
- Learn that food is produced, processed and sold in different ways, e.g. conventional and organic farming and fair trade.
- Use learning from science to help design and make products that work.

Resources:
- Sustainable Farms Session 3 PPT
- Advantages and Disadvantages card sort Activity
- Access to computers for research
- Seedlings for a quick growing crop such as radishes or lettuce
- Low tech approach: Plastic bottles, craft knife, absorbent fabric strips/string, glue gun, sponge/gravel to support seedling, nutrient water (See CLEAPSS recipe card 66 for Sach's culture solution (complete recipe), Chemicals are LOW HAZARD)

Suggested Activities

1

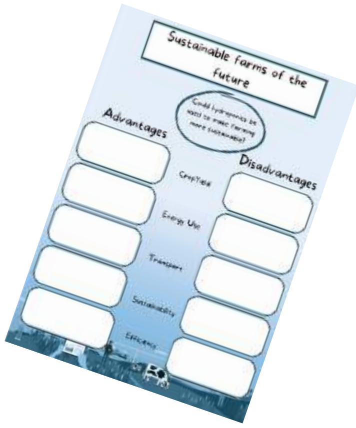
Show learners a collection of photos of contemporary farms
(Slide 2)
In talking pairs learners should decide on an odd one out and be able to justify their choice. Challenge them to also come up with a list of what all of these future farms have in common? (Sustainable/hydroponics/indoors/growing plants for food etc)

1. Offendam Vertical Farm, Scotland
2. Nordic Harvest, the largest vertical farm in the world, Denmark. Supplying fresh produce to all of Copenhagen's markets.
3. Closed loop system, aquaponics, where fish and veggies are grown together with recirculated water.
4. Growing Underground, the world's first underground farm, London - growing herbs, lettuce and other vegetables, and even fruit.

2

What are hydroponics?
The image on this slide shows a NASA scientist working on hydroponic systems for growing plants on the Moon or Mars. Could hydroponics be a possible approach to net zero farming here on Earth? (Slide 3)

Learners work in teams to sort the statements into advantages of hydroponics farms and disadvantages. A graphic organiser is available to support this activity. Ask learners to share how they grouped the cards and discuss key questions: What problems have you found with hydroponics? What problems with sustainable farming might hydroponics help to solve? (Slide 4)



What do you think could be grown with hydroponics? Show learners 12 vegetables/fruits - ask them to decide which ones they think could be grown with hydroponics. Then reveal the answers (Slide 5-6)

Optional activity: Allow learners time to independently research hydroponics focusing on how they work, different systems for hydroponics and where they are being used as a contemporary farming method.

Optional Activity: Using systems thinking to explore hydroponics

To help prepare your learners for the Sustainable Growing Challenge you may want to take some additional time to explore how hydroponic systems work. Explain to the learners that they are going to be working like engineers by **systems thinking**. They will be identifying the parts in a hydroponic system and using their prior science knowledge to explain how things work together and why each part is there (Slide 7).

Learners deduce which number on the diagram corresponds to which component in the hydroponic system using the table of definitions and their prior scientific knowledge (Technical vocabulary focus). Use questioning to elicit learners' ideas, while doing this get them to explain the importance of each component in the system using their science knowledge.

3

Reservoir	**7**	Watertight container to hold nutrient solution
Growing chamber	**2**	Container with drain holes that holds the plant
Growing medium	**3**	Non-soil substance that plants grow in
Nutrient solution	**9**	A solution of the 16 elements essential for plant growth
Submersible pump	**8**	Moves nutrient solution from reservoir to plant chamber
Delivery system	**4**	Tubing or wick that carries nutrient solution from the reservoir to the plant chamber
Simple timer	**5**	Controls when the pump and or lights come on
Return pipe	**6**	Unused nutrient solution returned to the reservoir tank
Light	**1**	8-10 hours of daily light
Air pump	**10**	To oxygenate the nutrient solution as roots use oxygen for aerobic respiration

Introduce learners to the different ways that hydroponic systems can be put together. You could organise the class into groups and give them all one to find out about and explain to the other groups (Slide 8).

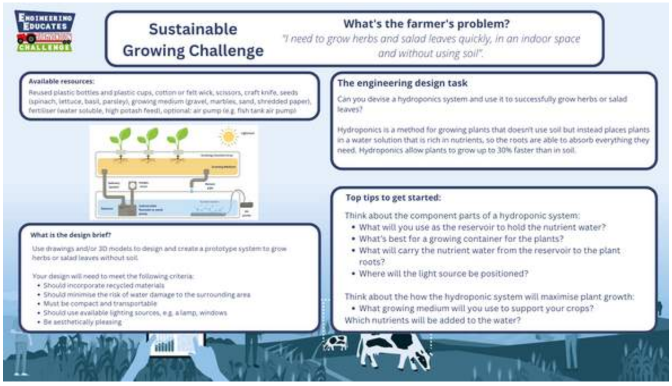
Research website: https://www.custommade.com/blog/introduction-to-hydroponics/

Sustainable Growing Challenge: Create a working hydroponic prototype

4

Learners apply their knowledge and understanding while working in teams, to design and create an inexpensive, compact, portable, working hydroponic gardening system that can be conveniently used on your window sill or table top to grow lettuce, radishes, basil, or another quick growing, edible plant. Encourage them to make their system aesthetically appealing since it will be highly visible for a long period of time as they test them.

Provide learners with the Problem on a Page: Sustainable Growing Challenge handout to support them with imagining & planning, then creating their prototype (Slide 9).



Evaluate

5

Provide some time for learners to self and peer evaluate how well their prototypes meet the success criteria on their design brief. This could then be revisited after a number of weeks when their crops are starting to grow.

There is a useful evaluation grid on the Problem on a page handout to support this activity.

Take it further

- Medium tech approach: For ideas on increasing the complexity of your learners hydroponics prototypes explore this website or watch this video.
- High tech approach: For ideas on how to include a timer, pump, lighting system and data loggers to support monitoring explore these teacher notes from SAPS available from the STEM learning resource collection.

Sustainable farms of the future

Could hydroponics be used to make farming more sustainable?

Advantages		Disadvantages
	Crop Yield	
	Energy Use	
	Transport	
	Sustainability	
	Efficiency	

What do the experts say about hydroponics?

Hydroponic systems use 10 times less water that soil-based growing methods.

Microbes in the soil are beneficial for plant growth.

Hydroponic systems can produce year round crops.

Hydroponic systems can produce higher yields that soil-based alternatives.

Hydroponic systems that use artificial lighting can use lots of electricity.

Hydroponic systems can be located close to where the food is needed reducing travel distance and time from the farm to the table.

Hydroponic systems can be stacked high and don't need as much land as conventional soil-based farming.

Hydroponic equipment including pumps, pipes, lights, air filters, lights, fans can all be expensive.

Weeds are not an issue with hydroponic methods because they need soil to grow.

Systems are made of materials which require resources to build and maintain.

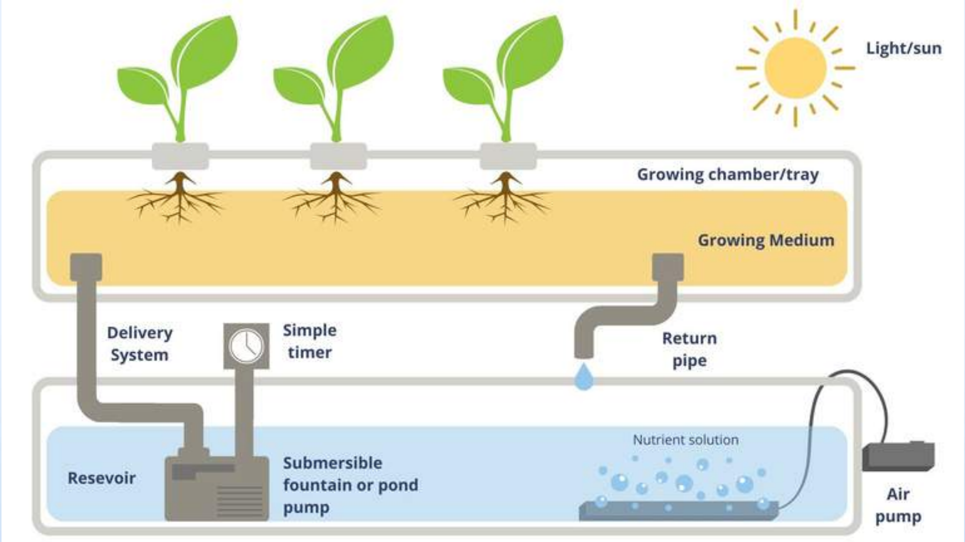
Sustainable Growing Challenge

What's the farmer's problem?

"I need to grow herbs and salad leaves quickly, in an indoor space and without using soil".

Available resources:

Reused plastic bottles and plastic cups, cotton or felt wick, scissors, craft knife, seeds (spinach, lettuce, basil, parsley), growing medium (gravel, marbles, sand, shredded paper), fertiliser (water soluble, high potash feed), optional: air pump (e.g. fish tank air pump)



What is the design brief?

Use drawings and/or 3D models to design and create a prototype system to grow herbs or salad leaves without soil.

Your design will need to meet the following criteria:

- Should incorporate recycled materials
- Should minimise the risk of water damage to the surrounding area
- Must be compact and transportable
- Should use available lighting sources, e.g. a lamp, windows
- Be aesthetically pleasing

The engineering design task

Can you devise a hydroponics system and use it to successfully grow herbs or salad leaves?

Hydroponics is a method for growing plants that doesn't use soil but instead places plants in a water solution that is rich in nutrients, so the roots are able to absorb everything they need. Hydroponics allow plants to grow up to 30% faster than in soil.

Top tips to get started:

Think about the component parts of a hydroponic system:

- What will you use as the reservoir to hold the nutrient water?
- What's best for a growing container for the plants?
- What will carry the nutrient water from the reservoir to the plant roots?
- Where will the light source be positioned?

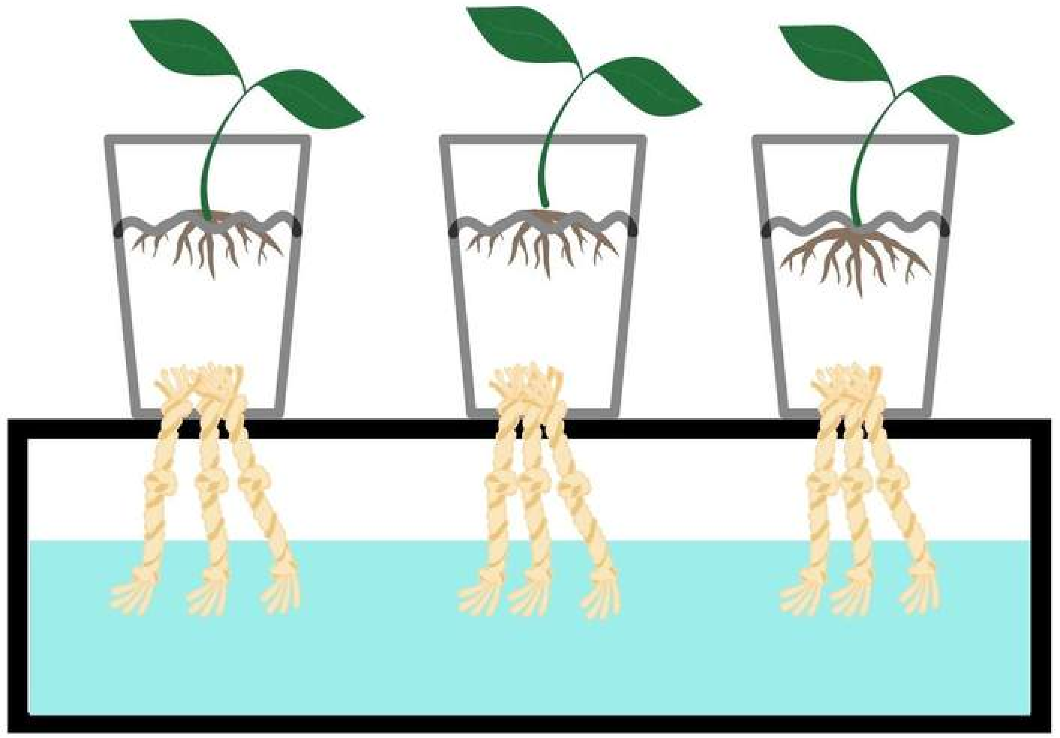
Think about the how the hydroponic system will maximise plant growth:

- What growing medium will you use to support your crops?

Which nutrients will be added to the water?

Background Information:

The wick system is simple and easy hydroponics system to set up which is cheap and easy to set up.



Water is drawn into the wick by capillary action. Water is sticks to the porous material of the wick and keeps moving up, this is how the water and nutrients get from the reservoir to the plants. Each plant will need one or more wicks, connecting it to the reservoir.

In hydroponic systems the water needs to be a nutrient solution as the plants are not grown in soil. You could research the best nutrients to use but a high potash feed with nitrogen, phosphorus and Potassium would work well.

Glossary:

Hydroponic system: a system that grows plants without soil.
Reservoir: somewhere water is stored.
Growing chamber: containers that give space and support to plants as they grow.
Growing medium: the material that plants are grown in.
Nutrient solution: a mix of concentrated minerals that plants need to grow.
Crop: a plant grown on a large scale for commercial use.
Yield: a measurement of the amount of crop harvested per unit area of farmland.
Wick: a strip of porous material that liquid is drawn up by capillary action.
Prototype: a version of a made-up design that can be improved and developed.
Compact: something that is small and conveniently shaped.
Aesthetic: the look and feel of something – related to beauty.

More information and inspiration!

Find out more about hydroponics from the Royal Horticulture Society.
For ideas on setting up a hydroponic system read the SAPS guide.
Example Youtube videos to inspire you by demonstrating how to make a simple hydroponic system and wick system.

Want to take it further?

Can you plan a science investigation to gather some data to evaluate the effectiveness of your hydroponic system? How does your data compare with others?
Can you evidence how effective your system is?

How well did you do?

Success Criteria	Score /5
The system grows plant without soil.	
The system uses recycled materials.	
Water is contained in the system, it doesn't leak.	
The system allows plants to get the light they need.	
The system is compact, portable and aesthetically pleasing.	

Sustainable Farms - Session 3

How can more sustainable growing techniques innovate how we grow plants for food?

Context:
In this session learners will be introduced to contemporary farming methods for growing plants for food and learn what is meant by a 'hydroponics system', its advantages and disadvantages. Learners will think about the key components within a hydroponic system and consider how they interact. They will apply their science knowledge to this real-life application. Learners will then be challenged to work in teams and use recycled materials to create a simple hydroponic farm to successfully grow the seedlings and evaluate their prototype.

Engineering focus:
Learners will be working as an engineer by systems thinking thinking, creating and adapting in their creative problem solving.

Learning time:
2 hours

Suggested age group:
11-14 years old

Curriculum for Excellence links:

Third Level:
I can apply my knowledge and understanding of engineering disciplines and can develop/build solutions to given tasks. TCH 3-12a
Through investigations and based on experimental evidence, I can explain the use of different types of chemicals in agriculture and their alternatives and can evaluate their potential impact on the world's food production. SCN 3-03a
I understand how scientific and technological developments have contributed to changes in everyday products. TCH 3-05a
I can create solutions in 3D and 2D and can justify the construction/graphic methods and the design features. TCH 3-09a
I can explore the properties and performance of materials before justifying the most appropriate material for a task. TCH 3-10a
Scientific analytical thinking skills (see Sciences Benchmarks for further details)
While working through a design process in response to a design brief, I can develop and communicate imaginative design solutions. EXA 3-06a

Fourth Level:
I can solve problems through the application of engineering principles and can discuss the impact engineering has on the world around me. TCH 4-12a
I have propagated and grown plants using a variety of different methods. I can compare these methods and develop my understanding of their commercial use. SCN 4-02a
I can analyse products taking into consideration sustainability, scientific and technological developments. TCH 4-05a
I can apply design thinking skills when designing and manufacturing models/products which satisfy the user or client. TCH 4-09a
I consider the material performance as well as sustainability of materials and apply these to real world tasks. TCH 4-10a
Scientific analytical thinking skills (see Sciences Benchmarks for further details)
By working through a design process in response to a design brief, I can develop and communicate imaginative and original design solutions. EXA 4-06a

Keywords
hydroponics
vertical farm
aquaponics
sustainable
systems thinking
reservoir
growing chamber
growing medium
nutrient solution
delivery system
wick system
drip system
ebb and flow system
nutrient film system

Resources:
- Sustainable Farms Session 3 PPT
- Sustainable Farms Session 3 Optional Handout and graphic organiser
- Access to computers for research
- Seedlings for a quick growing crop such as radishes or lettuce
- Low tech approach: Plastic bottles, craft knife, absorbent fabric strips/string, glue gun, sponge/gravel to support seedling, nutrient water (Sach's culture solution (complete recipe), Chemicals are LOW HAZARD)

Suggested Activities

1

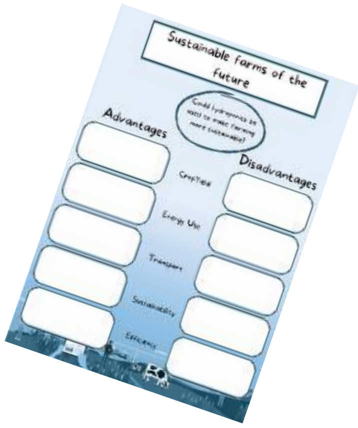
Show learners a collection of photos of contemporary farms
(Slide 2)
In talking pairs learners should decide on an odd one out and be able to justify their choice. Challenge them to also come up with a list of what all of these future farms have in common? (Sustainable/hydroponics/indoors/growing plants for food etc)

1. Offendam Vertical Farm, Scotland
2. Nordic Harvest, the largest vertical farm in the world, Denmark. Supplying fresh produce to all of Copenhagen's markets.
3. Closed loop system, aquaponics, where fish and veggies are grown together with recirculated water.
4. Growing Underground, the world's first underground farm, London - growing herbs, lettuce and other vegetables, and even fruit.

2

What are hydroponics?
The image on this slide shows a NASA scientist working on hydroponic systems for growing plants on the Moon or Mars. Could hydroponics be a possible approach to net zero farming here on Earth? (Slide 3)

Learners work in teams to sort the statements into advantages of hydroponics farms and disadvantages. A graphic organiser is available to support this activity. Ask learners to share how they grouped the cards and discuss key questions: What problems have you found with hydroponics? What problems with sustainable farming might hydroponics help to solve? (Slide 4)



What do you think could be grown with hydroponics? Show learners 12 vegetables/fruits - ask them to decide which ones they think could be grown with hydroponics. Then reveal the answers (Slide 5-6)

Optional activity: Allow learners time to independently research hydroponics focusing on how they work, different systems for hydroponics and where they are being used as a contemporary farming method.

Optional Activity: Using systems thinking to explore hydroponics

To help prepare your learners for the Sustainable Growing Challenge you may want to take some additional time to explore how hydroponic systems work. Explain to the learners that they are going to be working like engineers by **systems thinking**. They will be identifying the parts in a hydroponic system and using their prior science knowledge to explain how things work together and why each part is there (Slide 7).

Learners deduce which number on the diagram corresponds to which component in the hydroponic system using the table of definitions and their prior scientific knowledge (Technical vocabulary focus). Use questioning to elicit learners' ideas, while doing this get them to explain the importance of each component in the system using their science knowledge.

3

Reservoir	7	Watertight container to hold nutrient solution
Growing chamber	2	Container with drain holes that holds the plant
Growing medium	3	Non-soil substance that plants grow in
Nutrient solution	9	A solution of the 16 elements essential for plant growth
Submersible pump	8	Moves nutrient solution from reservoir to plant chamber
Delivery system	4	Tubing or wick that carries nutrient solution from the reservoir to the plant chamber
Simple timer	5	Controls when the pump and or lights come on
Return pipe	6	Unused nutrient solution returned to the reservoir tank
Light	1	8-10 hours of daily light
Air pump	10	To oxygenate the nutrient solution as roots use oxygen for aerobic respiration

Introduce learners to the different ways that hydroponic systems can be put together. You could organise the class into groups and give them all one to find out about and explain to the other groups (Slide 8).

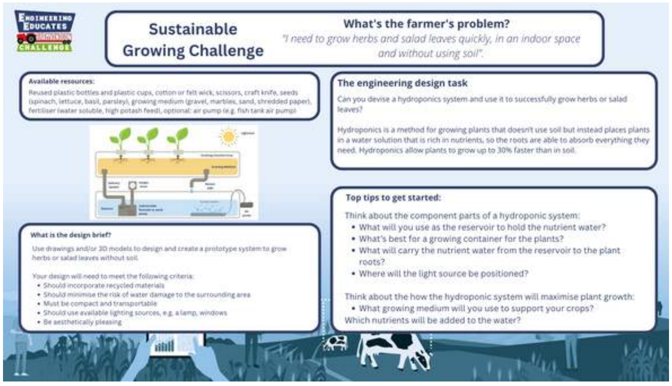
Research website: https://www.custommade.com/blog/introduction-to-hydroponics/

4

Sustainable Growing Challenge: Create a working hydroponic prototype

Learners apply their knowledge and understanding while working in teams, to design and create an inexpensive, compact, portable, working hydroponic gardening system that can be conveniently used on your window sill or table top to grow lettuce, radishes, basil, or another quick growing, edible plant. Encourage them to make their system aesthetically appealing since it will be highly visible for a long period of time as they test them.

Provide learners with the Problem on a Page: Sustainable Growing Challenge handout to support them with imagining & planning, then creating their prototype (Slide 9).



5

Evaluate

Provide some time for learners to self and peer evaluate how well their prototypes meet the success criteria on their design brief. This could then be revisited after a number of weeks when their crops are starting to grow.

