Soil Defenders Pathway

Full resources list

Session 1

- Access to the internet

Optional:

- plant trays
- compost
- watering cans
- arable seeds (e.g. winter wheat)

Session 2

Per group:

- 8 level tbs of soil
- 4 small wads of cotton wool
- access to running water
- 4 measuring cylinders
- 4 funnels
- stopwatch
- a selection of weights

Optional

- cameras/iPads
- cotton reel
- metal knitting needle (which fits inside cotton reel)
- permanent marker
- rubber band
- 30cm ruler

Session 3

- Oat, wheat and barley seeds
- Foods made from oat, wheat and barley
- Hand lens
- Laptops or electronic devices for research
- paper, pencils and rulers etc.

Optional

- a small bag of wheat seeds for planting
- soil or compost
- 4 seed trays
- 30cm ruler
- large sheets of paper

Session 4

Per group:

- 5mm thick corrugated card
- 3mm skewers, dowel or straws
- seeds, beads, or marbles
- PVA glue or masking tape
- scissors
- cardboard tube
- recycled boxes
- A4 sheet of light card
- craft sticks
- rubber bands
- paper cups

Optional access to additional tools:

- glue gun
- craft knife
- cutting board

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/

Optional:

- servos

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Soil Defenders - Session 1

Introduction to British Farming

Context:
Learners are introduced to the types of farms in our country, e.g. arable, dairy etc. and where they are located. They use information presented in tables and graphs to find out more about farming in the UK. 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 and by identifying problems.

Learning time:
2 hours

Suggested age group:
7-9 years old

Curriculum links
Mathematics: Data Handling
Learners will be using and applying their skills and knowledge:
- To interpret and present data using bar charts, pictograms and tables.
- To interpret and present discrete and continuous data using appropriate graphical methods.
- To complete, interpret and read information in tables.

Keywords
Elevation
Arable
Horticulture
Roots
Nutrients
Compaction
Drainage
Waterlogged
Sowing
Fertiliser
Weeding
Harvesting
Irrigation
Ploughing

Resources:
- NFU Video: Introduction to Arable Farming
- Soil Defenders Session 1 Presentation
- Access to the internet for mapping exercise

Optional:
- Plant trays
- Compost
- Watering cans
- Arable seeds eg. winter wheat

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Step-by-step plan

1

What do we know happens on farms in the United Kingdom? (5 minutes)
In groups of 3, ask the learners to quick-fire idea storm about things they think happen on farms. Ask them to decide on 4 things that they think happen most often, and challenge them to compose a short poem, ditty or key phrases to share with the class.

Farmers caring for their animals and crops.
Animals grazing.
Rows and rows of crops.
Machinery and tractors get the work done.

2

What sort of farms are there? (60 minutes)
Use Slides 1–10 to introduce learners to the two types of farming that are most common in the UK. The slides engage the learners in using their maths skills to interpret and present data about different types of farms across the UK and local to them. New vocabulary to describe types of farms will be introduced.
Learners can also use Google maps to research farms in their local area and keep a tally of the different farm types to test their understanding of new vocabulary.

Key learning points to reinforce:

- Different farms appear in different parts of the country because of the type of land and space available.
- Arable farms are farms that grow plants for crops. They are common in the south east where the summers are warm and the land is low, flat and fertile.
- Dairy farms are livestock farms, which are common in the south west and the west of England where the climate is warm and wet. The land may be flat or hilly, but not too steep.

3

What is an arable farm? (10 mins)
Use the ***NFU Video: Introduction to Arable Farming*** to explain what an arable farm is. This is slide 8 in the PowerPoint.

Activity: Use active listening to enable the learners to understand keywords and **identify the problems** that the farmer describes.

4

Optional: Learners become arable farmers

Groups of learners can prepare soil trays and plant their own arable crop such as winter wheat in rows. They can take care of their crop and make observations over time of the crop as it grows.

This could be developed into a science enquiry where learners explore the factors that affect the growth of their crop. Different groups of learners could change particular variables such as the depth of seeds, spacing of seeds or use of a fertiliser.

5

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

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 10 includes quotes from the video. 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 9 to explain the relationship between farmers and agricultural engineers. Key things to note:

- Agricultural engineers 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.

What's arable farming?

Watch the video carefully.

Whenever you hear one of these keywords on the list tick it off.

arable ☐	water ☐	waterways ☐	roots ☐	waterlogged ☐	crop ☐
soil ☐	ecosystem ☐	artificial ☐	nutrients ☐	sowing ☐	weeding ☐
healthy ☐	organism ☐	carbon ☐	biodiversity ☐	fertiliser ☐	ploughing ☐
earthworms ☐	compaction ☐	irrigation ☐	greenhouse gas ☐	global warming ☐	climate change ☐
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Problems with arable farming

Name:

Listen carefully to Farmer Hannah describe the problems she faces on her farm. Use this writing frame to identify three problems or arable farms.
Challenge: Use the third column to explain why this is a problem.

Problem	What is the problem?	Why is it a problem?
1		
2		
3		
4		

Drawing bar charts

Name:

1) Draw a bar chart to compare the percentage of land used for arable farms in each region.
2) Draw a bar chart to compare the percentage of land used for dairy farms in each region.
3) Give each of your bar charts a title to describe what they show.

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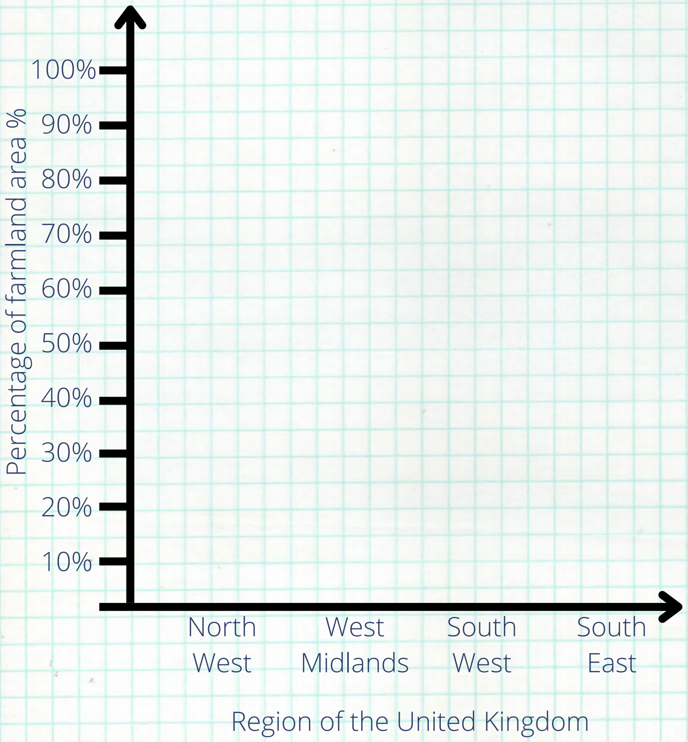