There is a useful evaluation grid on the Problem on a page handout to support this activity.

Take it further

- Medium tech approach: For ideas on increasing the complexity of your learners hydroponics prototypes explore this website or watch this video.
- High tech approach: For ideas on how to include a timer, pump, lighting system and data loggers to support monitoring explore these teacher notes from SAPS available from the STEM learning resource collection.

What do the experts say about hydroponics?

Hydroponic systems use 10 times less water that soil-based growing methods.

Microbes in the soil are beneficial for plant growth.

Hydroponic systems can produce year round crops.

Hydroponic systems can produce higher yields that soil-based alternatives.

Hydroponic systems that use artificial lighting can use lots of electricity.

Hydroponic systems can be located close to where the food is needed reducing travel distance and time from the farm to the table.

Hydroponic systems can be stacked high and don't need as much land as conventional soil-based farming.

Hydroponic equipment including pumps, pipes, lights, air filters, lights, fans can all be expensive.

Weeds are not an issue with hydroponic methods because they need soil to grow.

Systems are made of materials which require resources to build and maintain.

Sustainable farms of the future

Could hydroponics be used to make farming more sustainable?

Advantages		Disadvantages
	Crop Yield	
	Energy Use	
	Transport	
	Sustainability	
	Efficiency	

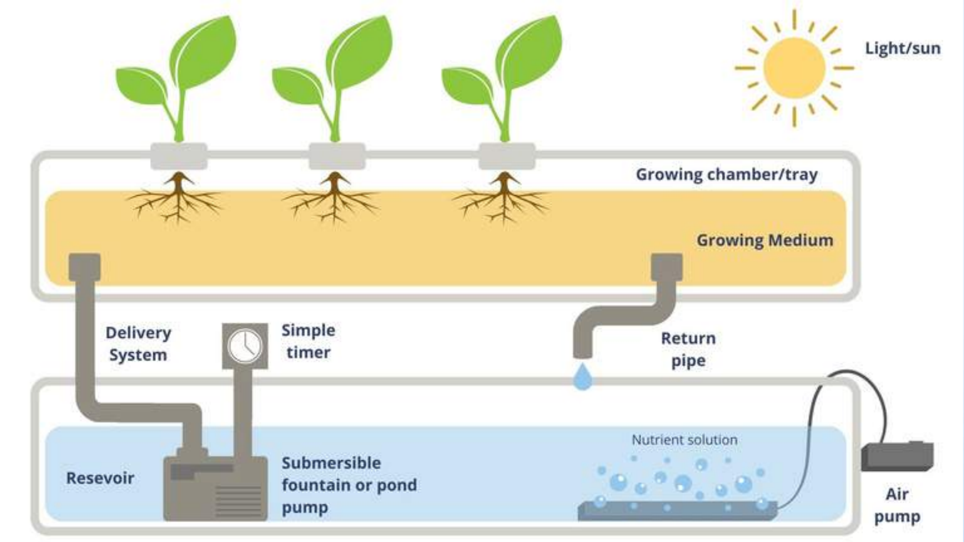
Sustainable Growing Challenge

What's the farmer's problem?

"I need to grow herbs and salad leaves quickly, in an indoor space and without using soil".

Available resources:

Reused plastic bottles and plastic cups, cotton or felt wick, scissors, craft knife, seeds (spinach, lettuce, basil, parsley), growing medium (gravel, marbles, sand, shredded paper), fertiliser (water soluble, high potash feed), optional: air pump (e.g. fish tank air pump)



What is the design brief?

Use drawings and/or 3D models to design and create a prototype system to grow herbs or salad leaves without soil.

Your design will need to meet the following criteria:

- Should incorporate recycled materials
- Should minimise the risk of water damage to the surrounding area
- Must be compact and transportable
- Should use available lighting sources, e.g. a lamp, windows
- Be aesthetically pleasing

The engineering design task

Can you devise a hydroponics system and use it to successfully grow herbs or salad leaves?

Hydroponics is a method for growing plants that doesn't use soil but instead places plants in a water solution that is rich in nutrients, so the roots are able to absorb everything they need. Hydroponics allow plants to grow up to 30% faster than in soil.

Top tips to get started:

Think about the component parts of a hydroponic system:

- What will you use as the reservoir to hold the nutrient water?
- What's best for a growing container for the plants?
- What will carry the nutrient water from the reservoir to the plant roots?
- Where will the light source be positioned?

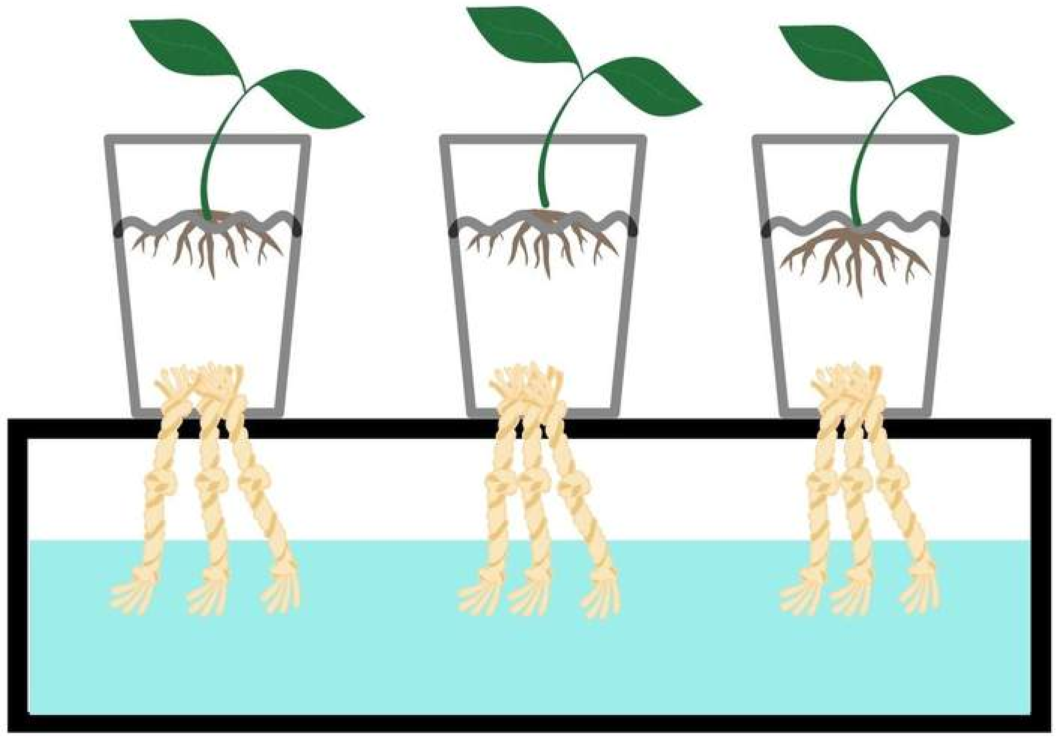
Think about the how the hydroponic system will maximise plant growth:

- What growing medium will you use to support your crops?

Which nutrients will be added to the water?

Background Information:

The wick system is simple and easy hydroponics system to set up which is cheap and easy to set up.



Water is drawn into the wick by capillary action. Water is sticks to the porous material of the wick and keeps moving up, this is how the water and nutrients get from the reservoir to the plants. Each plant will need one or more wicks, connecting it to the reservoir.

In hydroponic systems the water needs to be a nutrient solution as the plants are not grown in soil. You could research the best nutrients to use but a high potash feed with nitrogen, phosphorus and Potassium would work well.

Glossary:

Hydroponic system: a system that grows plants without soil.
Reservoir: somewhere water is stored.
Growing chamber: containers that give space and support to plants as they grow.
Growing medium: the material that plants are grown in.
Nutrient solution: a mix of concentrated minerals that plants need to grow.
Crop: a plant grown on a large scale for commercial use.
Yield: a measurement of the amount of crop harvested per unit area of farmland.
Wick: a strip of porous material that liquid is drawn up by capillary action.
Prototype: a version of a made-up design that can be improved and developed.
Compact: something that is small and conveniently shaped.
Aesthetic: the look and feel of something – related to beauty.

More information and inspiration!

Find out more about hydroponics from the Royal Horticulture Society.
For ideas on setting up a hydroponic system read the SAPS guide.
Example Youtube videos to inspire you by demonstrating how to make a simple hydroponic system and wick system.

Want to take it further?

Can you plan a science investigation to gather some data to evaluate the effectiveness of your hydroponic system? How does your data compare with others?
Can you evidence how effective your system is?

How well did you do?

Success Criteria	Score /5
The system grows plant without soil.	
The system uses recycled materials.	
Water is contained in the system, it doesn't leak.	
The system allows plants to get the light they need.	
The system is compact, portable and aesthetically pleasing.	

SESSION 3

How can more sustainable growing techniques innovate how we grow plants for food?

Farms of the future

Which is the odd one out?
What have they all got in common?

Image credits: Bio tech Vertical farming/YesHealth/PlantsPests&Diseases/Growing Underground

What are hydroponics?

Using **Hydroponics** is an effective method for growing plants that instead of using soil places the plants in a **water solution** that's rich in **nutrients** so the roots are able to take in everything they need.

The plants will also have access to large amounts of oxygen, which helps to facilitate growth. The advantage of using hydroponics to grow plants is that it allows for a much quicker growth rate which can be up to **30% faster** than soil-based planting methods.

What do the experts say about hydroponics?

Hydroponic systems use 10 times less water that soil-based growing methods.

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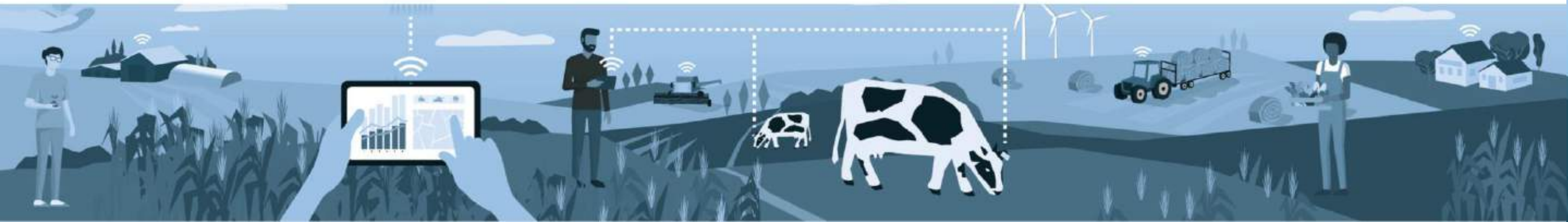


What foods can be grown with hydroponics?

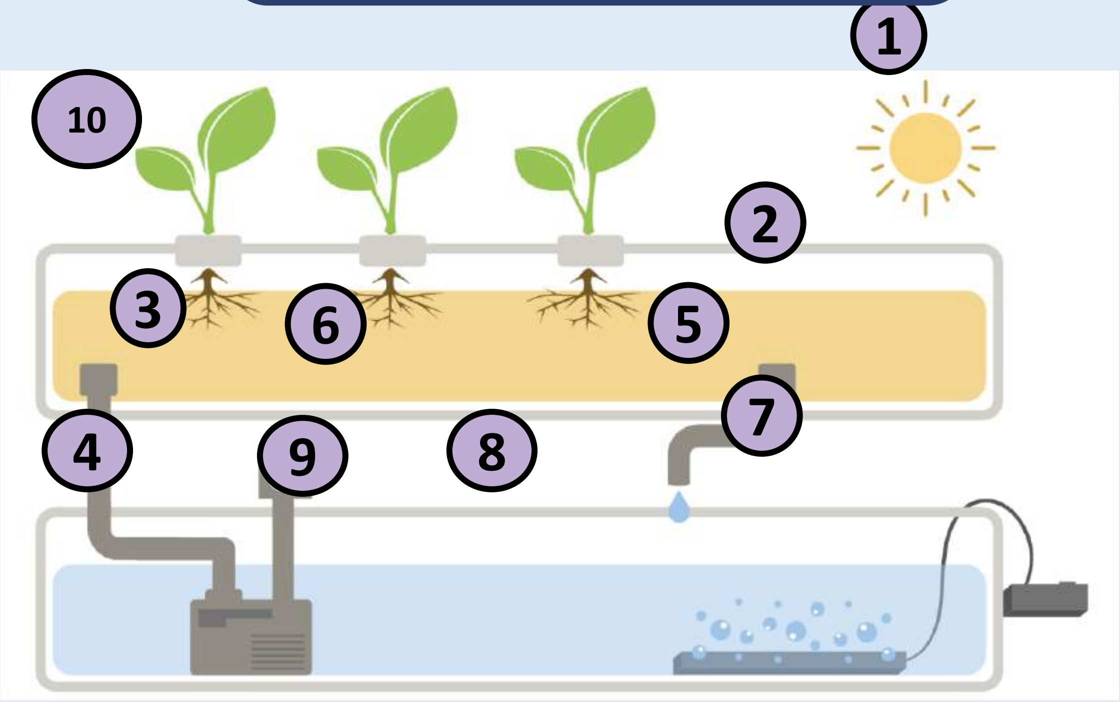
Image credits: Jorge Zapico/mhaithaca/Didriks/Stacey Spensley/Muffet/The Ewan/16:9clue/Scott 97006/CAIT/Suzie's Farm/ilovebutter

What foods can be grown with hydroponics?

Image credits: Jorge Zapico/mhaithaca/Didriks/Stacey Spensley/Muffet/The Ewan/16:9clue/Scott 97006/CAIT/Suzie's Farm/ilovebutter

Systems Thinking

Identify the parts that make up a typical hydroponic system.



Reservoir	Watertight container to hold nutrient solution
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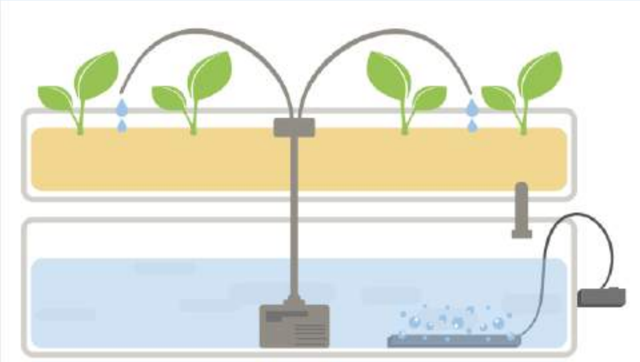
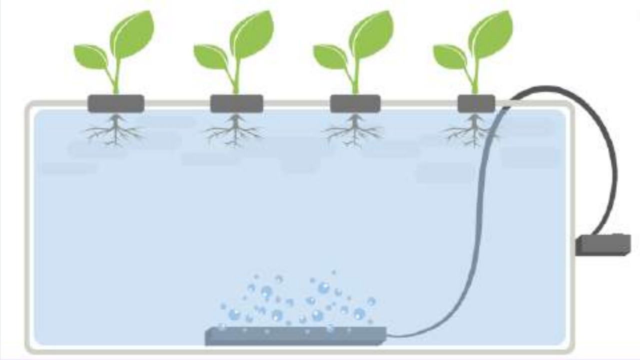
Air pump	To oxygenate the nutrient solution as roots use oxygen for aerobic respiration

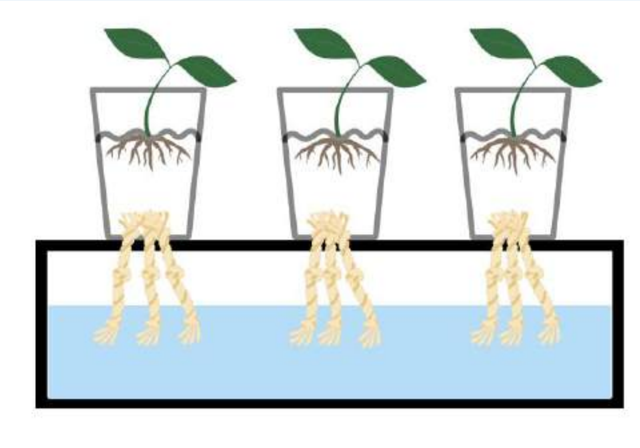
Some different types of hydroponic system for inspiration



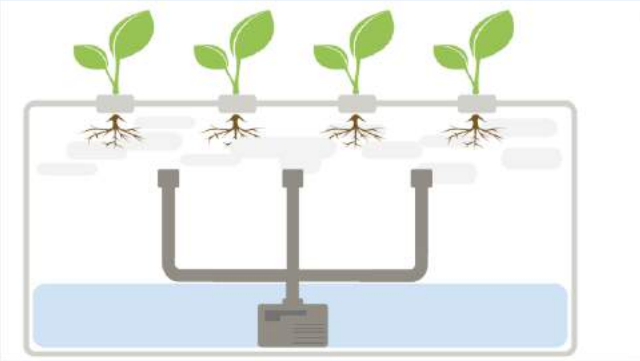
Drip System



Water Culture System

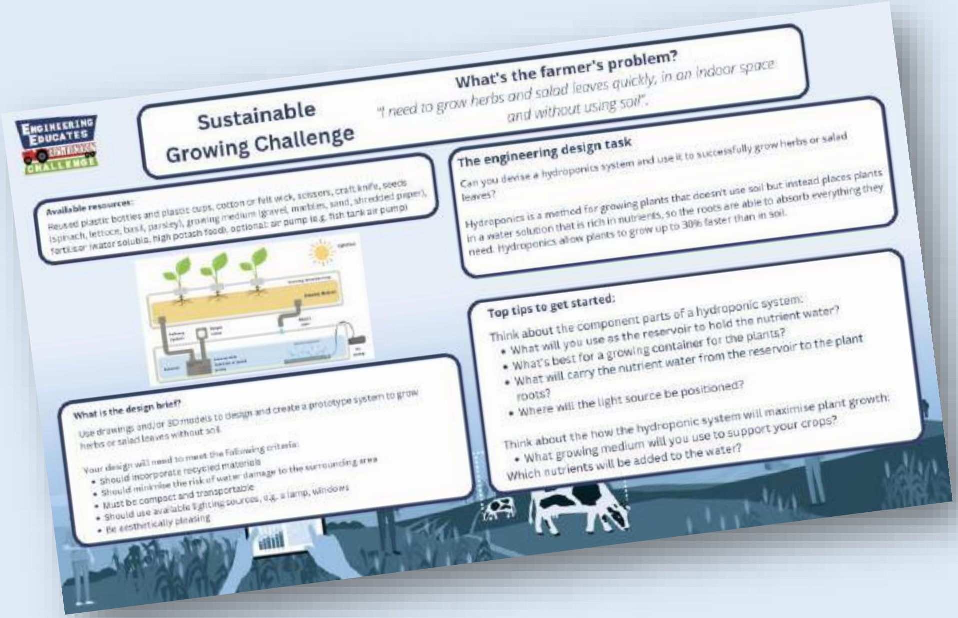


Wick System



Aeroponics System

Sustainable Growing Challenge



Sustainable Growing Challenge

What's the farmer's problem?

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The engineering design task

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- What will you use as the reservoir to hold the nutrient water?
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- Be aesthetically pleasing

Work collaboratively to create a working hydroponic system prototype

Image credit: Spark CBC

In this challenge we have worked like agricultural engineers by **imagining**, **planning** and **creating** a prototype hydroponic system to grow crops indoors.

SUSTAINABLE FARMS

Sustainable Farms - Session 4

What do engineers need to consider when designing large farming machines?

Context:
Learners explore the advantages and disadvantages of using large farm machinery to help with various processes in arable farming. They link some of these advantages and disadvantages to the ongoing theme of sustainability, looking for where greenhouse gas emissions might increase and where they might be reduced. They then focus on one problem - moving large farm machinery around country lanes - and adapt the simple mechanism in a pair of scissors to visualise new ideas to reduce and increase the size of machine attachments for tractors.

Engineering focus:
Learners will be working as an engineer by imagining and planning solutions to problems.

Learning time:
1.5 hours

Suggested age group:
11-14 years old

Keywords
soil compaction
mechanism
machine
machinery
tractor
efficient
emissions
climate
lever
pivot
visualise
adapt

Curriculum links: Design technology
Leaners will:

- Generate, develop, model and communicate their ideas through discussion, annotated sketches, cross-sectional and exploded diagrams and prototypes.
- Evaluate their ideas and products against their own design criteria and consider the views of others to improve their work.

Resources:

- Sustainable farms Session 4 PPT
- Sustainable farms Session 4 -Problem on a page
- Paper and pens
- Modelling resources: Cardboard, split pins, rubber bands, drawing pins, lolly sticks, string, scissor, craft knives and cutting boards
- Optional: Access to tinker CAD

Suggested Activities

1

What are the advantages and disadvantages of using large farm machinery?
Share the video of Claas farm machinery in action so learners observe a range of contemporary large agricultural machines in use (Slide 2).

Ask learners to collaborate in pairs to think about the possible advantages and disadvantages of using large farm machinery - particularly in relation to the ideas of sustainability covered in the previous session. Provide pairs with large paper and markers/post-its to gather and record their ideas.

Allow time for pairs to share their advantages and disadvantages with the group. Compare the learners ideas with some of the advantages and disadvantages listed in Slide 3.

2

How do engineers adapt machinery to make particular jobs more efficient?
Help learners to understand the concept of adapting by sharing different ways in which the tractor has been adapted to solve different problems in farming (Slide 4) - Encourage learners to talk about what problems they think the different adaptations have helped to solve (Compact battery-powered, Track tractors, Orchard Tractors, Remote controlled tractors).

Provide learners with the opportunity to identify the problem of moving large farm machinery around country lanes (slide 5). Learners think of questions to ask to find problems with using large attachments on the farm. They are looking to identify issues with moving large machines around country lanes under bridges etc.

Now they have identified a problem - now it is time to get creative and think of ways to solve the problem. Advantage of large farm machinery: they spend less time driving up and down the field so less fuel is burnt, it is efficient and time saving, the tractor drives over less of the field so there is less compaction of soil. But farms are in the countryside where roads are typically narrow lanes so how can we have a large attachment and get around the farm easily?

3

Focus on a simple mechanism- scissors

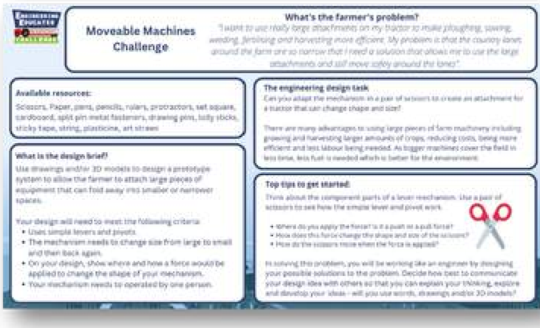
Learners work in teams of 3 or 4 and are challenged to look carefully at the simple mechanism in a pair of scissors. It is a simple lever with a pivot.

- Where do you apply the force?
- How does this affect the scissors? Size? Shape? Movement?

4

Moveable Machines Challenge

As a team the learners imagine and plan how they would adapt this simple scissor mechanism to create an attachment for a tractor that can change size with ease - from super large on the fields for more efficient processes to compact for moving around country lanes and travelling under bridges. Provide teams with the **Problem on a page: Moveable Machines** to set the challenge and provide support (slide 6).



Moveable Machines Challenge

What's the farmer's problem?

"I want to use really large attachments on my tractor to make ploughing, sowing, weeding, fertilising and harvesting more efficient. My problem is that the country lanes around the farm are so narrow that I need a solution that allows me to use the large attachments and still move safely around the lanes."

Available resources:

Scissors, Paper, pens, pencils, rulers, protractors, set square, cardboard, split pin metal fasteners, drawing pins, lolly sticks, sticky tape, string, plasticine, art straws

The engineering design task

Can you adapt the mechanism in a pair of scissors to create an attachment for a tractor that can change shape and size?

There are many advantages to using large pieces of farm machinery including growing and harvesting larger amounts of crops, reducing costs, being more efficient and less labour being needed. As bigger machines cover the field in less time, less fuel is needed which is better for the environment.

What is the design brief?

Use drawings and/or 3D models to design a prototype system to allow the farmer to attach large pieces of equipment that can fold away into smaller or narrower spaces.

Your design will need to meet the following criteria:

- Uses simple levers and pivots.
- The mechanism needs to change size from large to small and then back again.
- On your design, show where and how a force would be applied to change the shape of your mechanism.
- Your mechanism needs to operated by one person.

Top tips to get started:

Think about the component parts of a lever mechanism. Use a pair of scissors to see how the simple lever and pivot work.

- Where do you apply the force? Is it a push or a pull force?
- How does this force change the shape and size of the scissors?
- How do the scissors move when the force is applied?

In solving this problem, you will be working like an engineer by designing your possible solutions to the problem. Decide how best to communicate your design idea with others so that you can explain your thinking, explore and develop your ideas - will you use words, drawings and/or 3D models?

Make resources available for teams to use but allow them to make their own decisions about their design and how they will share their ideas. Slide 7 provides some inspiration on how learners could visualise their design ideas.

5

Share your design ideas

Learners are given a few minutes to present their idea for adapting the scissor mechanism to solve the problem to the rest of the groups. They share their visualisations and answer questions.

The audience are provided with an evaluation tool to make judgements about the success of their peers' suggestion - identifying how the success criteria has been met, strengths of the design idea and suggestions about areas that could be improved (slide 8).

Take some time to reflect on the stages of the Engineering Design Cycle that learners have be working on through this challenge (slide 9).

Take it further

Learners explore contemporary agricultural machines that have been adapted to make different types of farm more efficient, safe and sustainable. The video on slide 10 will support with this showing a range of innovative machines in action on farms.

Moveable Machines Challenge

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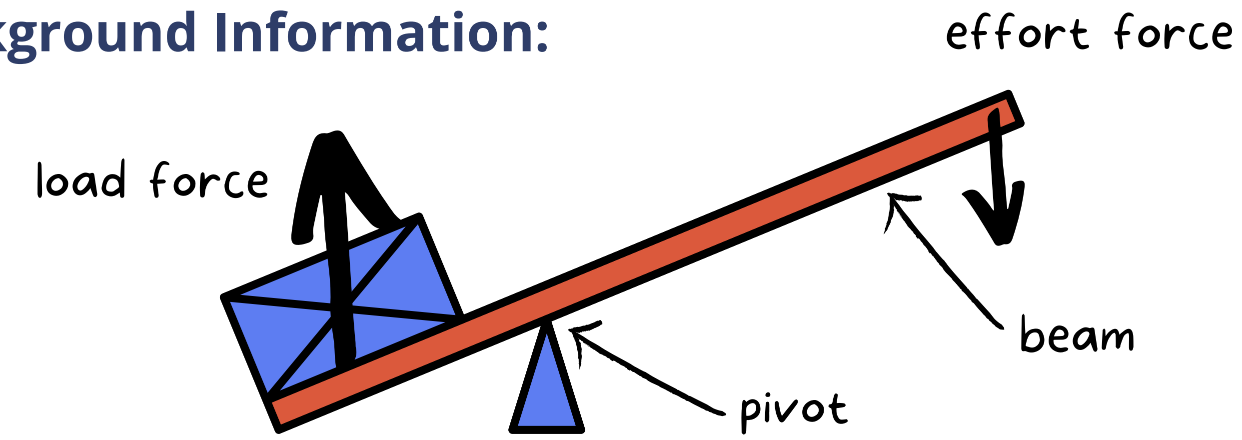
Background Information:



A simple lever mechanism is used in a number of simple machines and toys. Levers consist of a beam or rod pivoted at a fixed pivot. When a load or effort force is applied to the beam or rod it causes the lever to turn about the pivot.

Many common tools include levers. A lever increase the input effort force to produce a larger output force, it is a mechanical advantage device.

Can you identify the pivots on these simple tools?

Levers can be combined in more complex mechanism such as a scissor lift. A scissor lift is a lifting mechanism that has a series of supporting beams under a platform that are hinged with pivot points to produce an assembly that looks like several sets of scissor blade. When the working mechanism pushes the beams together the structure extends, raising the platform vertically.

Glossary:

Mechanism – a system of parts working together in a machine.
Lever – a simple machine with a rigid bar resting on a pivot. They are used to move a load at one side by using effort force applied to the other.
Pivot- a central point around which a mechanism turns.
Visualise- to share ideas by drawing, sketching and talking
Tractor- a vehicle with large rear wheels used mainly on farms for hauling large equipment or farming processes.
Attachment- an extra part or extension
Ploughing- to turn over the soil on a field before planting seeds.
Fertilising- to make soil more fertile by adding nutrients to it.
Sowing- planting seeds by scattering them on the soil.
Harvesting- to gather crops from the fields.

More information and inspiration!

Example Youtube videos to inspire you..

- To learn more about levers and how they work.
- Look at this lift used in a warehouse to move boxes.

Want to take it further?

Why not use CAD software to visualise and communicate your designs in 3D. Tinkercad is free to use and can be accessed HERE.

Watch how Tinkercad can help you HERE.

How well did you do?

Use the problem-solving score card to evaluate how well you performed on this design task.

Success Criteria	Score /5
Your mechanism simple levers and pivots.	
Your mechanism can be reduced in size then returned to its original size.	
You have correctly identified where the force should be applied to operate.	
Can be operated by one person.	

Image credit: Smail

Sustainable Farms - Session 4

What do engineers need to consider when designing large farming machines?

Context:
Learners explore the advantages and disadvantages of using large farm machinery to help with various processes in arable farming. They link some of these advantages and disadvantages to the ongoing theme of sustainability, looking for where greenhouse gas emissions might increase and where they might be reduced. They then focus on one problem - moving large farm machinery around country lanes - and adapt the simple mechanism in a pair of scissors to visualise new ideas to reduce and increase the size of machine attachments for tractors.

Engineering focus:
Learners will be working as an engineer by imagining and planning solutions to problems.

Learning time:
1.5 hours

Suggested age group:
11-14 years old

Curriculum for Excellence links:

Third Level:

I can apply my knowledge and understanding of engineering disciplines and can develop/build solutions to given tasks. TCH 3-12a

I understand how scientific and technological developments have contributed to changes in everyday products. TCH 3-05a

I can create solutions in 3D and 2D and can justify the construction/graphic methods and the design features. TCH 3-09a

I can explore the properties and performance of materials before justifying the most appropriate material for a task. TCH 3-10a

I can apply a range of graphic techniques and standards when producing images using sketching, drawing and software. TCH 3-11a

Scientific analytical thinking skills (see Sciences Benchmarks for further details)

While working through a design process in response to a design brief, I can develop and communicate imaginative design solutions. EXA 3-06a

Fourth Level:

I can solve problems through the application of engineering principles and can discuss the impact engineering has on the world around me. TCH 4-12a

I can analyse products taking into consideration sustainability, scientific and technological developments. TCH 4-05a

I can apply design thinking skills when designing and manufacturing models/products which satisfy the user or client. TCH 4-09a

I consider the material performance as well as sustainability of materials and apply these to real world tasks. TCH 4-10a

I can extend my use of manual and digital graphic techniques to realise ideas, concepts and products and recognise the importance of real world standards. TCH 4-11a

Scientific analytical thinking skills (see Sciences Benchmarks for further details)

By working through a design process in response to a design brief, I can develop and communicate imaginative and original design solutions. EXA 4-06a

Keywords
soil compaction
mechanism
machine
machinery
tractor
efficient
emissions
climate
lever
pivot
visualise
adapt

Resources:

- Sustainable farms Session 4 PPT
- Sustainable farms Session 4 -Problem on a page
- Paper and pens
- Modelling resources: Cardboard, split pins, rubber bands, drawing pins, lolly sticks, string, scissor, craft knives and cutting boards
- Optional: Access to tinker CAD

Suggested Activities

1

What are the advantages and disadvantages of using large farm machinery?

Share the video of Claas farm machinery in action so learners observe a range of contemporary large agricultural machines in use (Slide 2).

Ask learners to collaborate in pairs to think about the possible advantages and disadvantages of using large farm machinery - particularly in relation to the ideas of sustainability covered in the previous session. Provide pairs with large paper and markers/post-its to gather and record their ideas.

Allow time for pairs to share their advantages and disadvantages with the group. Compare the learners ideas with some of the advantages and disadvantages listed in Slide 3.

2

How do engineers adapt machinery to make particular jobs more efficient?

Help learners to understand the concept of adapting by sharing different ways in which the tractor has been adapted to solve different problems in farming (Slide 4) - Encourage learners to talk about what problems they think the different adaptations have helped to solve (Compact battery-powered, Track tractors, Orchard Tractors, Remote controlled tractors).

Provide learners with the opportunity to identify the problem of moving large farm machinery around country lanes (slide 5). Learners think of questions to ask to find problems with using large attachments on the farm. They are looking to identify issues with moving large machines around country lanes under bridges etc.

Now they have identified a problem - now it is time to get creative and think of ways to solve the problem. Advantage of large farm machinery: they spend less time driving up and down the field so less fuel is burnt, it is efficient and time saving, the tractor drives over less of the field so there is less compaction of soil. But farms are in the countryside where roads are typically narrow lanes so how can we have a large attachment and get around the farm easily?

Focus on a simple mechanism- scissors

3

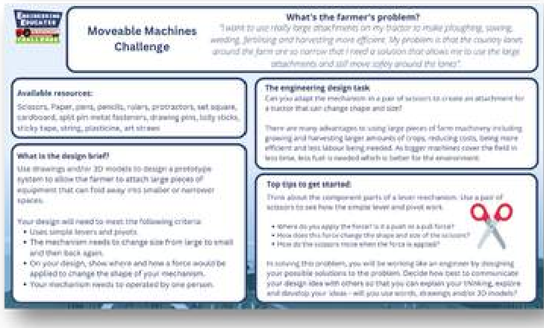
Learners work in teams of 3 or 4 and are challenged to look carefully at the simple mechanism in a pair of scissors. It is a simple lever with a pivot.

- Where do you apply the force?
- How does this affect the scissors? Size? Shape? Movement?

Moveable Machines Challenge

4

As a team the learners imagine and plan how they would adapt this simple scissor mechanism to create an attachment for a tractor that can change size with ease - from super large on the fields for more efficient processes to compact for moving around country lanes and travelling under bridges. Provide teams with the **Problem on a page: Moveable Machines** to set the challenge and provide support (slide 6).


Moveable Machines Challenge

What's the farmer's problem?

"I want to use really large attachments on my tractor to make ploughing, sowing, weeding, fertilising and harvesting more efficient. My problem is that the country lanes around the farm are so narrow that I need a solution that allows me to use the large attachments and still move safely around the lanes"

Available resources:

Scissors, Paper, pens, pencils, rulers, protractors, set square, cardboard, split pin metal fasteners, drawing pins, lolly sticks, sticky tape, string, plasticine, art straws

What is the design brief?

Use drawings and/or 3D models to design a prototype system to allow the farmer to attach large pieces of equipment that can fold away into smaller or narrower spaces.

Your design will need to meet the following criteria:

- Uses simple levers and pivots.
- The mechanism needs to change size from large to small and then back again.
- On your design, show where and how a force would be applied to change the shape of your mechanism.
- Your mechanism needs to operated by one person.

The engineering design task

Can you adapt the mechanism in a pair of scissors to create an attachment for a tractor that can change shape and size?

There are many advantages to using large pieces of farm machinery including growing and harvesting larger amounts of crops, reducing costs, being more efficient and less labour being needed. As bigger machines cover the field in less time, less fuel is needed which is better for the environment.

Top tips to get started:

Think about the component parts of a lever mechanism. Use a pair of scissors to see how the simple lever and pivot work.

- Where do you apply the force? Is it a push or a pull force?
- How does this force change the shape and size of the scissors?
- How do the scissors move when the force is applied?

In solving this problem, you will be working like an engineer by designing your possible solutions to the problem. Decide how best to communicate your design idea with others so that you can explain your thinking, explore and develop your ideas - will you use words, drawings and/or 3D models?

Make resources available for teams to use but allow them to make their own decisions about their design and how they will share their ideas. Slide 7 provides some inspiration on how learners could visualise their design ideas.

Share your design ideas

5

Learners are given a few minutes to present their idea for adapting the scissor mechanism to solve the problem to the rest of the groups. They share their visualisations and answer questions.

The audience are provided with an evaluation tool to make judgements about the success of their peers' suggestion - identifying how the success criteria has been met, strengths of the design idea and suggestions about areas that could be improved (slide 8).

Take some time to reflect on the stages of the Engineering Design Cycle that learners have be working on through this challenge (slide 9).

Take it further

Learners explore contemporary agricultural machines that have been adapted to make different types of farm more efficient, safe and sustainable. The video on slide 10 will support with this showing a range of innovative machines in action on farms.

Moveable Machines Challenge

What's the farmer's problem?

"I want to use really large attachments on my tractor to make ploughing, sowing, weeding, fertilising and harvesting more efficient. My problem is that the country lanes around the farm are so narrow that I need a solution that allows me to use the large attachments and still move safely around the lanes".

Available resources:

Scissors, Paper, pens, pencils, rulers, protractors, set square, cardboard, split pin metal fasteners, drawing pins, lolly sticks, sticky tape, string, plasticine, art straws

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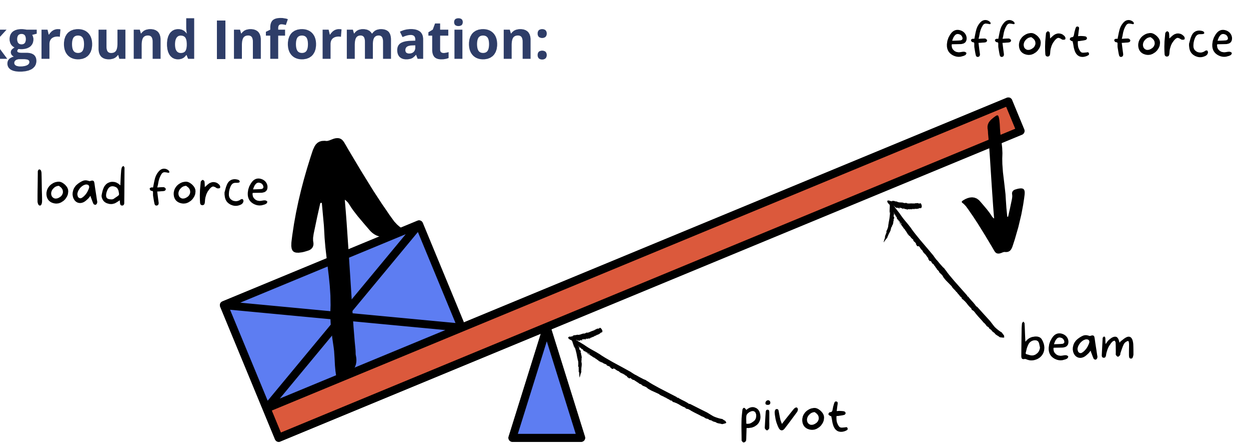
Top tips to get started:

Think about the component parts of a lever mechanism. Use a pair of scissors to see how the simple lever and pivot work.

- Where do you apply the force? Is it a push or a pull force?
- How does this force change the shape and size of the scissors?
- How do the scissors move when the force is applied?

In solving this problem, you will be working like an engineer by designing your possible solutions to the problem. Decide how best to communicate your design idea with others so that you can explain your thinking, explore and develop your ideas - will you use words, drawings and/or 3D models?

Background Information:



A simple lever mechanism is used in a number of simple machines and toys. Levers consist of a beam or rod pivoted at a fixed pivot. When a load or effort force is applied to the beam or rod it causes the lever to turn about the pivot.

Many common tools include levers. A lever increase the input effort force to produce a larger output force, it is a mechanical advantage device.

Can you identify the pivots on these simple tools?

Levers can be combined in more complex mechanism such as a scissor lift. A scissor lift is a lifting mechanism that has a series of supporting beams under a platform that are hinged with pivot points to produce an assembly that looks like several sets of scissor blade. When the working mechanism pushes the beams together the structure extends, raising the platform vertically.

Glossary:

Mechanism – a system of parts working together in a machine.
Lever – a simple machine with a rigid bar resting on a pivot. They are used to move a load at one side by using effort force applied to the other.
Pivot- a central point around which a mechanism turns.
Visualise- to share ideas by drawing, sketching and talking
Tractor- a vehicle with large rear wheels used mainly on farms for hauling large equipment or farming processes.
Attachment- an extra part or extension
Ploughing- to turn over the soil on a field before planting seeds.
Fertilising- to make soil more fertile by adding nutrients to it.
Sowing- planting seeds by scattering them on the soil.
Harvesting- to gather crops from the fields.

More information and inspiration!

Example Youtube videos to inspire you..

- To learn more about levers and how they work.
- Look at this lift used in a warehouse to move boxes.

Want to take it further?

Why not use CAD software to visualise and communicate your designs in 3D. Tinkercad is free to use and can be accessed HERE.

Watch how Tinkercad can help you HERE.

How well did you do?

Use the problem-solving score card to evaluate how well you performed on this design task.

Success Criteria	Score /5
Your mechanism simple levers and pivots.	
Your mechanism can be reduced in size then returned to its original size.	
You have correctly identified where the force should be applied to operate.	
Can be operated by one person.	

Image credit: Smail

SESSION 4

What do engineers need to consider when designing new farm machinery?

Look at this large farm machinery in action.

Thinking about sustainable farming make a list of the advantages and disadvantages of using larger farm machinery.

https://www.youtube.com/watch?v=cKOfOg4ptGI

Video credit: Norbert Schindhelm

Did you get any of these advantages or disadvantages?

Easy to grow and harvest larger amounts of crops which increases income for farmers.

Working on a big scale produces larger amounts of food for growing populations.

Food grown on a large scale will lower the cost of produce for the customers.

Less fuel required (bigger kit operates more efficiently and covers the field in less time).

More efficient and less labour needed

Soil compaction.

Massive cost of machinery to farmers.

Use of fuels adding to greenhouse gases.

Employing less people affects jobs in agriculture.

Creating larger fields would lead to the destruction of hedgerows (ecosystems).

Engineers have adapted the tractor

Look at these examples of agricultural engineers adapting the tractor to solve different problems.

Modern farmers have a huge range of equipment options for the various activities they do throughout the year.

The ultimate farming machine is undoubtedly the tractor, which comes in a range of sizes to suit any farming operation.

There are several different tractor types that have been adapted for different purposes.