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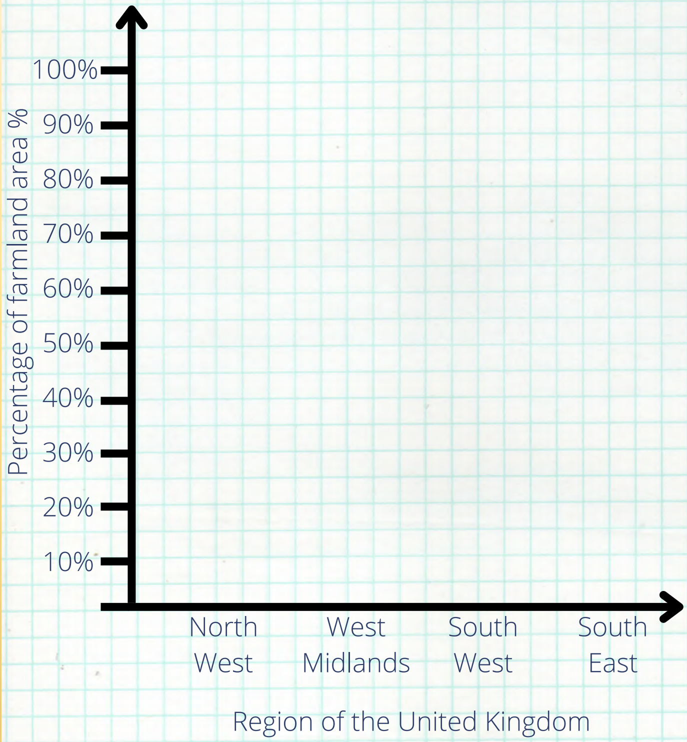

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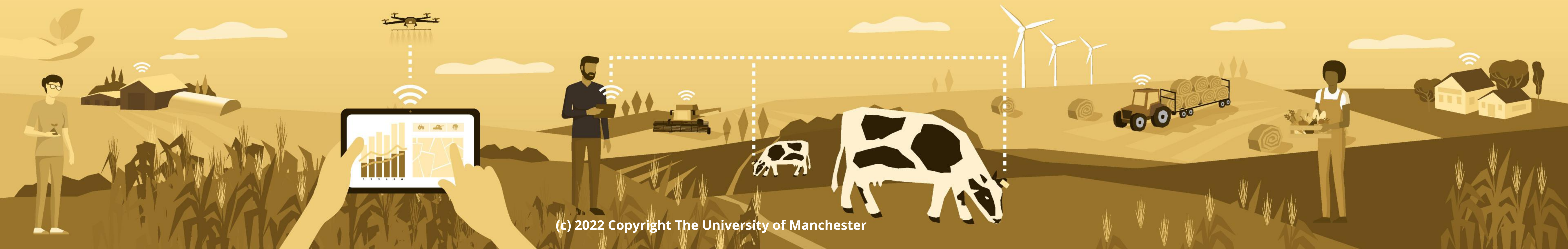

Soil Defenders - Session 1

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Curriculum for Excellence links:

First Level:
I explore and discover engineering disciplines and can create solutions. TCH 1-12a
I have explored a variety of ways in which data is presented and can ask and answer questions about the information it contains. MNU 1-20a
Using technology and other methods, I can display data simply, clearly and accurately by creating tables, charts and diagrams, using simple labelling and scale. MTH 1-21a
When preparing and cooking a variety of foods, I am becoming aware of the journeys which foods make from source to consumer, their seasonality, their local availability and their sustainability. HWB 1-35a

Second Level:
I can extend my knowledge and understanding of engineering disciplines to create solutions. TCH 2-12a
Having discussed the variety of ways and range of media used to present data, I can interpret and draw conclusions from the information displayed, recognising that the presentation may be misleading. MNU 2-20a
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 2-21a
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Keywords

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ENGINEERING EDUCATES FARMVENTION CHALLENGE

SOIL DEFENDERS

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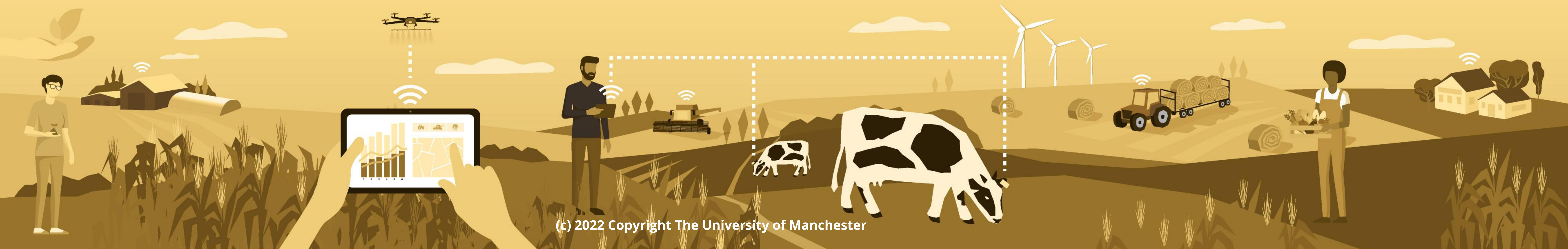

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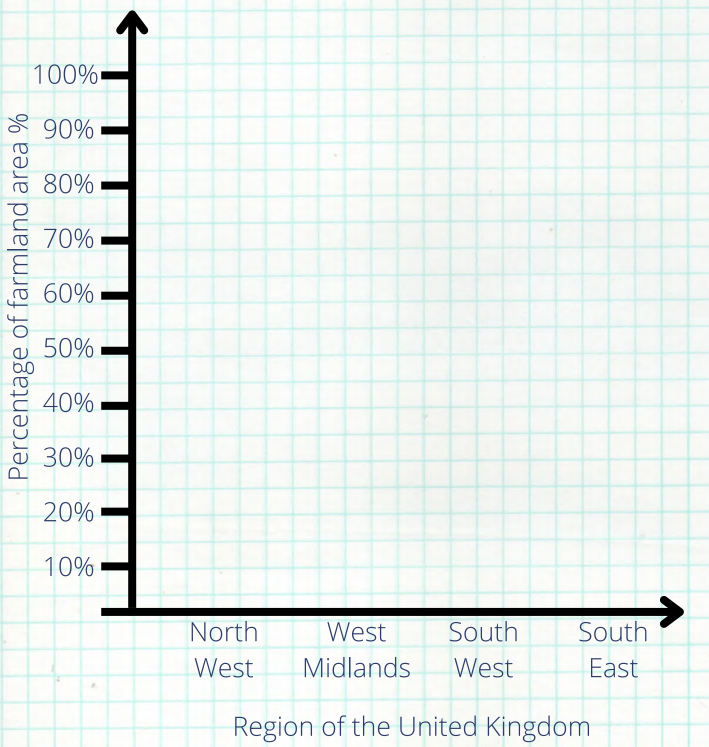