Compact battery-powered tractors

Track tractors

Orchard tractors

Remote-controlled tractors

Photo credit: Kubota/Scott Garvey/Case IH/Lamma

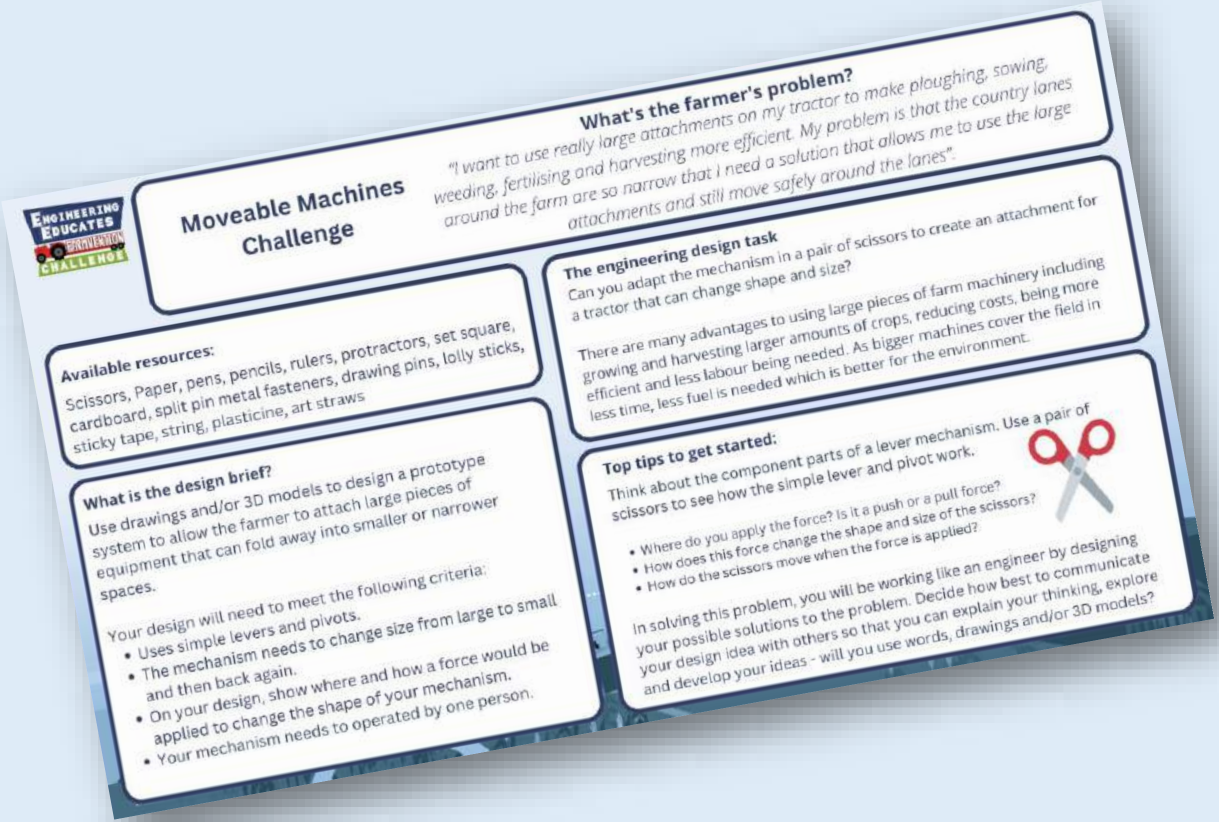
Can you spot any problems with large farm machines and UK roadways?

Tractors can have attachments added to:

- Plough
- Till
- Fertilise
- Sow
- Irrigate
- Harvest

Photo credit: Agriland/Tony Atkin

Moveable Machines Challenge



Moveable Machines Challenge

What's the farmer's problem?

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Available resources:
Scissors, Paper, pens, pencils, rulers, protractors, set square, cardboard, split pin metal fasteners, drawing pins, lolly sticks, sticky tape, string, plasticine, art straws

The engineering design task
Can you adapt the mechanism in a pair of scissors to create an attachment for a tractor that can change shape and size?

There are many advantages to using large pieces of farm machinery including growing and harvesting larger amounts of crops, reducing costs, being more efficient and less labour being needed. As bigger machines cover the field in less time, less fuel is needed which is better for the environment.

What is the design brief?
Use drawings and/or 3D models to design a prototype system to allow the farmer to attach large pieces of equipment that can fold away into smaller or narrower spaces.

Your design will need to meet the following criteria:
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Top tips to get started:
Think about the component parts of a lever mechanism. Use a pair of scissors to see how the simple lever and pivot work.
- Where do you apply the force? Is it a push or a pull force?
- How does this force change the shape and size of the scissors?
- How do the scissors move when the force is applied?

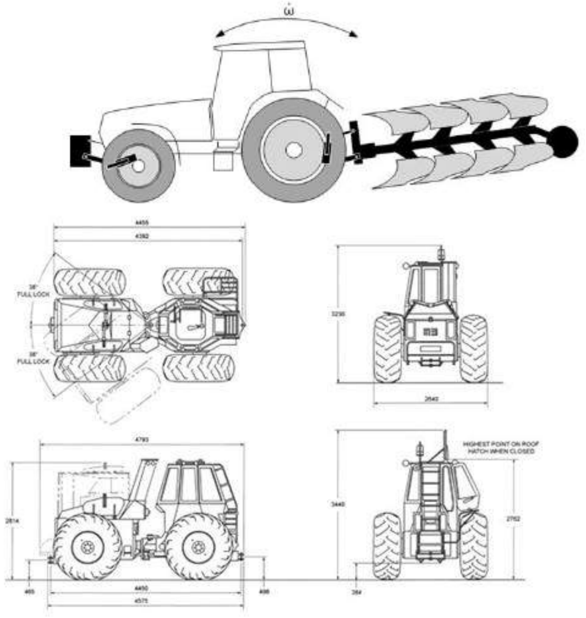
In solving this problem, you will be working like an engineer by designing your possible solutions to the problem. Decide how best to communicate your design idea with others so that you can explain your thinking, explore and develop your ideas - will you use words, drawings and/or 3D models?

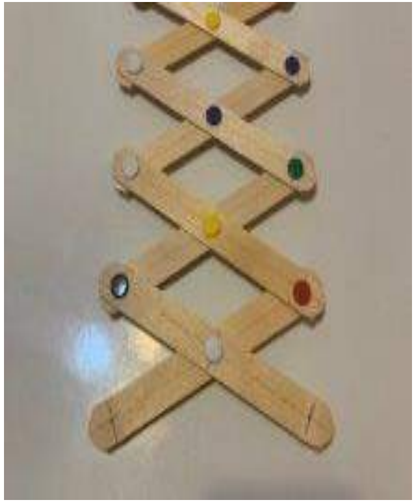
Adapt the mechanism in a pair of scissors to design an attachment to add to a tractor that would enable it to change shape and size to fit on country lanes and under small narrow bridges.

Visualise your design ideas

Using drawings and diagrams

Using 3D models





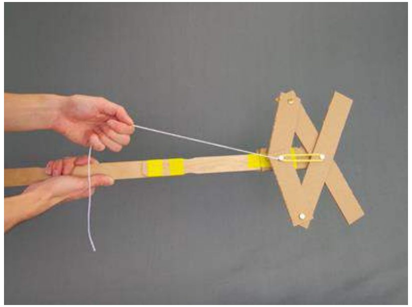


Photo credit: Thomas Langer/Clayton Engineering/Backworth Park/White Plains/Instructables

Share your design ideas

You have 3 minutes to present your adaptation idea to the group using your visualisations to share your thinking with the audience.

Be ready to answer questions about your idea.

Success Criteria	Score /5
Your mechanism simple levers and pivots.	
Your mechanism can be reduced in size then returned to its original size.	
You have correctly identified where the force should be applied to operate.	
Can be operated by one person.	

In this challenge we have worked like agricultural engineers by **imagining**, **planning** and **creating** a prototype attachment for a tractor that can easily change size.

Look how these amazing agricultural machines have been adapted to make different types of farm more efficient and sustainable: https://www.youtube.com/watch?v=97JZMrnRnYM

Video credit: Quantum Tech HD

SUSTAINABLE FARMS

Sustainable Farms - Session 5

How could farming benefit from automation?

Context:
Learners create a program on the micro:bit which logs data about the environment for growing plants, specifically the temperature. The learners focus on how data like this can be used to provide information about the environmental conditions on a farm, to support farmers to make decisions, or automate parts of the farming processes - e.g. switching on irrigation systems during periods of warm weather.

Engineering focus:
Learners will be working as an engineer by improving solutions to farming problems with the use of technology.

Learning time:
1.5 hours

Suggested age group:
11-14 years old

Keywords
automation
sensors
Micro:bit
program
code
debug
controlling systems
monitoring systems
environment
conditions
thermometer
data logger
temperature sensor

Curriculum links: Computing
Learners will:

- solve a variety of computational problems; make appropriate use of data structures [for example, lists, tables or arrays.

Resources:

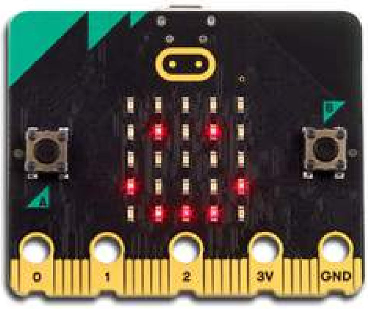
- Note - this lesson uses features exclusive to the V2 micro:bits. However if you have V1 micro:bits, or indeed don't have micro:bits at all, you can still complete this lesson using the online simulator at https://makecode.microbit.org/
- computer with access to the internet for MakeCode
- micro:bits V2 (or micro:bit simulator at MakeCode

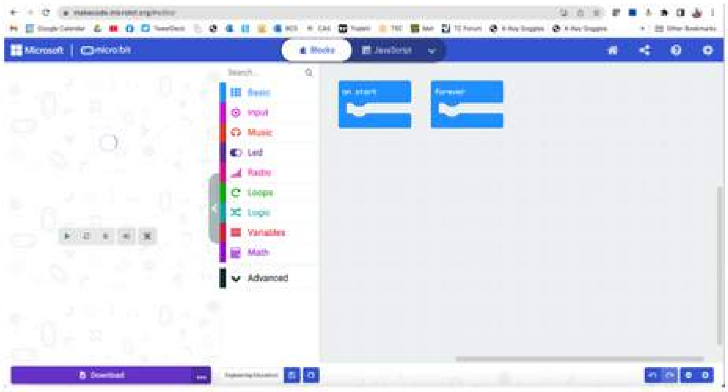
Suggested Activities

1

Display images of a micro:bit and the MakeCode editor, such as those shown below (slide 2). Lead a discussion with Learners:

- Have learners used the micro:bit before? If so, what did they create and how did they create this?
- Have learners used the MakeCode editor before? What does the MakeCode editor remind learners of? Why do they think this? (Make code looks and functions in a similar manner to Scratch - it is a graphical programming language)
- If learners haven't used MakeCode before, but have used Scratch, lead a discussion on what they have previously created in Scratch. How did they create and run these programs?





2

Setting the context:

Show the photo shown (slide 3). What do Learners think this is a photo of? Why do they think this? What might have happened to the plants in the photo? What could have caused this?

Lead a discussion to conclude this is a photo of plants (sunflowers) which have died as a result of not receiving enough water during hot weather. This could be due to extended periods of sunshine without rain.

3

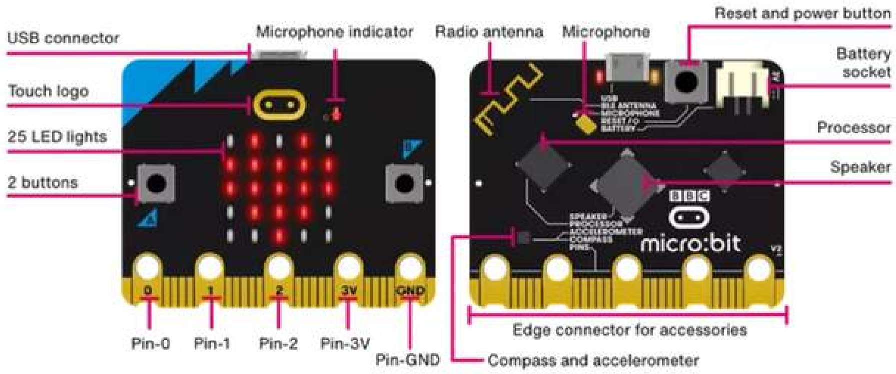
Introducing the challenge:

Explain that in this unit, learners will build a prototype digital device to automatically monitor temperatures on a field to help farmers decide if extra water is required and hopefully prevent crops from dying. Add that as an extension, learners will consider how to add additional code to automate the process of providing additional water.

Model the Micro:bit:

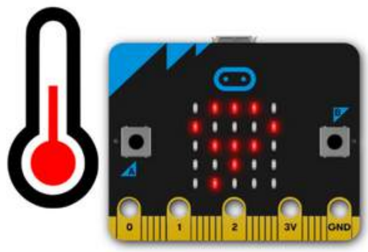
4

Explain to learners that we will be using the micro:bit to prototype our solutions. Add that we will first explore how these work by exploring some simple code (slide 4).



Hand the Micro:bits out to learners. Can learners find the thermometer on the micro:bit which we can use to measure temperature? Note - This is a trick question as learners won't be able to see it - it is located inside the processor!

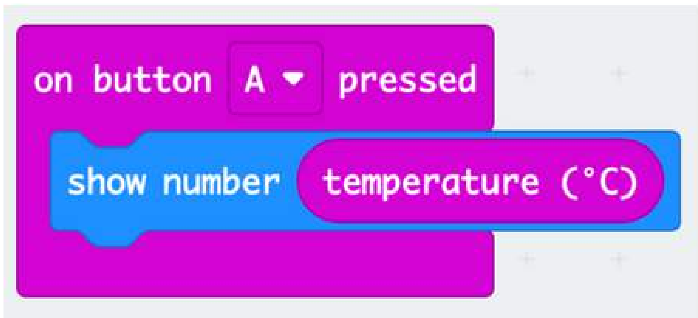
The micro:bit uses the digital thermometer to measure the temperature of the micro:bit's processor, but we can also use it to get a fairly accurate measurement of the temperature around the micro:bit (slide 5).



Code Exploration Part 1 - A simple temperature sensor

5

Explain to learners they will be adding the following code to their micro:bits. Before doing so, what do learners predict the code will do when run? Why do they think this? Can they talk through the code with a partner to help their predictions? (Slide 6)



Code Exploration Part 1 Cont.

6

Ask learners to add the code to their micro:bit and run it. Were their predictions correct? Did anything surprise them? When this code is run, pressing the button A will cause the micro:bit to display the temperature value it measures on the screen of LEDs.

Explore the following questions as a class:

- Could this simple device be used to keep track of the temperature on a field?
- What are the problems with this device so far?
- How could we improve it?

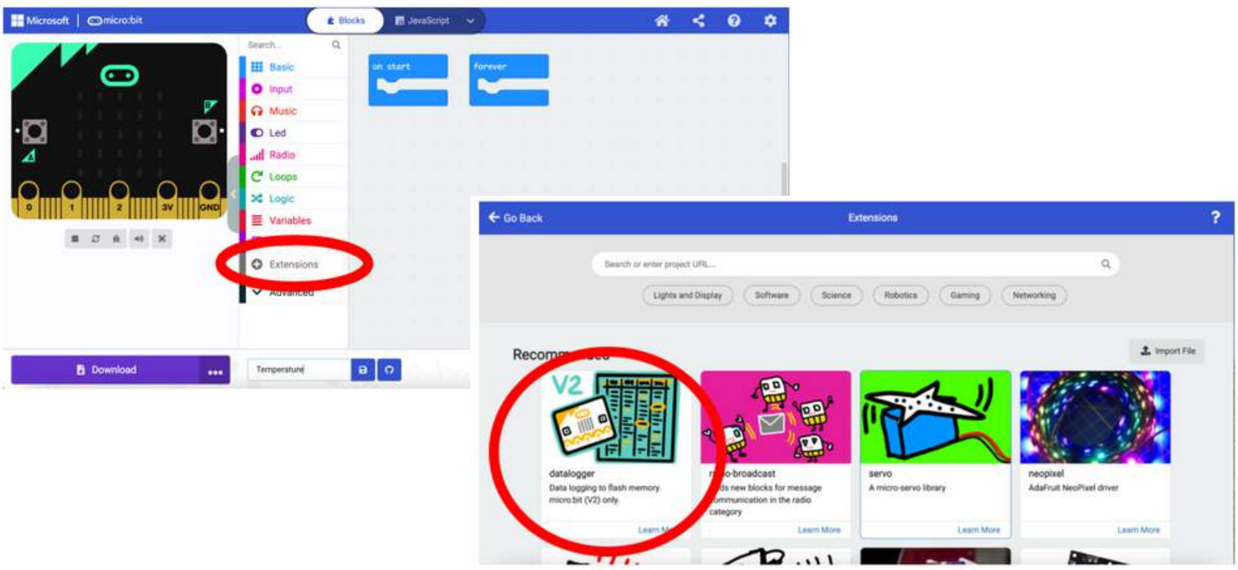
Lead a discussion to conclude that it would be impractical for someone to have to walk to temperature sensors across different fields to push the button and take a measurement - plus this would then have to be recorded somewhere!

We could improve the device if it automatically measured the temperature AND recorded this for us. Explain that the micro:bit is capable of this using its data logger extension which we will explore now.

Code Exploration Part 2 - Collecting data over time

7

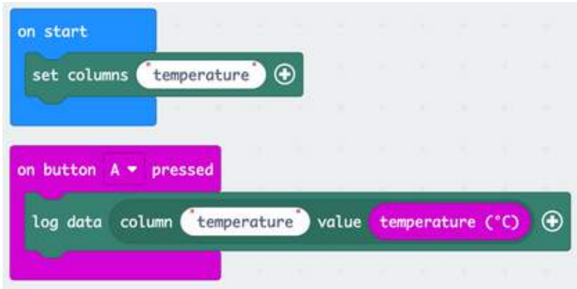
Show learners how to activate the data logger extension commands by selection 'extension' and 'data logger' (slide 8 and 9) as shown below:



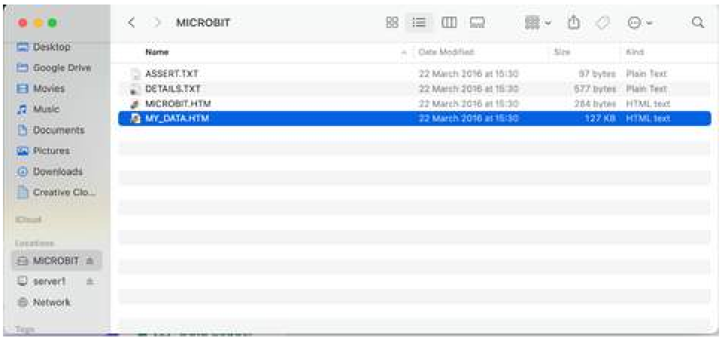
Code Exploration Part 2 cont.

Display the code below which uses a selection of the 'data logging' commands. Can Learners predict what the code will do when run? Why do they think this? Note - a full explanation of this code is shared in the following 'Explain' section (slide 9).

Ask learners to add the code to their micro:bits and then press button A several times.

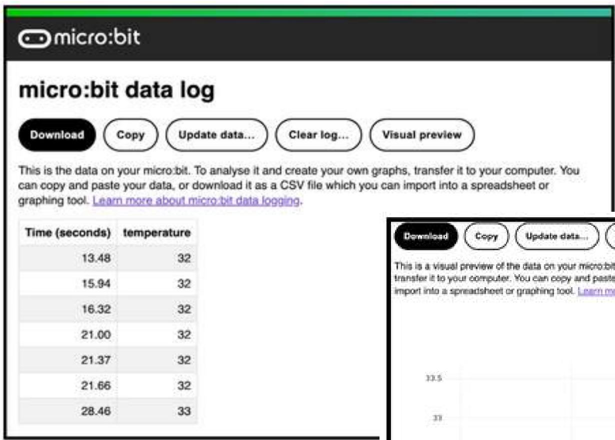


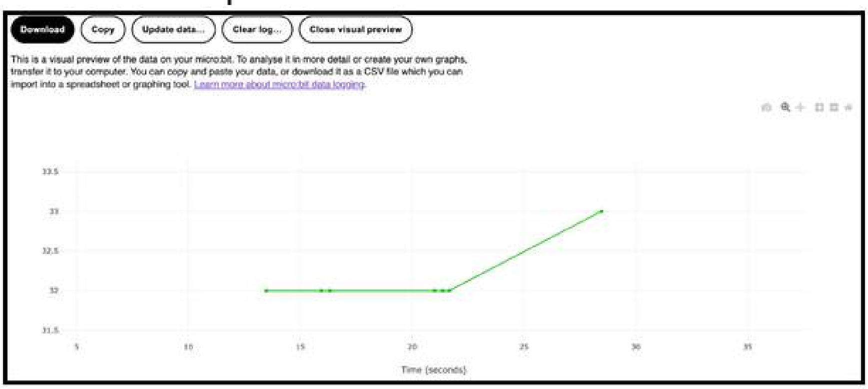
7



Ask learners to now reconnect their micro:bit to their computer, and click on 'My Data' (slide 10).

They will now see the temperature which was measured and stored every time they clicked button A, as shown below. The time stored relates to how long has elapsed after the program was loaded onto the micro:bit before the button is pressed (slide 11 and 12).



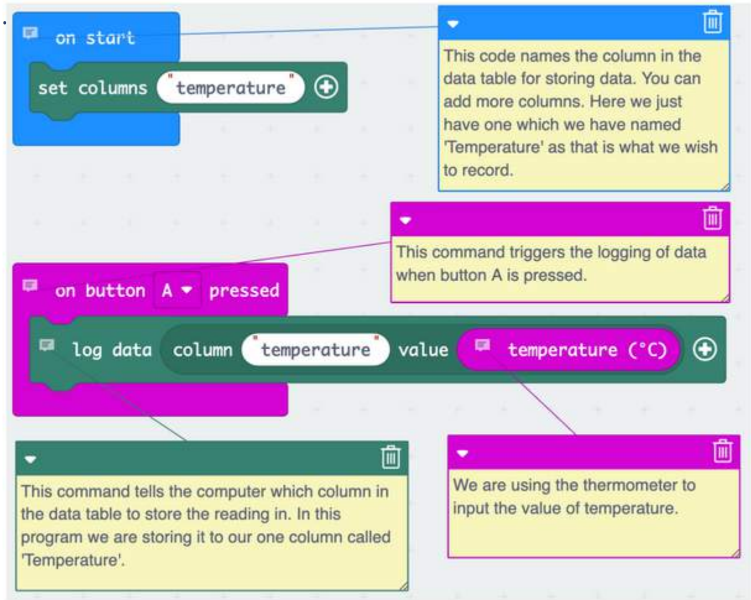


8

Summarise learning

We have now shown how the micro:bit can store temperature data for us, but so far our solution still requires us to manually press the button A to take a reading. Remind learners that our ideal solution would do this automatically for us, which is the challenge they are about to tackle (slide 13).