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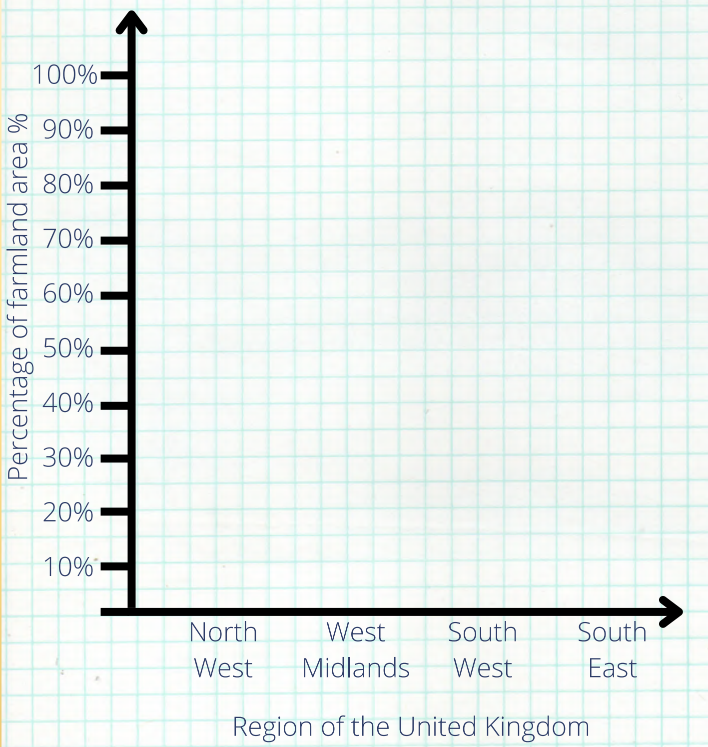
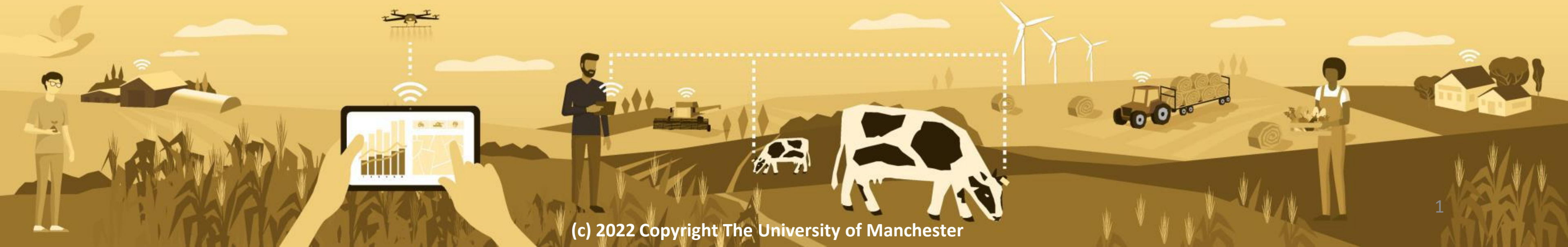


SOIL DEFENDERS

SESSION 1
Introduction to British farming



Where does farming take place in the UK?

This is a **topographic map** of the UK.

The colours show the **elevation** of the land, which is the height above the level of the sea.

What do you notice from the map?

Which UK country has the most farmland?

Region	Farmland	Natural	Built on and green urban areas
England	$\frac{73}{100}$	$\frac{15}{100}$	$\frac{12}{100}$
Northern Ireland	$\frac{72}{100}$	$\frac{23}{100}$	$\frac{5}{100}$
Scotland	$\frac{26}{100}$	$\frac{71}{100}$	$\frac{3}{100}$
Wales	$\frac{59}{100}$	$\frac{35}{100}$	$\frac{6}{100}$

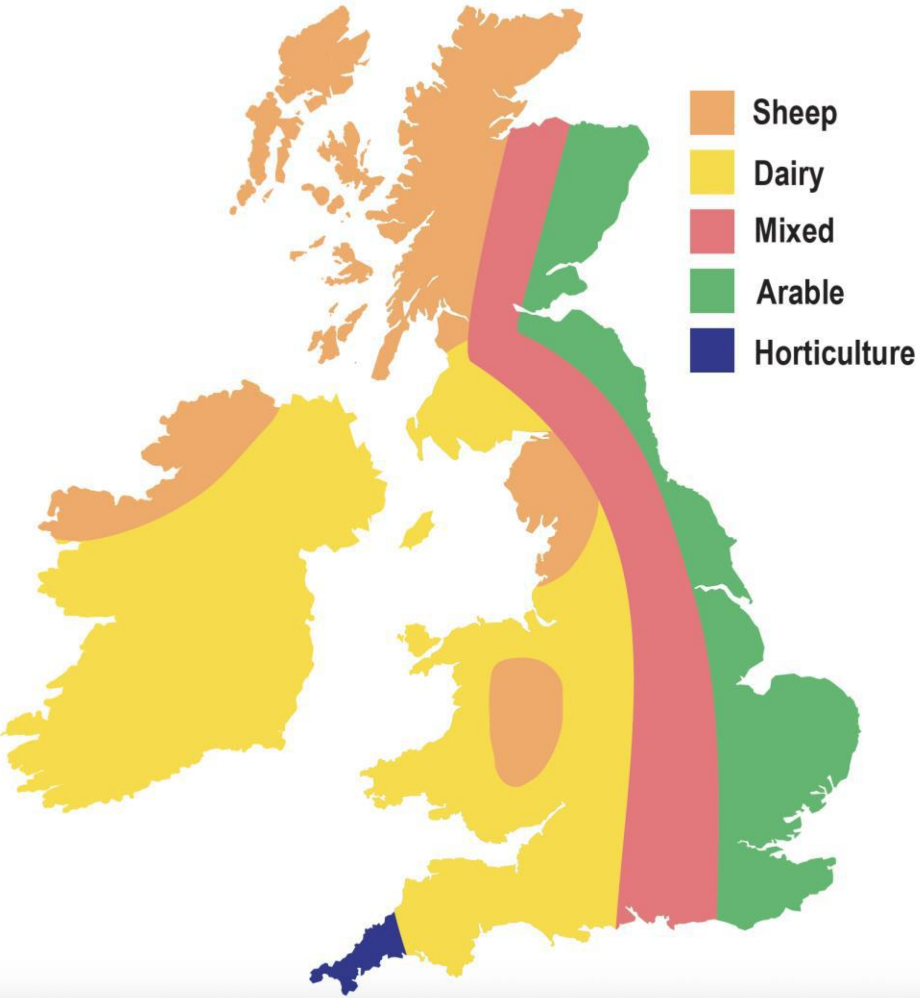
What else does the data tell you?

How are farms different?

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

What do you think happens on these types of farms?

What relationship is there between the type of farm and where it is?



Use your maths skills to compare and contrast data about farming in regions across the UK.

	Fraction of farmland area		
	Arable	**Dairy**	**Other (horticulture/ livestock/pigs/ poultry)**
United Kingdom	$\frac{49}{100}$	$\frac{9}{100}$	$\frac{42}{100}$
North West	$\frac{52}{100}$	$\frac{14}{100}$	$\frac{34}{100}$
West Midlands	$\frac{21}{100}$	$\frac{25}{100}$	$\frac{54}{100}$
South West	$\frac{41}{100}$	$\frac{39}{100}$	$\frac{20}{100}$
South East	$\frac{55}{100}$	$\frac{6}{100}$	$\frac{39}{100}$

Draw a bar chart to compare the percentage of land used for

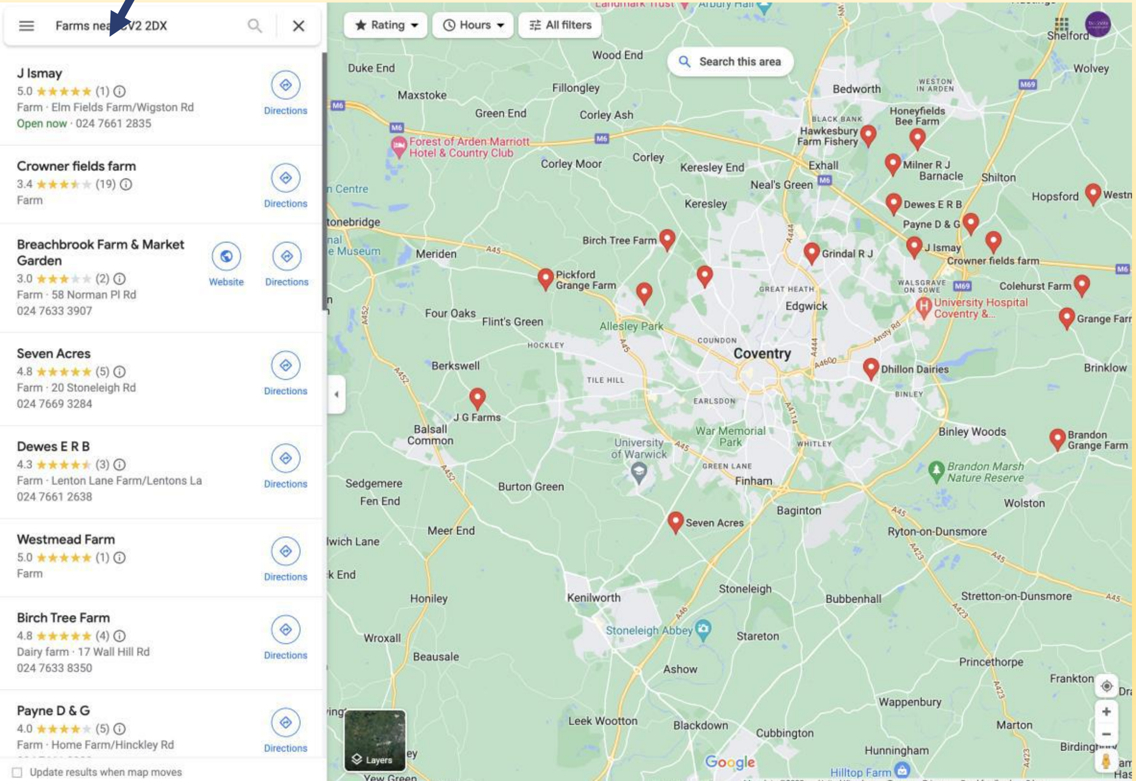
- **arable**
- **dairy farms.**

What farming takes place near you?

From your bar chart – can you work out what farms might be near you.

Find out some more about farms near you...

Search box



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

Visit https://maps.google.com

In the search box type: ‘Farms near [insert school postcode]’.

NFU Video
Introduction to Arable Farming

Listen carefully and tick off the keywords as you hear them. Are there any words you don't understand?

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

They will move back and forth between the different steps as they develop solutions to problems in farming.

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 farmer's problems.

Can you make things to make things better?

SOIL DEFENDERS

Soil Defenders - Session 2

What problems do farmers face with soil quality?

Context:
Learners build on their learning about the problems that agricultural engineers are finding solutions for on arable farms. They work scientifically to better understand the causes and effects of soil compaction. The link between science and engineering is key in this session as the Learners will use their science skills and understanding to consider engineering solutions to problems related to soil.

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

Learning time:
2 hours

Suggested age group:
7-9 years old

Keywords
soil
compaction
drainage
tractor
machinery
ploughing
fertilisers
permeability
permeable
impermeable
healthy
greenhouse gases
climate
penetrometer

Curriculum links:
Science: Soils, Comparative testing
Learners will be:
- Learning that soil is made from rocks and organic matter, noticing that the structure and properties of soils change when forces cause it to become compacted.
- Developing skills in working scientifically through enquiry, data gathering, analysis and drawing conclusions.

Resources:
Materials for each group:
- 8 x level tbs of soil (2 x level tbs for each condition)
- 4 x small wads of cotton wool (enough to prevent soil falling through the funnels)
- access to water
- measuring cylinders (x4)
- funnels (x4)
- stop watches (x1)
- a selection of weights to compact soil in the funnel

Optional:
Cameras/ipads
Materials for each group:
- 1 x cotton reel
- 1 x metal knitting needle (or similar) - must fit inside cotton reel
- 1 x permanent marker
- 1 x rubber band
- 1 x 30cm ruler

Step-by-step plan

1

What do you see? Listen & Match

Remind Learners that farmers say that soil is the most valuable resource on earth! Rewatch the **NFU Introduction to arable farming** video, engaging learners in listening and matching to elicit what they think they can see happening in the different photos on Slide 2 and what problems are linked to this activity.

Photo	Description	Problem it relates to
1	Heavy farm vehicles have compacted the soil in the field. Root growth will be restricted and it is difficult for water/nutrient uptake which decreases crop yield.	Soil Compaction
2	Ploughing gets more oxygen in the soil, however different bacteria turn the oxygen into carbon dioxide which contributes to the level of greenhouse gases in the air. We need a good balance of oxygen in the soil for it to be healthy.	Release of Greenhouse gases
3	Natural fertilisers such as liquid manure pollute the air with ammonia. This is harmful to human health and can also pollute waterways.	Soils need regular fertilising to put the nutrients back that the crops/plants remove when growing.
4	Artificial fertilisers are produced by burning fossil fuels which adds greenhouse gases which leads to global warming.	Release of greenhouse gases

2

What's the soil like in our school?

Take a walk around the school grounds to look at where soil is found, e.g. a flower bed which has been recently dug up for gardening, somewhere that is regularly walked on, the middle of a grassy area, where vehicles frequently pass over it etc. Take the opportunity to observe and explain the differences between compacted soil and non-compacted soil.

You could take a camera/ipad and make a montage of soil around the school. Sort and classify into areas that are more or less compacted. This could be developed into an optional science investigation with Learners measuring soil compaction (page 4).