But first, if required, recap the function of each element of code in our last exploration to consolidate learners' understanding. Explanations appear below in the form of code comments.

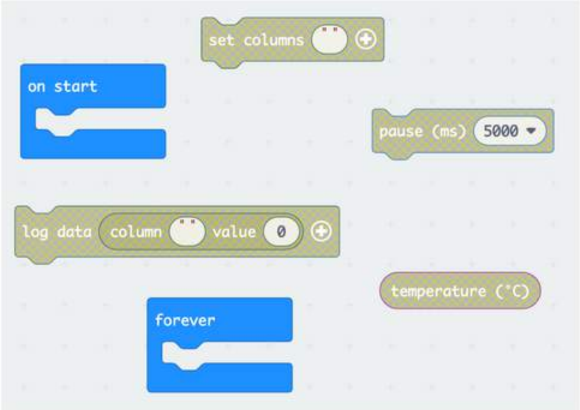


9

Parson's Problem

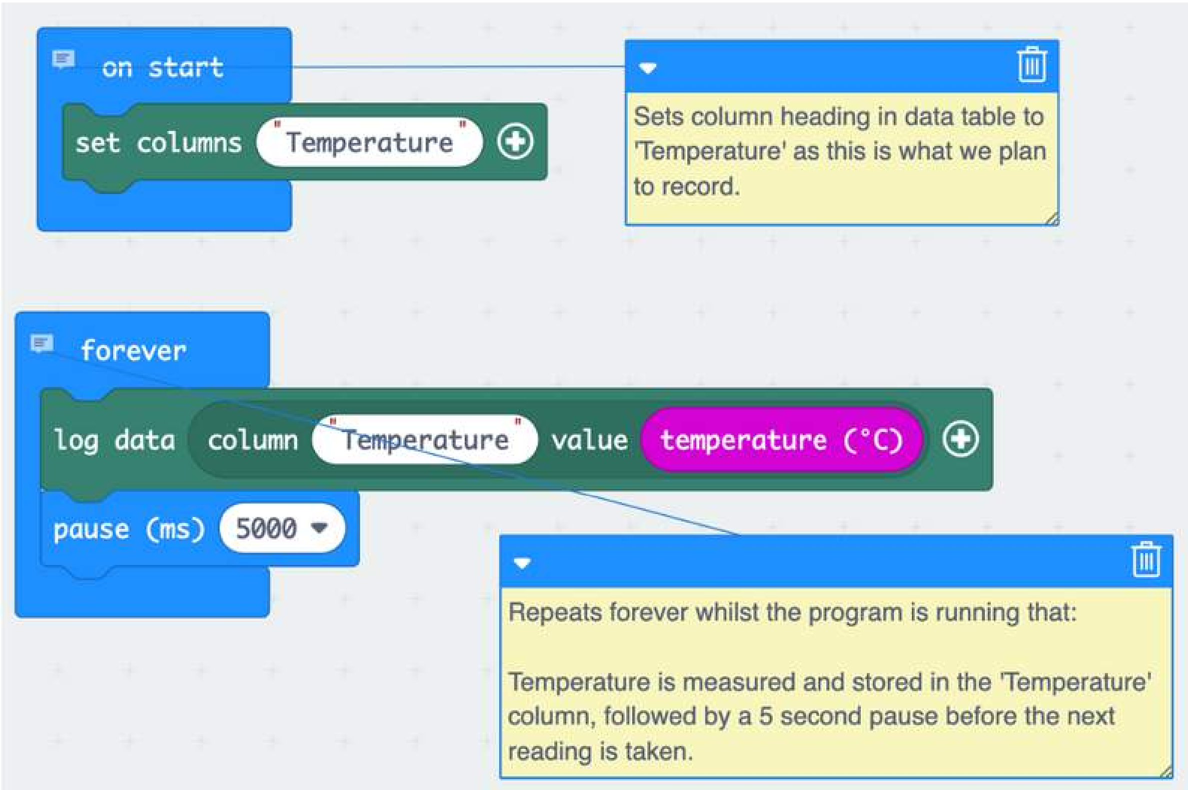
A Parson's problem scaffolds programming tasks by providing learners all the code they need to complete a problem but doesn't show how the code should be combined (slide 14).

Ask learners to add the following commands to their micro:bit project and task them to combine the code to complete our challenge. I.e. When the program is run, it automatically measures and stores temperature data for us at regular intervals.



10

Solution with comments (slide 15)



11

Evaluate

Lead a discussion with learners to evaluate the success of their program. Did their program:

- Automatically log the temperature at set time intervals?
- Store the temperatures measured so these could be viewed at a later date and used to decide if additional water was required for crops?

Discuss with learners whether they encountered any bugs in their program - what were these and how did they remove them?

reflect on how learners have been working as agricultural engineers in this challenge (slide 16).

Further links:

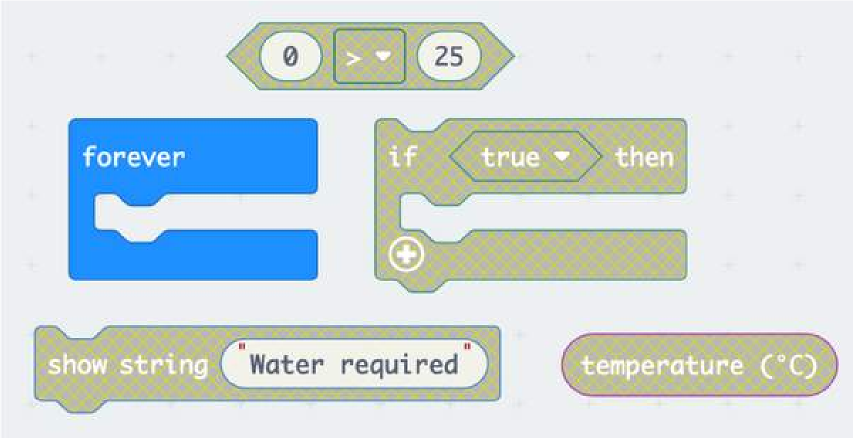
- Micro:bit Education Foundation https://microbit.org/
- Information about the new (2022) micro:bit V2 https://microbit.org/new-microbit/

Information about data logging using the micro:bit https://microbit.org/get-started/user-guide/data-logging/

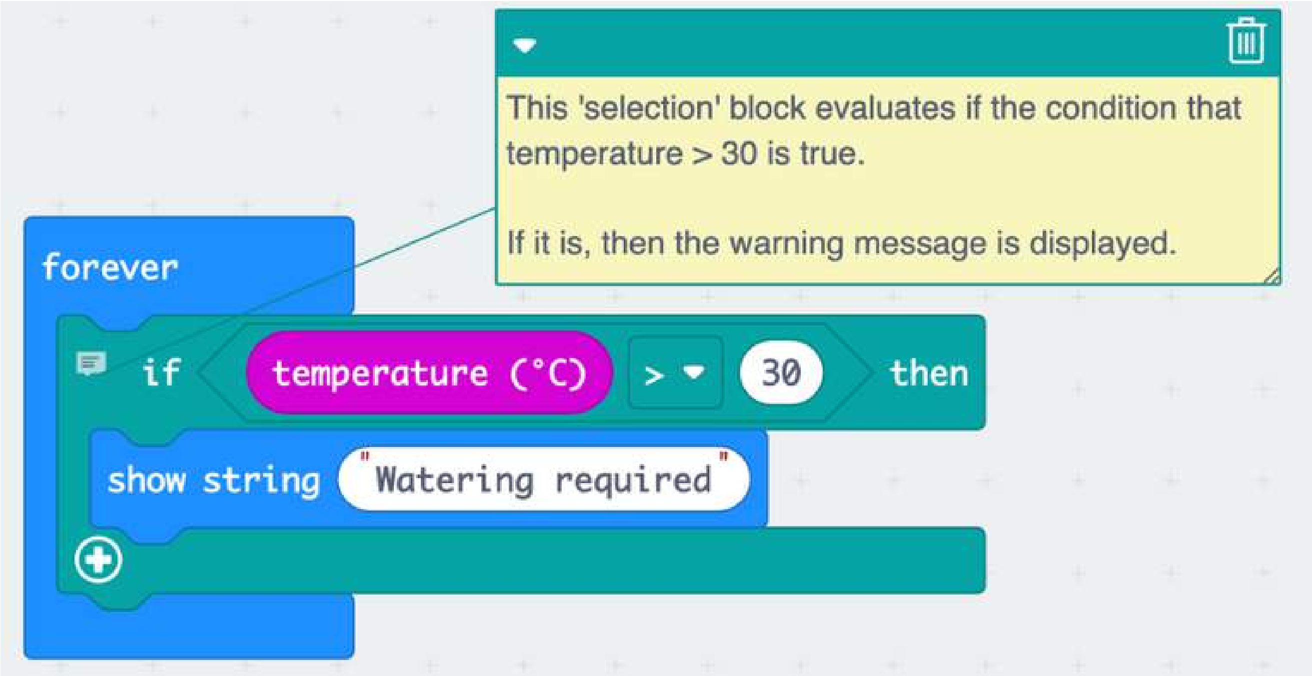
Take it further

Improve
In the introduction to this resource, we mentioned the idea of a device not only measuring and storing temperature, but also triggering the flow of water if temperatures were excessive (slide 17).

As an extension challenge, can learners combine the following code (and add it to their existing program), to prototype the idea that when a certain excessively high temperature is reached, i.e. 30 degrees, the micro:bit automatically displays a message warning 'Watering required' - simulating the triggering of a watering system being activated?



Solution with comments (slide 18)



Sustainable Farms - Session 5

How could farming benefit from automation?

Context:
Learners create a program on the micro:bit which logs data about the environment for growing plants, specifically the temperature. The learners focus on how data like this can be used to provide information about the environmental conditions on a farm, to support farmers to make decisions, or automate parts of the farming processes - e.g. switching on irrigation systems during periods of warm weather.

Engineering focus:
Learners will be working as an engineer by improving solutions to farming problems with the use of technology.

Learning time:
1.5 hours

Suggested age group:
11-14 years old

Curriculum for Excellence links:

Third Level:
I can apply my knowledge and understanding of engineering disciplines and can develop/build solutions to given tasks. TCH 3-12a
I can select appropriate development tools to design, build, evaluate and refine computing solutions based on requirements TCH 3-15a
Fourth Level:
I can solve problems through the application of engineering principles and can discuss the impact engineering has on the world around me. TCH 4-12a
I can select appropriate development tools to design, build, evaluate and refine computing solutions to process and present information whilst making reasoned arguments to justify my decisions. TCH 4-15a

Keywords
automation
sensors
Micro:bit
program
code
debug
controlling systems
monitoring systems
environment
conditions
thermometer
data logger
temperature sensor

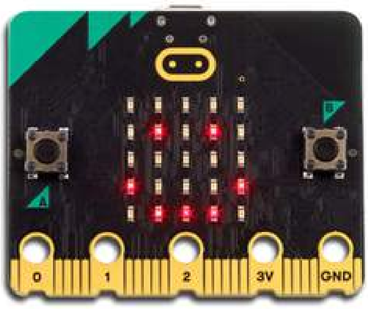
Resources:
- Note - this lesson uses features exclusive to the V2 micro:bits. However if you have V1 micro:bits, or indeed don't have micro:bits at all, you can still complete this lesson using the online simulator at https://makecode.microbit.org/
- computer with access to the internet for MakeCode
- micro:bits V2 (or micro:bit simulator at MakeCode

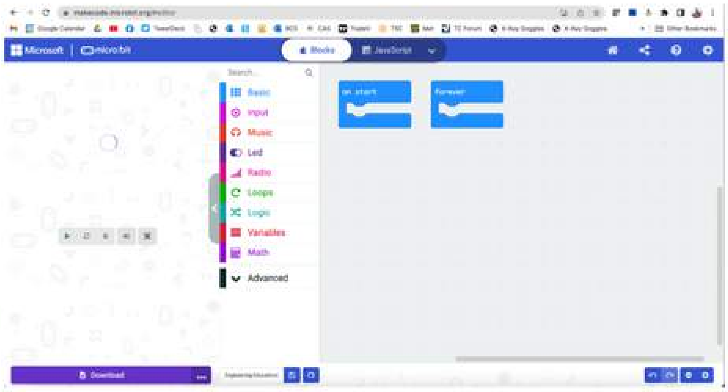
Suggested Activities

1

Display images of a micro:bit and the MakeCode editor, such as those shown below (slide 2). Lead a discussion with Learners:

- Have learners used the micro:bit before? If so, what did they create and how did they create this?
- Have learners used the MakeCode editor before? What does the MakeCode editor remind learners of? Why do they think this? (Make code looks and functions in a similar manner to Scratch - it is a graphical programming language)
- If learners haven't used MakeCode before, but have used Scratch, lead a discussion on what they have previously created in Scratch. How did they create and run these programs?





2

Setting the context:
Show the photo shown (slide 3). What do Learners think this is a photo of? Why do they think this? What might have happened to the plants in the photo? What could have caused this?
Lead a discussion to conclude this is a photo of plants (sunflowers) which have died as a result of not receiving enough water during hot weather. This could be due to extended periods of sunshine without rain.

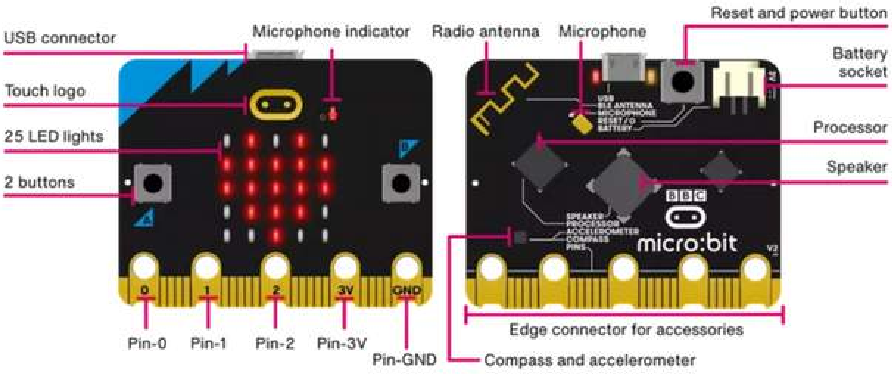
3

Introducing the challenge:
Explain that in this unit, learners will build a prototype digital device to automatically monitor temperatures on a field to help farmers decide if extra water is required and hopefully prevent crops from dying. Add that as an extension, learners will consider how to add additional code to automate the process of providing additional water.

4

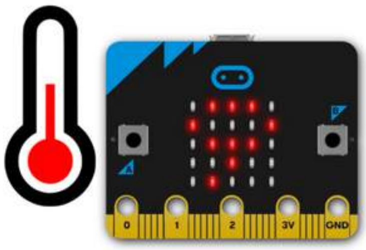
Model the Micro:bit:

Explain to learners that we will be using the micro:bit to prototype our solutions. Add that we will first explore how these work by exploring some simple code (slide 4).



Hand the Micro:bits out to learners. Can learners find the thermometer on the micro:bit which we can use to measure temperature? Note - This is a trick question as learners won't be able to see it - it is located inside the processor!

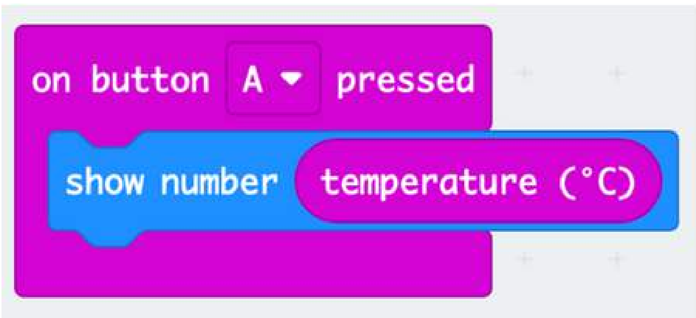
The micro:bit uses the digital thermometer to measure the temperature of the micro:bit's processor, but we can also use it to get a fairly accurate measurement of the temperature around the micro:bit (slide 5).



5

Code Exploration Part 1 - A simple temperature sensor

Explain to learners they will be adding the following code to their micro:bits. Before doing so, what do learners predict the code will do when run? Why do they think this? Can they talk through the code with a partner to help their predictions? (Slide 6)



Code Exploration Part 1 Cont.

6

Ask learners to add the code to their micro:bit and run it. Were their predictions correct? Did anything surprise them? When this code is run, pressing the button A will cause the micro:bit to display the temperature value it measures on the screen of LEDs.

Explore the following questions as a class:

- Could this simple device be used to keep track of the temperature on a field?
- What are the problems with this device so far?
- How could we improve it?

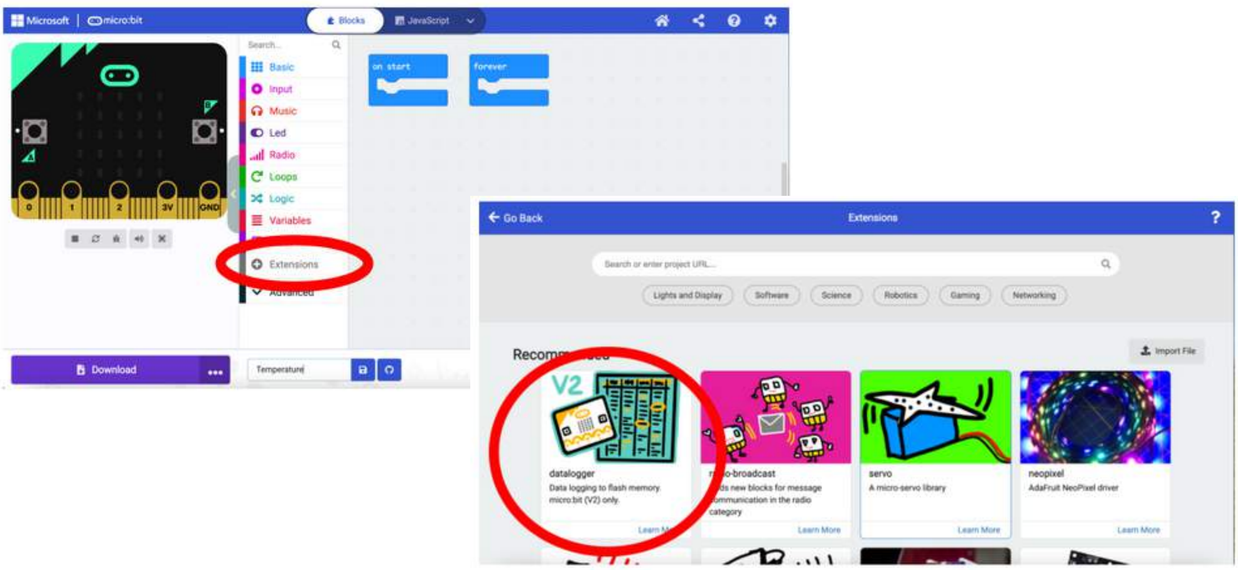
Lead a discussion to conclude that it would be impractical for someone to have to walk to temperature sensors across different fields to push the button and take a measurement - plus this would then have to be recorded somewhere!

We could improve the device if it automatically measured the temperature AND recorded this for us. Explain that the micro:bit is capable of this using its data logger extension which we will explore now.

Code Exploration Part 2 - Collecting data over time

7

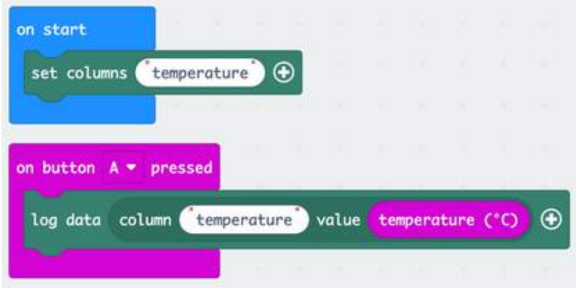
Show learners how to activate the data logger extension commands by selection 'extension' and 'data logger' (slide 8 and 9) as shown below:

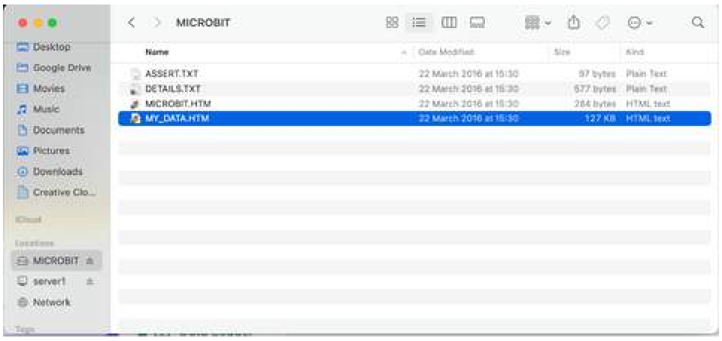


Code Exploration Part 2 cont.

Display the code below which uses a selection of the 'data logging' commands. Can Learners predict what the code will do when run? Why do they think this? Note - a full explanation of this code is shared in the following 'Explain' section (slide 9).

Ask learners to add the code to their micro:bits and then press button A several times.