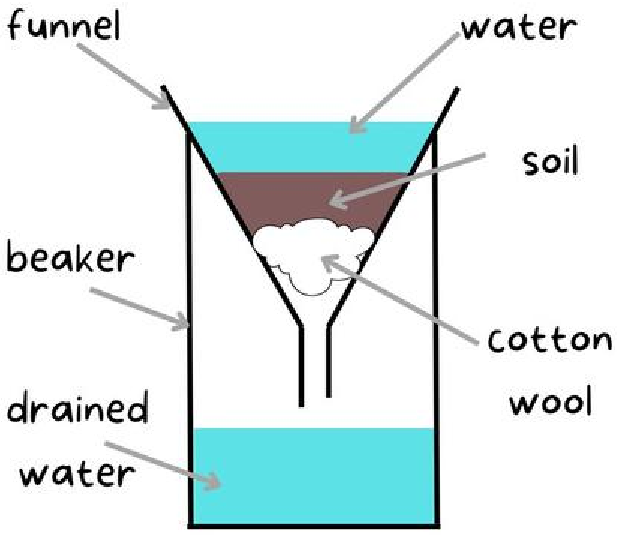
3

Investigation: How does compaction affect the amount of time taken for water to drain through soil? (comparative test)

Learners compare how quickly water drains through the soil (variable they measure) with different amounts of compaction (variable they change). They change the amount of compaction by squashing the soil down (no compaction, light compaction, moderate compaction and heavy compaction). This could be achieved by using different weights placed on the top of the soil.

Learners gather data through simple measurements by recording the time (mins/sec) for a fixed volume of water to drain through the various soil samples with different levels of compaction, recording their results in a table and then analysing by drawing a bar chart on pre-prepared axes.

Encourage Learners to use their bar chart to look for patterns and trends and develop these into conclusions that answer their scientific question. Their results should suggest that soil compaction increases the time it takes for water to permeate through the soil. Often this can result in the water running off the soil surface.



To support your Learners in their science enquiry work you could include some Great Science Skills Starters resources into you lesson, especially the 7-11 Conclusion Creator.

4

Relating their scientific evidence to what happens on a farm?

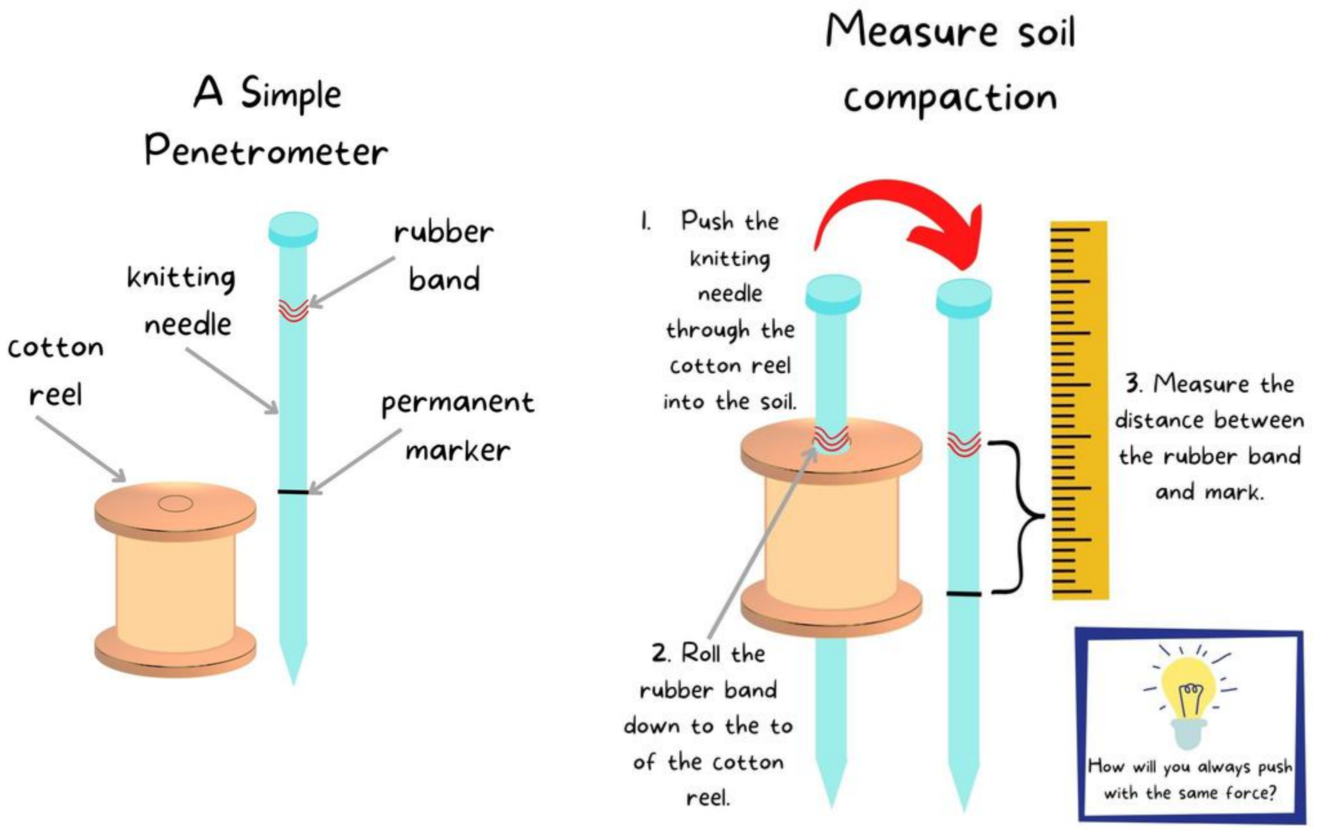
So what does this mean? Why is this a problem? Learners make the link between their enquiry findings and heavy machinery on the farms causing compaction. Ask Learners how they think this will affect seeds growing into healthy crops.

If possible organise the opportunity for your learners to talk to a farmer/engineer about how this problem relates to their work.

Take it further

Optional Investigation: Where is the soil on our school grounds most compact?

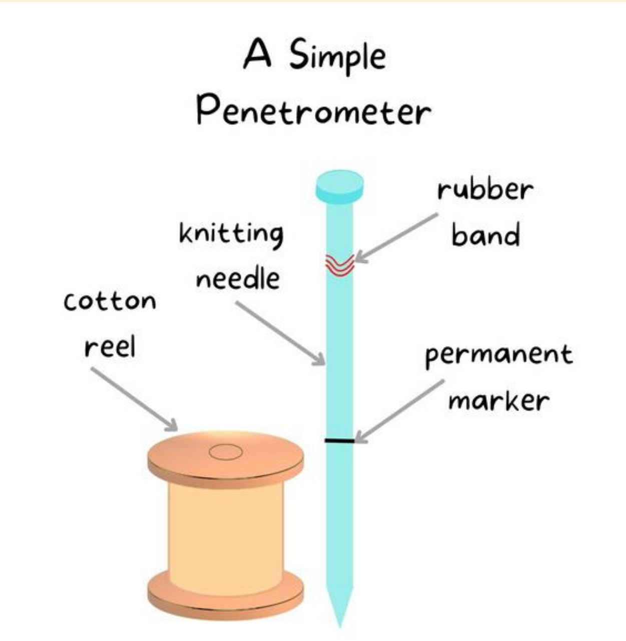
Why not develop step 2 of this session into an additional science enquiry? Using simple, readily available resources your learners could make their own 'penetrometer', a device for measuring the compaction of soil.