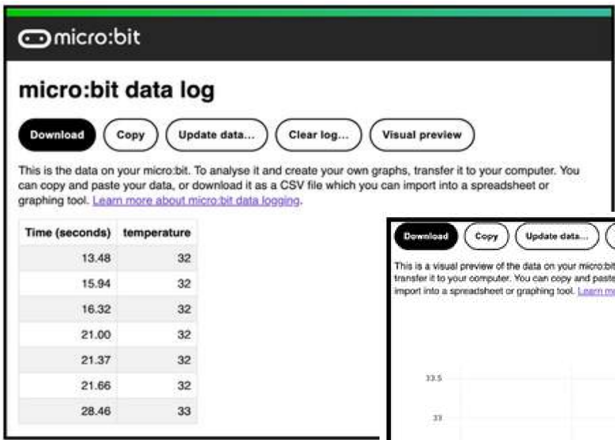




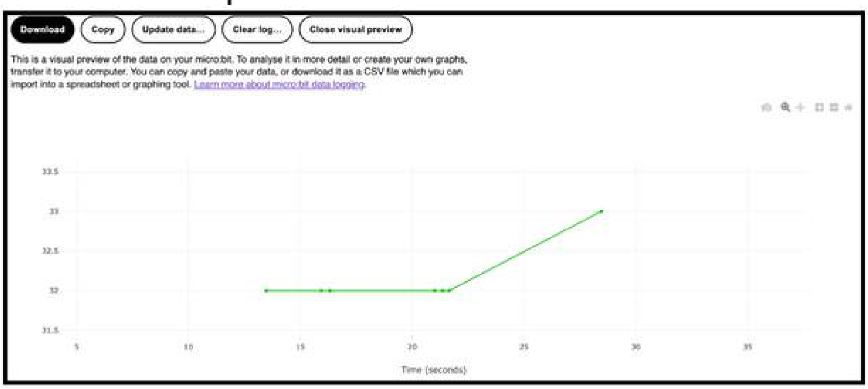
Ask learners to now reconnect their micro:bit to their computer, and click on 'My Data' (slide 10).

7

They will now see the temperature which was measured and stored every time they clicked button A, as shown below. The time stored relates to how long has elapsed after the program was loaded onto the micro:bit before the button is pressed (slide 11 and 12).



Time (seconds)	temperature
13.48	32
15.94	32
16.32	32
21.00	32
21.37	32
21.66	32
28.46	33



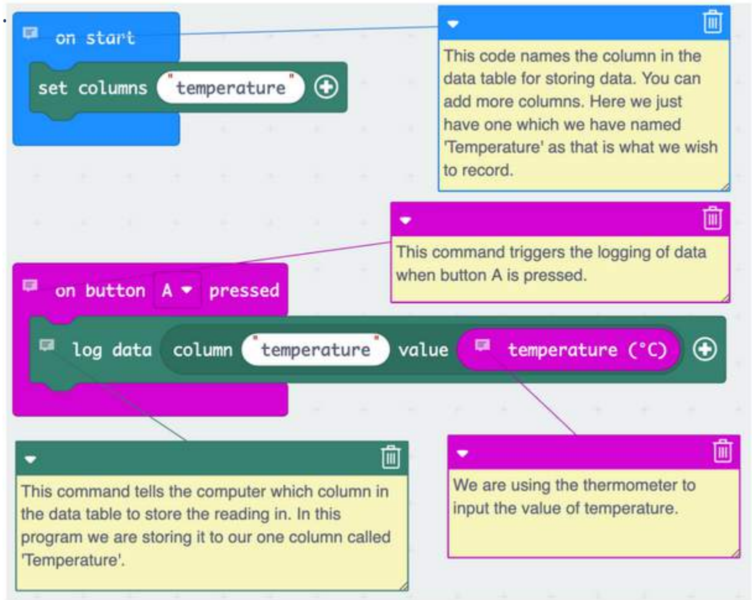
Engineering Educates Farmvention Challenge

8

Summarise learning

We have now shown how the micro:bit can store temperature data for us, but so far our solution still requires us to manually press the button A to take a reading. Remind learners that our ideal solution would do this automatically for us, which is the challenge they are about to tackle (slide 13).

But first, if required, recap the function of each element of code in our last exploration to consolidate learners' understanding. Explanations appear below in the form of code comments.

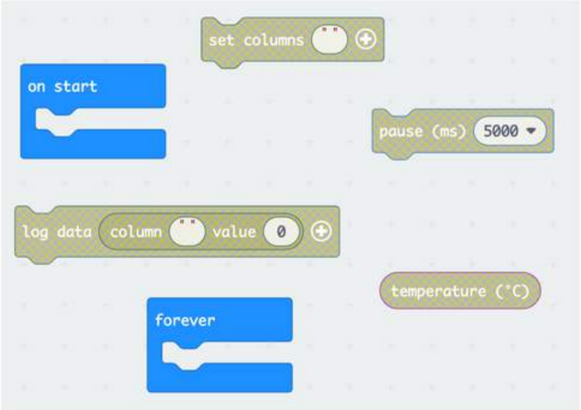


9

Parson's Problem

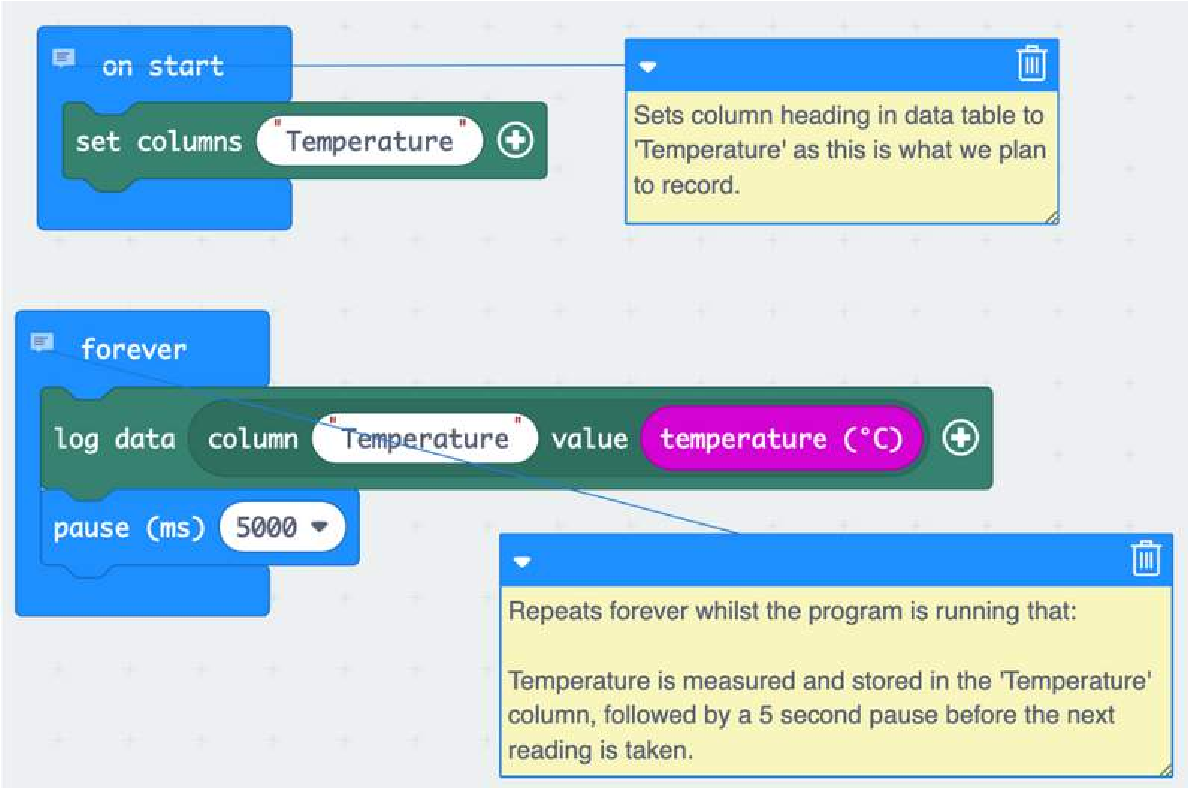
A Parson's problem scaffolds programming tasks by providing learners all the code they need to complete a problem but doesn't show how the code should be combined (slide 14).

Ask learners to add the following commands to their micro:bit project and task them to combine the code to complete our challenge. I.e. When the program is run, it automatically measures and stores temperature data for us at regular intervals.



10

Solution with comments (slide 15)



11

Evaluate

Lead a discussion with learners to evaluate the success of their program. Did their program:

- Automatically log the temperature at set time intervals?
- Store the temperatures measured so these could be viewed at a later date and used to decide if additional water was required for crops?

Discuss with learners whether they encountered any bugs in their program - what were these and how did they remove them?

reflect on how learners have been working as agricultural engineers in this challenge (slide 16).

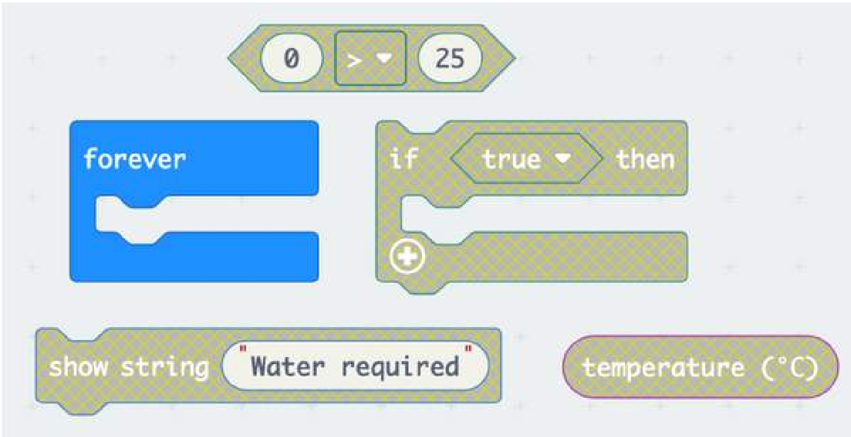
Further links:

- Micro:bit Education Foundation https://microbit.org/
- Information about the new (2022) micro:bit V2 https://microbit.org/new-microbit/

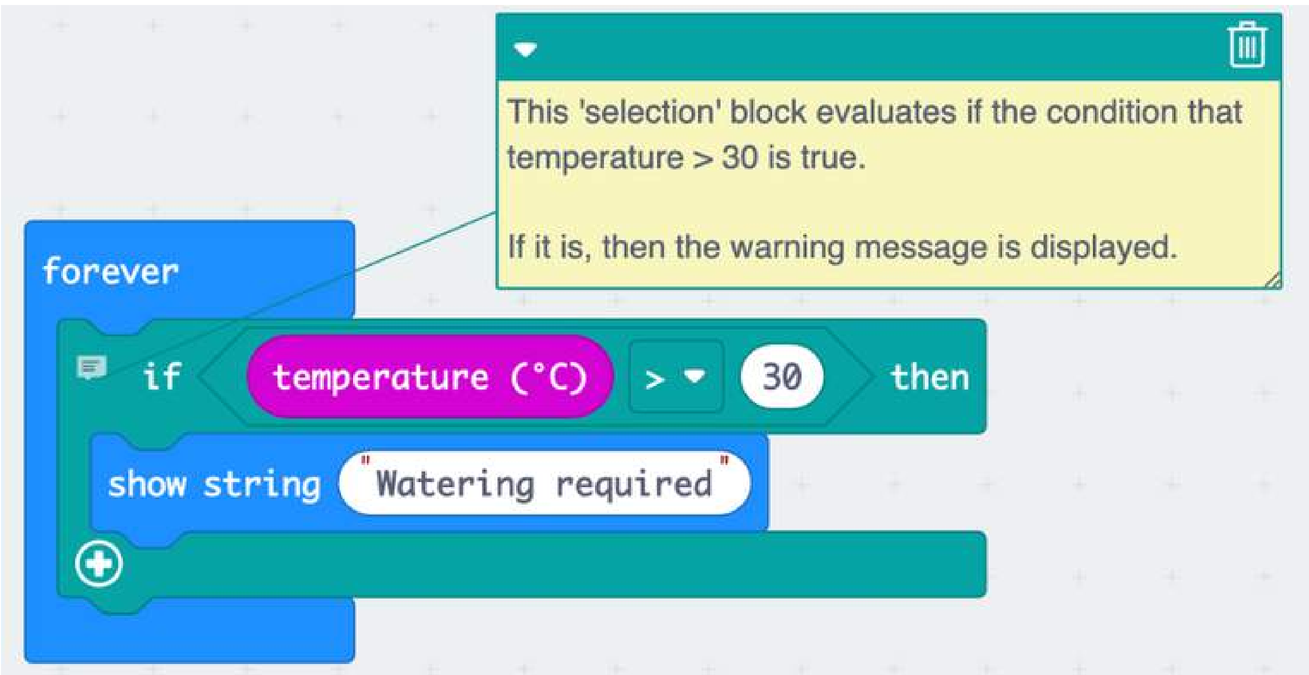
Information about data logging using the micro:bit https://microbit.org/get-started/user-guide/data-logging/

Improve
In the introduction to this resource, we mentioned the idea of a device not only measuring and storing temperature, but also triggering the flow of water if temperatures were excessive (slide 17).

As an extension challenge, can learners combine the following code (and add it to their existing program), to prototype the idea that when a certain excessively high temperature is reached, i.e. 30 degrees, the micro:bit automatically displays a message warning 'Watering required' - simulating the triggering of a watering system being activated?

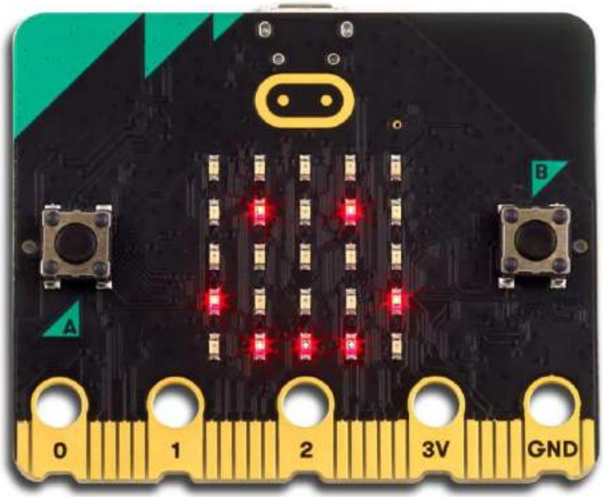


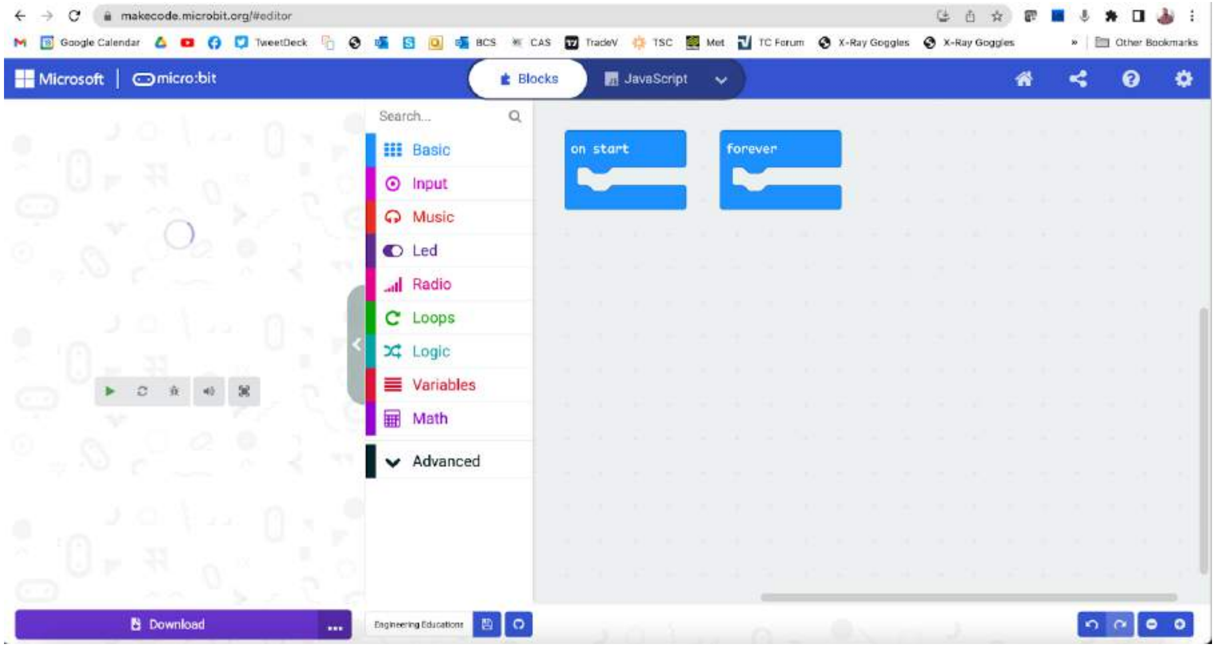
Solution with comments (slide 18)

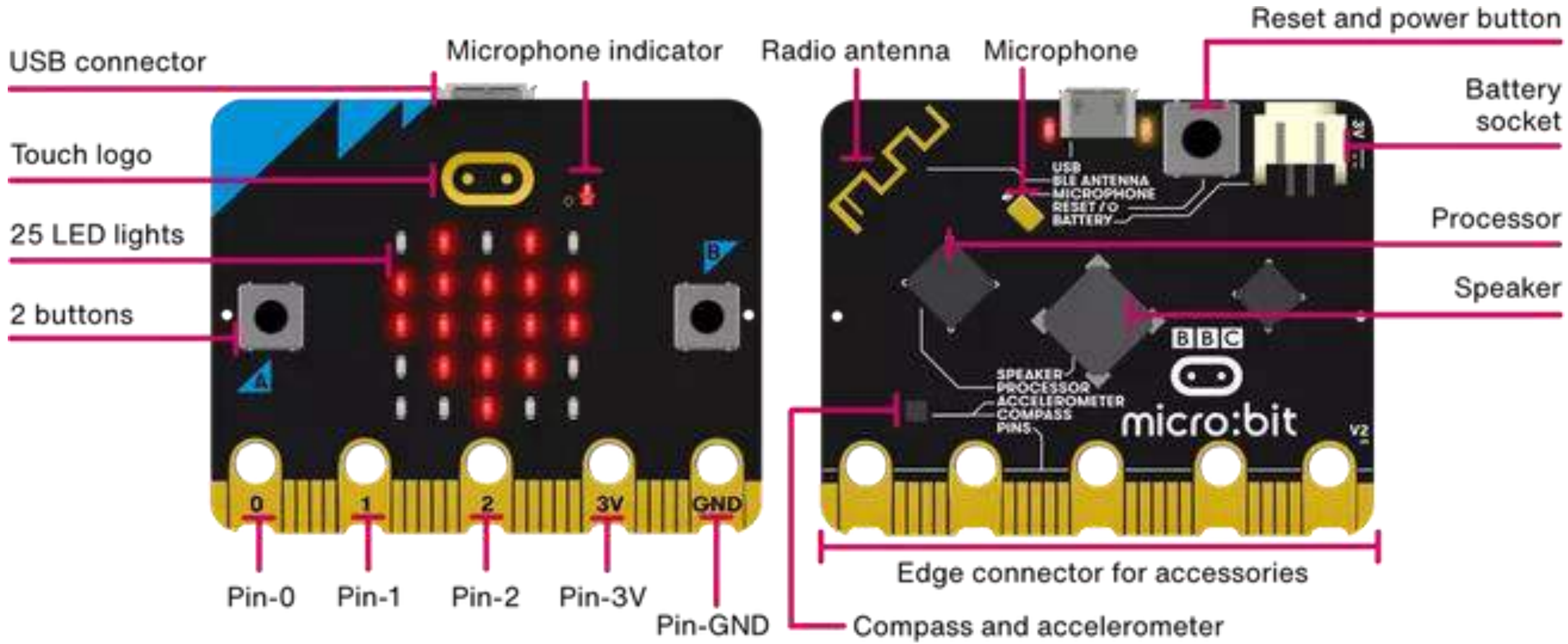


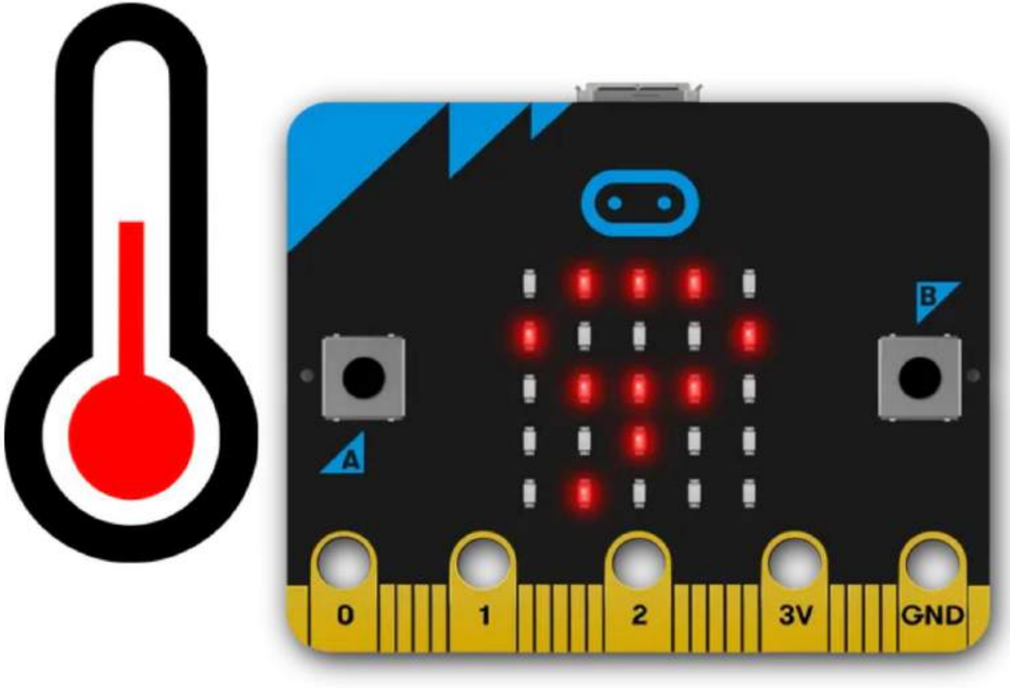
SESSION 5

How does farming benefit from automation?