As your Learners observe soil samples in different locations around the school grounds they could use this penetrometer and a ruler to take a measure the level of soil compaction.
They push the knitting needle through the cotton reel and into the soil (using the same force in each location they measure soil compaction). They then roll down the rubber band to mark where the top of the cotton reel is, remove their penetrometer and measure the distance between the rubber band and the mark.

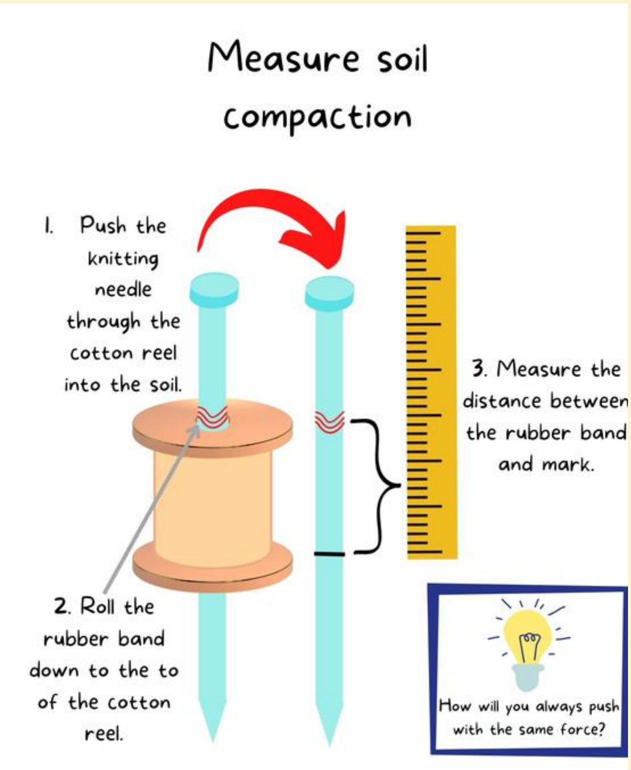
If the soil is more compact the knitting needle will not be easily pushed into the soil and the distance between the mark and the rubber band will be small. If the soil is less compact the knitting needle will easily be pushed into the soil and this distance will be bigger. Learners can record their measurements in a table and then use a bar chart to compare and analyse their findings. Encourage your Learners to draw conclusions that try to explain the differences in soil compaction in different locations.

Where is the soil most compact in our school grounds?

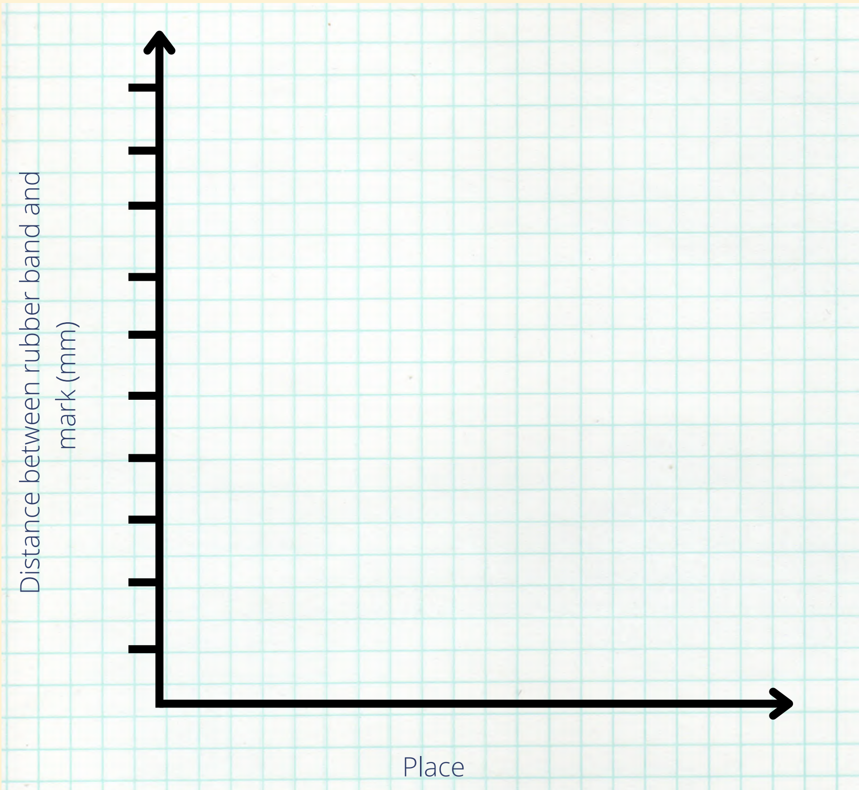


Results

Place	Distance between rubber band and mark (mm)



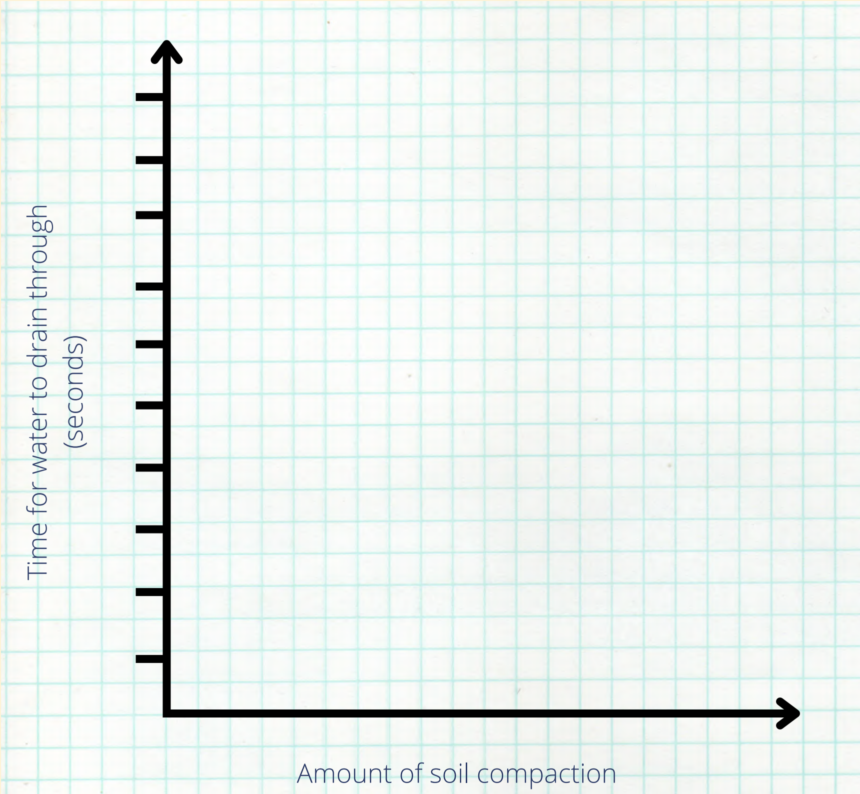
Analysis - bar chart



Does soil compaction affect the time it takes for water to drain through it?