A
B
0
1
2
3V
GND


makecode.microbit.org/#editor
Google Calendar
TweetDeck
BCS
CAS
TradeV
TSC
Met
TC Forum
X-Ray Goggles
X-Ray Goggles
Other Bookmarks
Microsoft
micro:bit
Blocks
JavaScript
Search...
Basic
Input
Music
Led
Radio
Loops
Logic
Variables
Math
Advanced
on start
forever
Download
Engineering Educations


USB connector
Microphone indicator
Radio antenna
Microphone
Reset and power button
Battery socket
Touch logo
25 LED lights
2 buttons
Processor
Speaker
0
1
2
3V
GND
Pin-0
Pin-1
Pin-2
Pin-3V
Pin-GND
BBC
micro:bit
Edge connector for accessories
Compass and accelerometer


B
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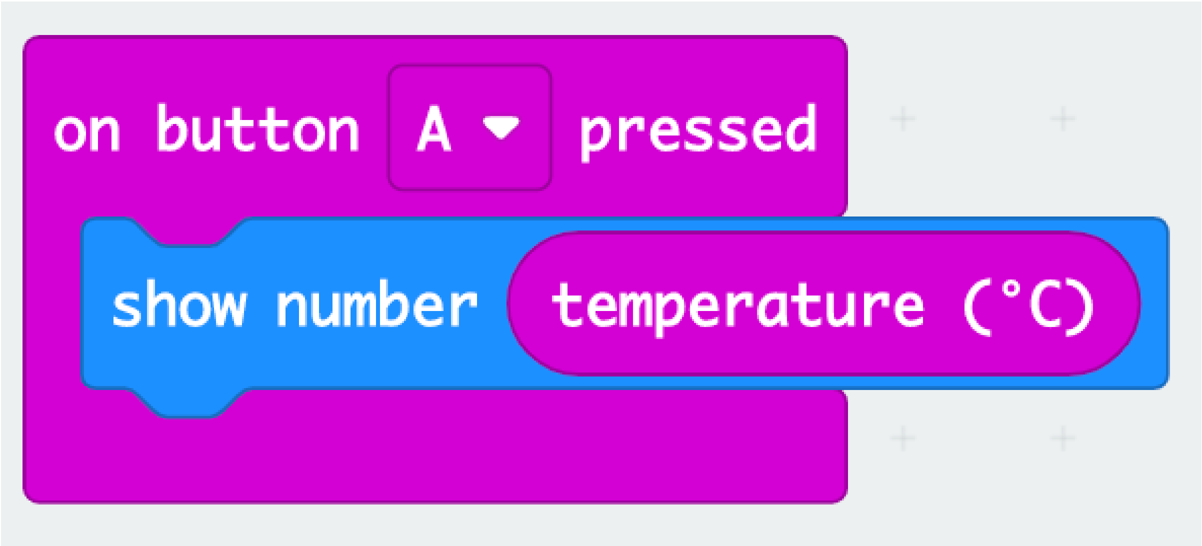
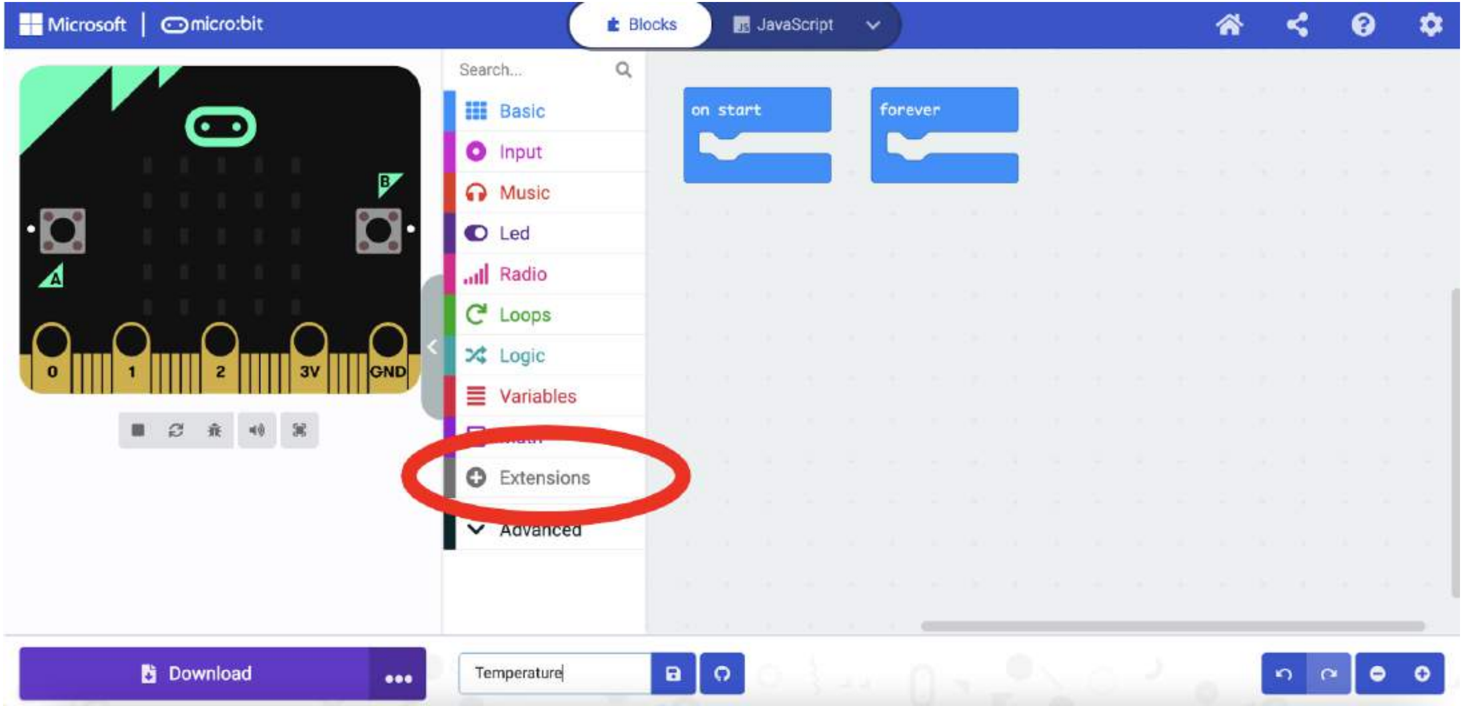

on button A pressed
show number
temperature (°C)



Microsoft
micro:bit
Blocks
JavaScript
Search...
Basic
Input
Music
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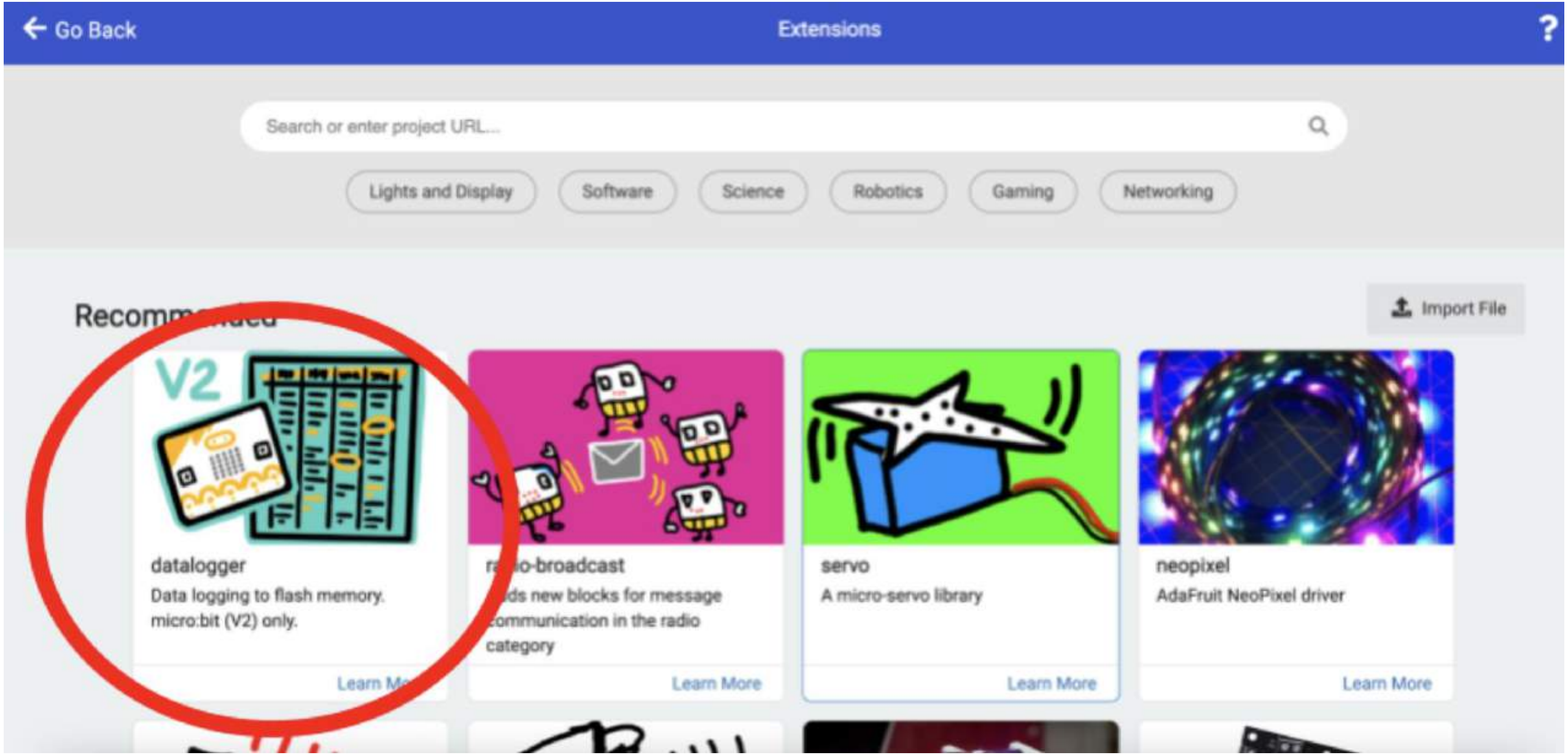
Radio
Loops
Logic
Variables
Extensions
Advanced
on start
forever
Download
Temperature


Go Back
Extensions
?
Search or enter project URL...
Lights and Display
Software
Science
Robotics
Gaming
Networking
Import File
V2
datalogger
Data logging to flash memory. micro:bit (V2) only.
communication in the radio
category
Learn More
servo
A micro-servo library
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neopixel
AdaFruit NeoPixel driver
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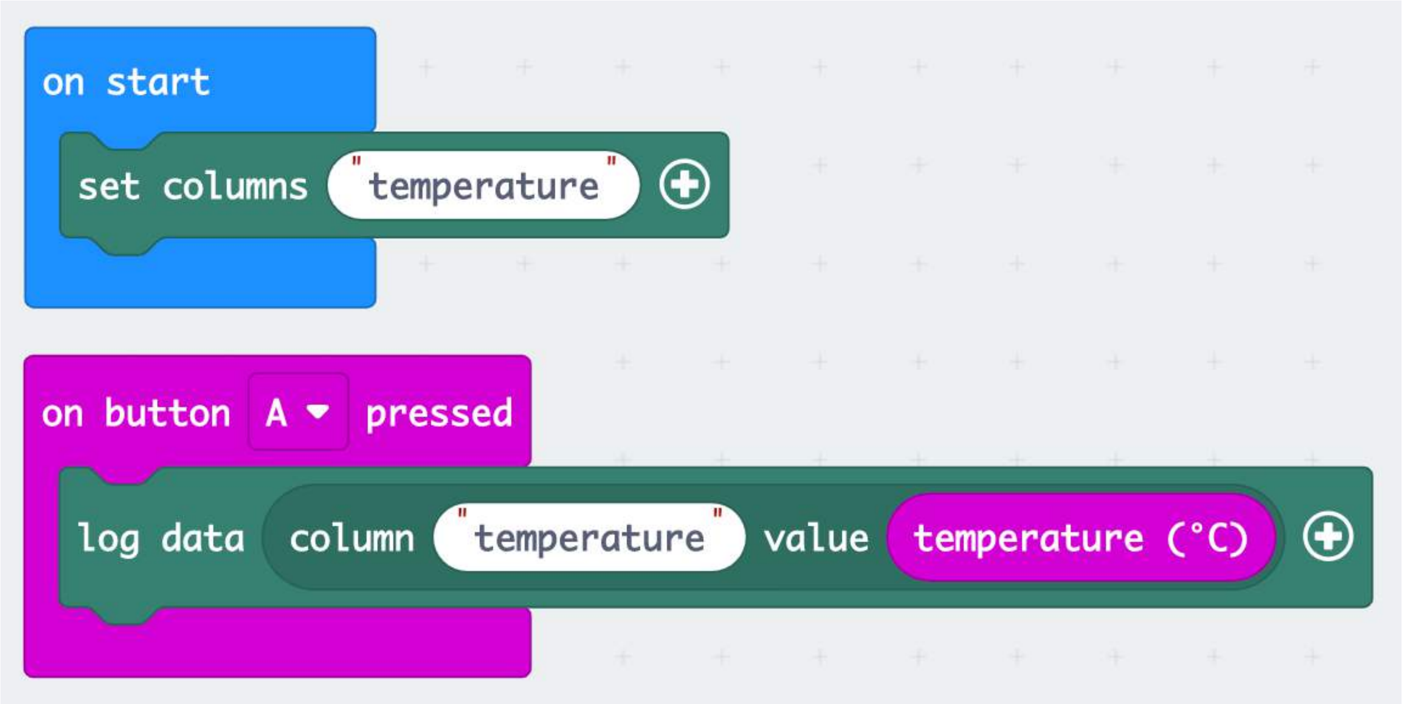
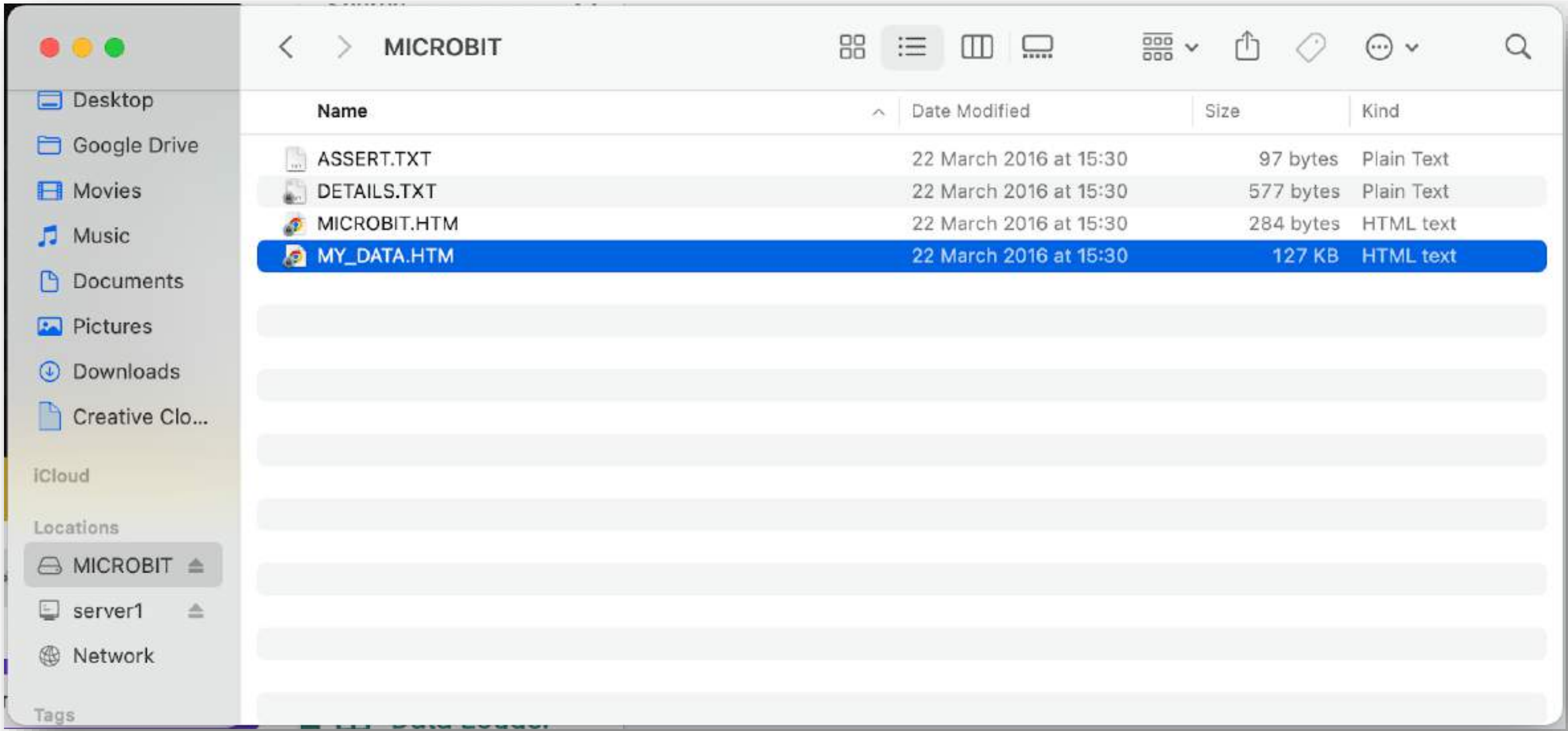

on start
set columns "temperature"
on button A pressed
log data column "temperature" value temperature (°C)


MICROBIT
Desktop
Google Drive
Movies
Music
Documents
Pictures
Downloads
Creative Clo...
iCloud
Locations
MICROBIT
server1
Network
Tags
Name
Date Modified
Size
Kind
ASSERT.TXT 22 March 2016 at 15:30 97 bytes Plain Text
DETAILS.TXT 22 March 2016 at 15:30 577 bytes Plain Text
MICROBIT.HTM 22 March 2016 at 15:30 284 bytes HTML text
MY_DATA.HTM 22 March 2016 at 15:30 127 KB HTML text

micro:bit

micro:bit data log

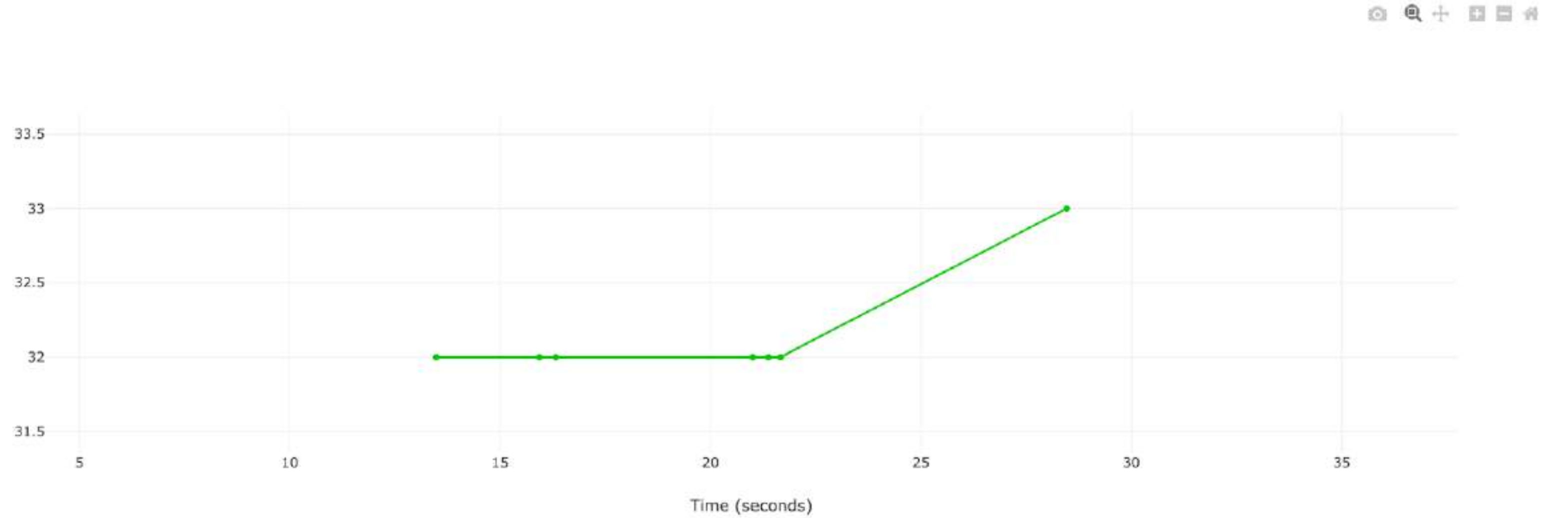
Download **Copy** **Update data...** **Clear log...** **Visual preview**