Planning

Analysis - bar chart



Results

Amount of soil compaction	Time for water to drain through (seconds)
no compaction	
light compaction	
moderate compaction	
heavy compaction	

Conclusion

Soil Defenders - Session 2

What problems do farmers face with soil quality?

Context:
Learners build on their learning about the problems that agricultural engineers are finding solutions for on arable farms. They work scientifically to better understand the causes and effects of soil compaction. The link between science and engineering is key in this session as the Learners will use their science skills and understanding to consider engineering solutions to problems related to soil.

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

Learning time:
2 hours

Suggested age group:
7-9 years old

Curriculum for Excellence links:

First Level:
I explore and discover engineering disciplines and can create solutions. TCH 1-12a
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

Second Level:
I can extend my knowledge and understanding of engineering disciplines to create solutions. TCH 2-12a
Having explored the substances that make up Earth's surface, I can compare some of their characteristics and uses. SCN 2-17a
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
soil
compaction
drainage
tractor
machinery
ploughing
fertilisers
permeability
permeable
impermeable
healthy
greenhouse gases
climate
penetrometer

Resources:
Materials for each group:
- 8 x level tbs of soil (2 x level tbs for each condition)
- 4 x small wads of cotton wool (enough to prevent soil falling through the funnels)
- access to water
- measuring cylinders (x4)
- funnels (x4)
- stop watches (x1)
- a selection of weights to compact soil in the funnel

Optional:
Cameras/ipads
Materials for each group:
- 1 x cotton reel
- 1 x metal knitting needle (or similar) - must fit inside cotton reel
- 1 x permanent marker
- 1 x rubber band
- 1 x 30cm ruler

Step-by-step plan

1 What do you see? Listen & Match

Remind Learners that farmers say that soil is the most valuable resource on earth! Rewatch the **NFU Introduction to arable farming** video, engaging learners in listening and matching to elicit what they think they can see happening in the different photos on Slide 2 and what problems are linked to this activity.

Photo	Description	Problem it relates to
1	Heavy farm vehicles have compacted the soil in the field. Root growth will be restricted and it is difficult for water/nutrient uptake which decreases crop yield.	Soil Compaction
2	Ploughing gets more oxygen in the soil, however different bacteria turn the oxygen into carbon dioxide which contributes to the level of greenhouse gases in the air. We need a good balance of oxygen in the soil for it to be healthy.	Release of Greenhouse gases
3	Natural fertilisers such as liquid manure pollute the air with ammonia. This is harmful to human health and can also pollute waterways.	Soils need regular fertilising to put the nutrients back that the crops/plants remove when growing.
4	Artificial fertilisers are produced by burning fossil fuels which adds greenhouse gases which leads to global warming.	Release of greenhouse gases

2 What's the soil like in our school?

Take a walk around the school grounds to look at where soil is found, e.g. a flower bed which has been recently dug up for gardening, somewhere that is regularly walked on, the middle of a grassy area, where vehicles frequently pass over it etc. Take the opportunity to observe and explain the differences between compacted soil and non-compacted soil.

You could take a camera/ipad and make a montage of soil around the school. Sort and classify into areas that are more or less compacted. This could be developed into an optional science investigation with Learners measuring soil compaction (page 4).

3

Investigation: How does compaction affect the amount of time taken for water to drain through soil? (comparative test)

Learners compare how quickly water drains through the soil (variable they measure) with different amounts of compaction (variable they change). They change the amount of compaction by squashing the soil down (no compaction, light compaction, moderate compaction and heavy compaction). This could be achieved by using different weights placed on the top of the soil.

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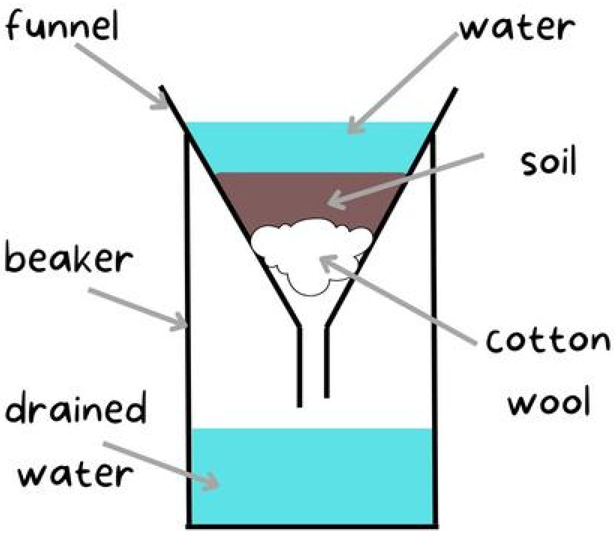


To support your Learners in their science enquiry work you could include some Great Science Skills Starters resources into you lesson, especially the 7-11 Conclusion Creator.

4

Relating their scientific evidence to what happens on a farm?

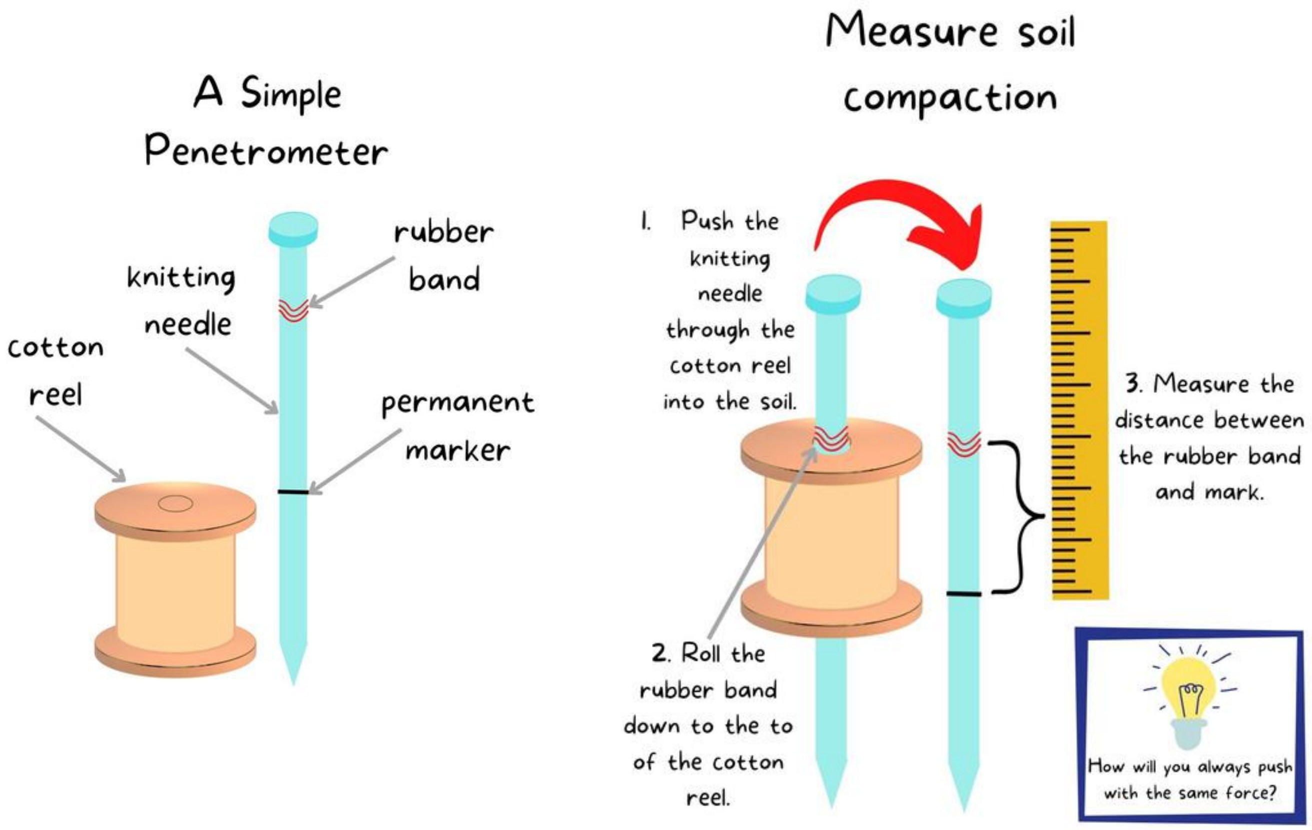
So what does this mean? Why is this a problem? Learners make the link between their enquiry findings and heavy machinery on the farms causing compaction. Ask Learners how they think this will affect seeds growing into healthy crops.