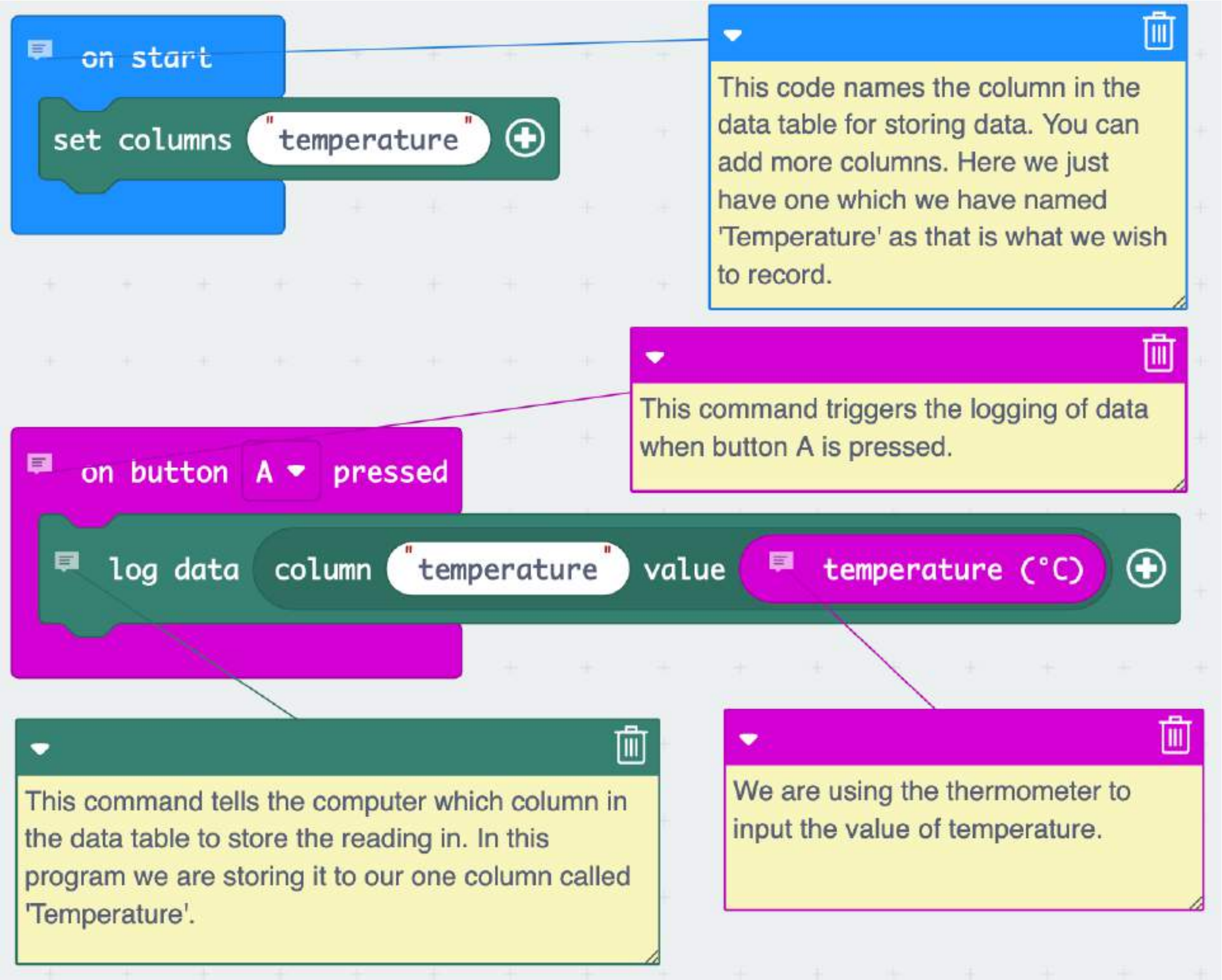
This is the data on your micro:bit. To analyse it and create your own graphs, transfer it to your computer. You can copy and paste your data, or download it as a CSV file which you can import into a spreadsheet or graphing tool. Learn more about micro:bit data logging.

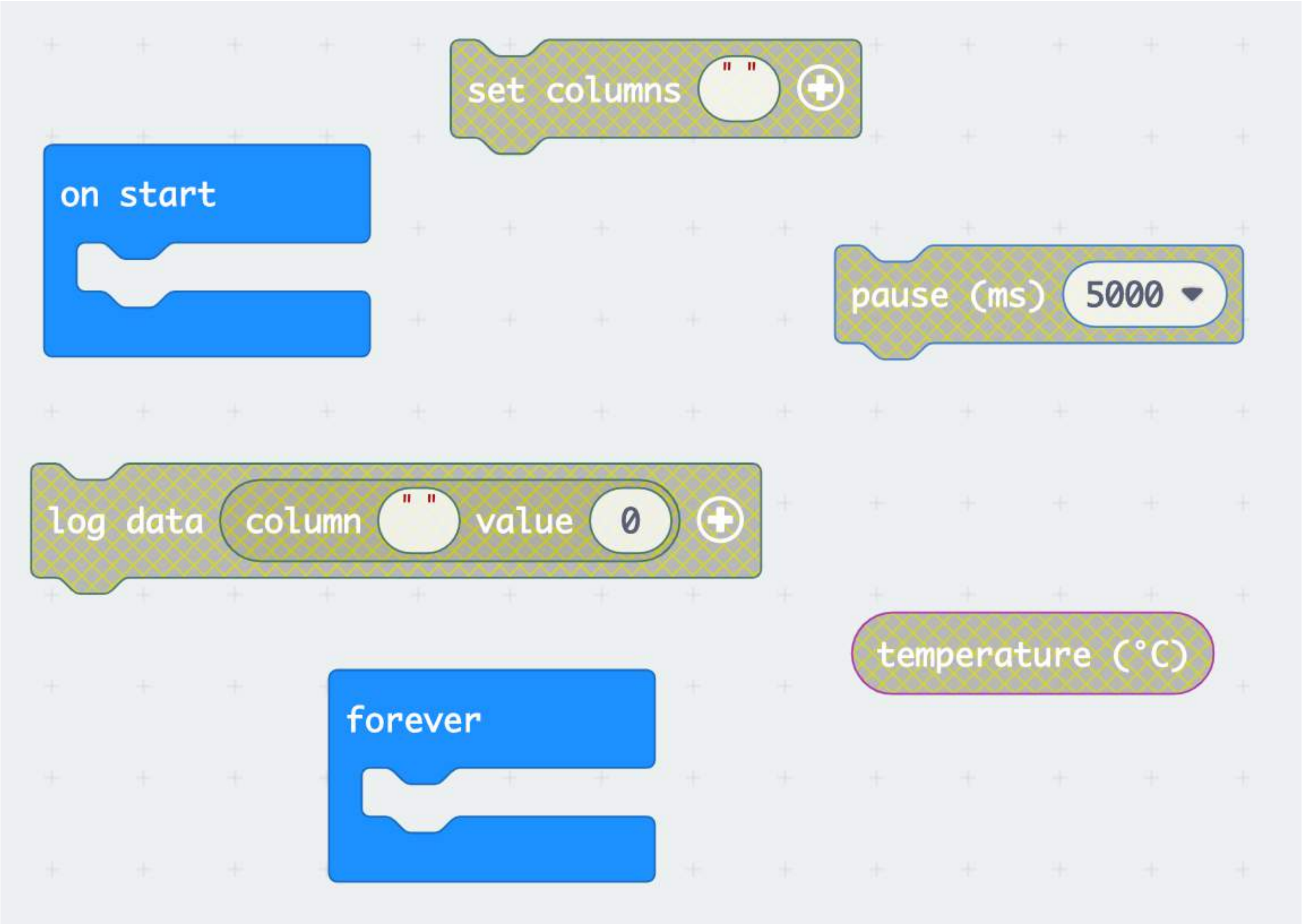
Time (seconds)	temperature
13.48	32
15.94	32
16.32	32
21.00	32
21.37	32
21.66	32
28.46	33

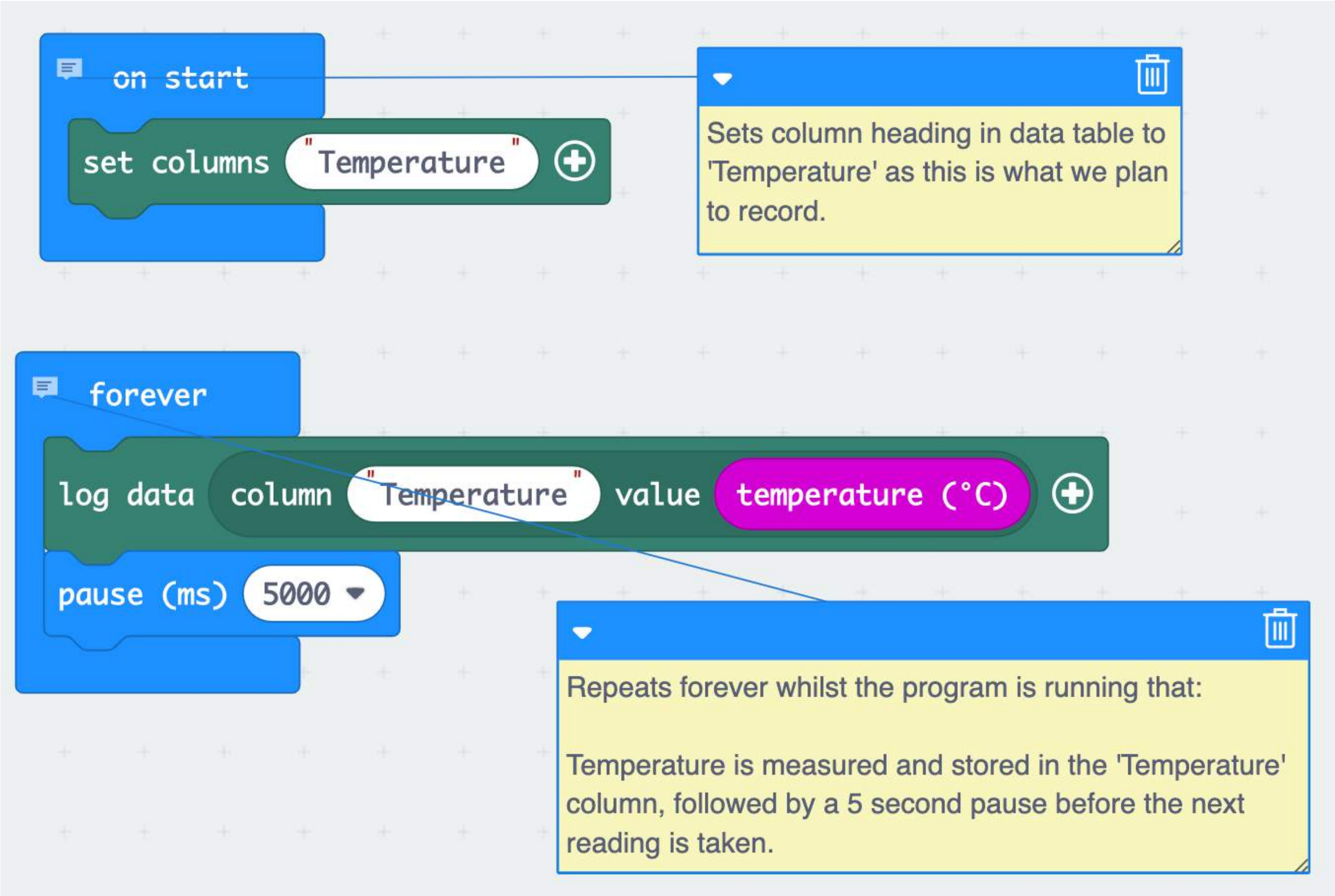
Download | Copy | Update data... | Clear log... | Close visual preview

This is a visual preview of the data on your micro:bit. To analyse it in more detail or create your own graphs, transfer it to your computer. You can copy and paste your data, or download it as a CSV file which you can import into a spreadsheet or graphing tool. Learn more about micro:bit data logging.

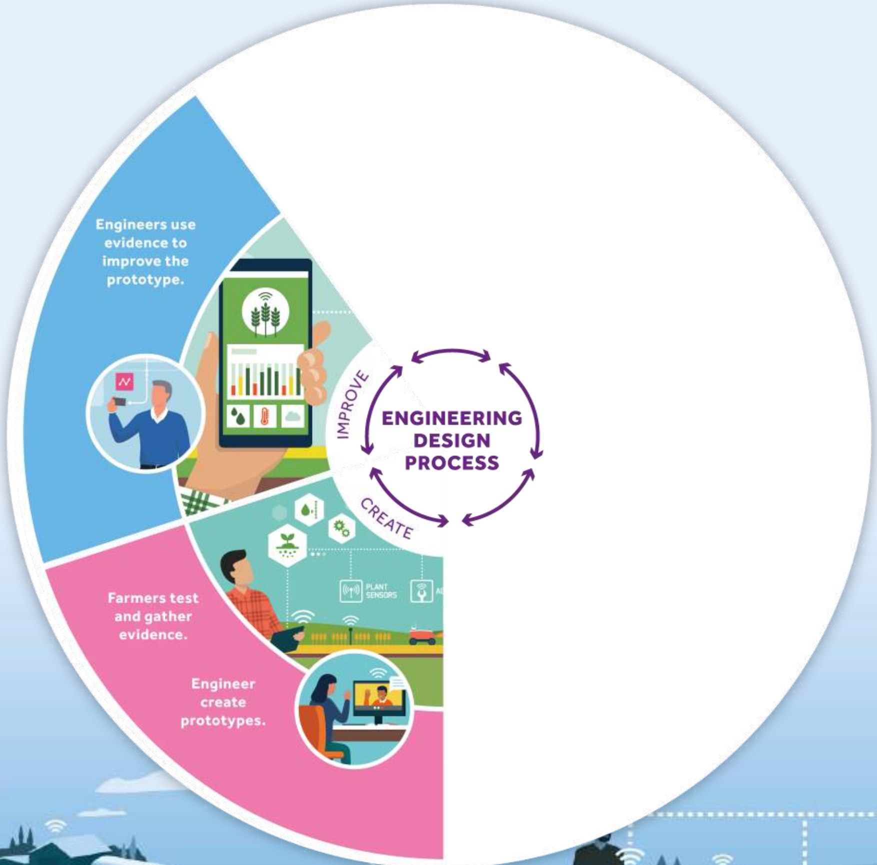



on start
set columns "temperature"
This code names the column in the data table for storing data. You can add more columns. Here we just have one which we have named 'Temperature' as that is what we wish to record.
This command triggers the logging of data when button A is pressed.
on button A pressed
log data column "temperature" value temperature (°C)
This command tells the computer which column in the data table to store the reading in. In this program we are storing it to our one column called 'Temperature'.
We are using the thermometer to input the value of temperature.

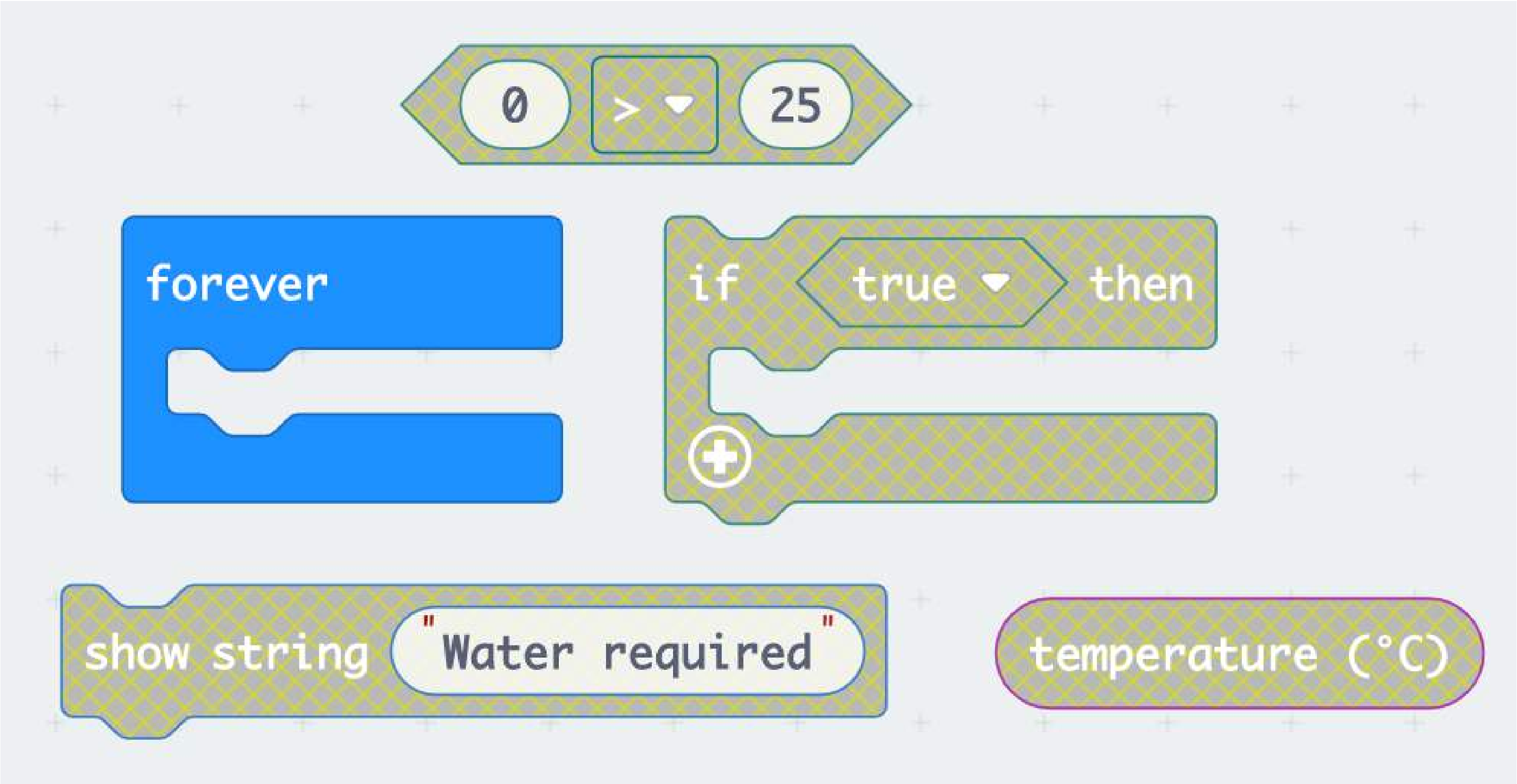

set columns " "
on start
pause (ms) 5000
log data column " " value 0
temperature (°C)
forever

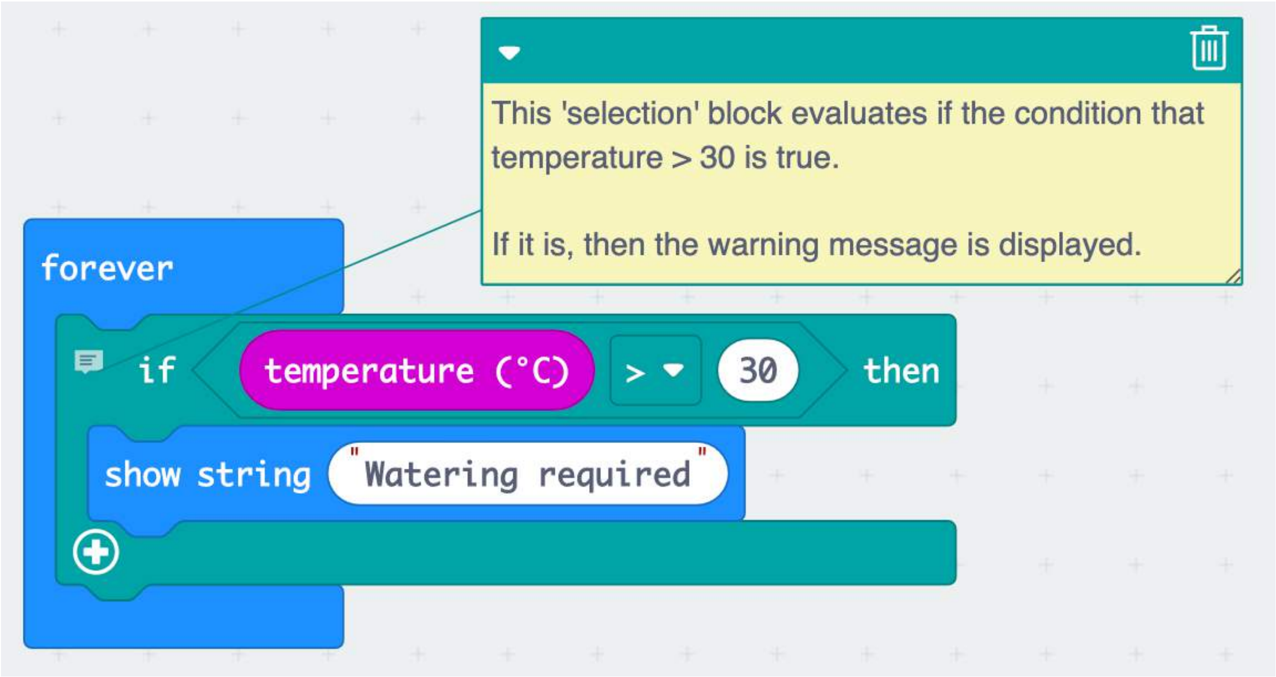


on start
set columns "Temperature"
Sets column heading in data table to 'Temperature' as this is what we plan to record.
forever
log data column "Temperature" value temperature (°C)
pause (ms) 5000
Repeats forever whilst the program is running that:
Temperature is measured and stored in the 'Temperature' column, followed by a 5 second pause before the next reading is taken.



In this challenge we have worked like agricultural engineers by **creating** and **improving** a computer programme to make a micro:bit logs environmental data on the farm.


0
>
25
forever
if
true
then
show string
"Water required"
temperature (°C)


This 'selection' block evaluates if the condition that temperature > 30 is true.
If it is, then the warning message is displayed.
forever
if
temperature (°C)
>
30
then
show string
"Watering required"

SUSTAINABLE FARMS