If possible organise the opportunity for your learners to talk to a farmer/engineer about how this problem relates to their work.

Take it further

Optional Investigation: Where is the soil on our school grounds most compact?

Why not develop step 2 of this session into an additional science enquiry? Using simple, readily available resources your learners could make their own 'penetrometer', a device for measuring the compaction of soil.



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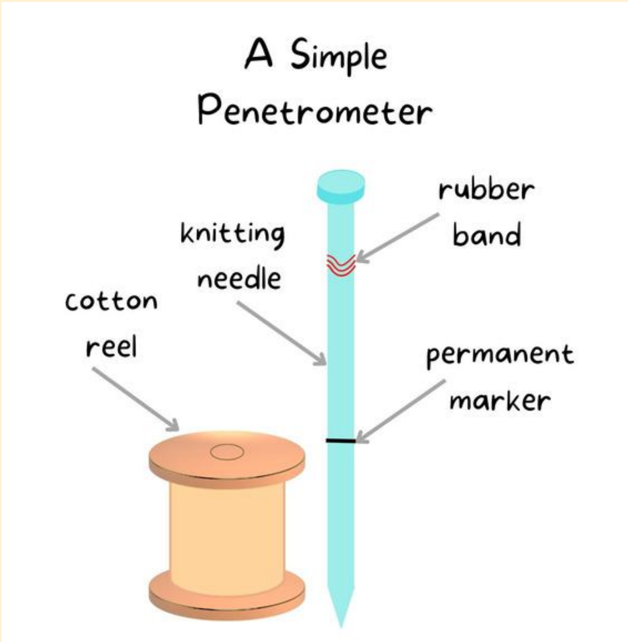
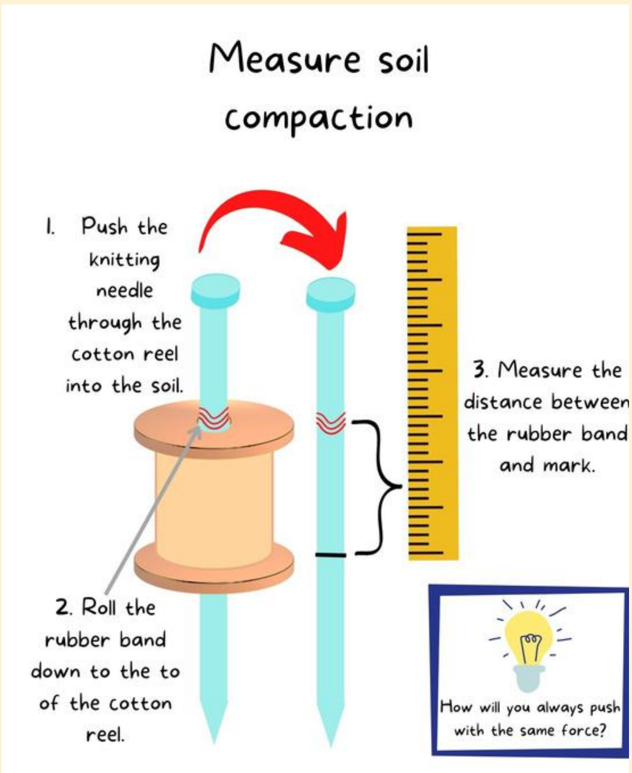
Where is the soil most compact in our school grounds?

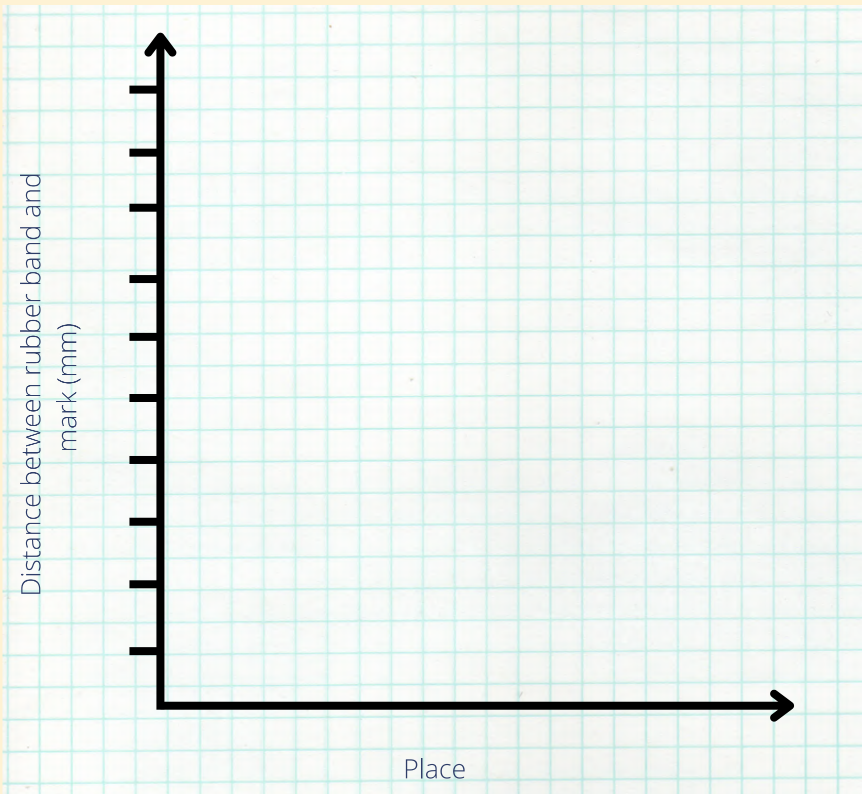




Results

Place	Distance between rubber band and mark (mm)

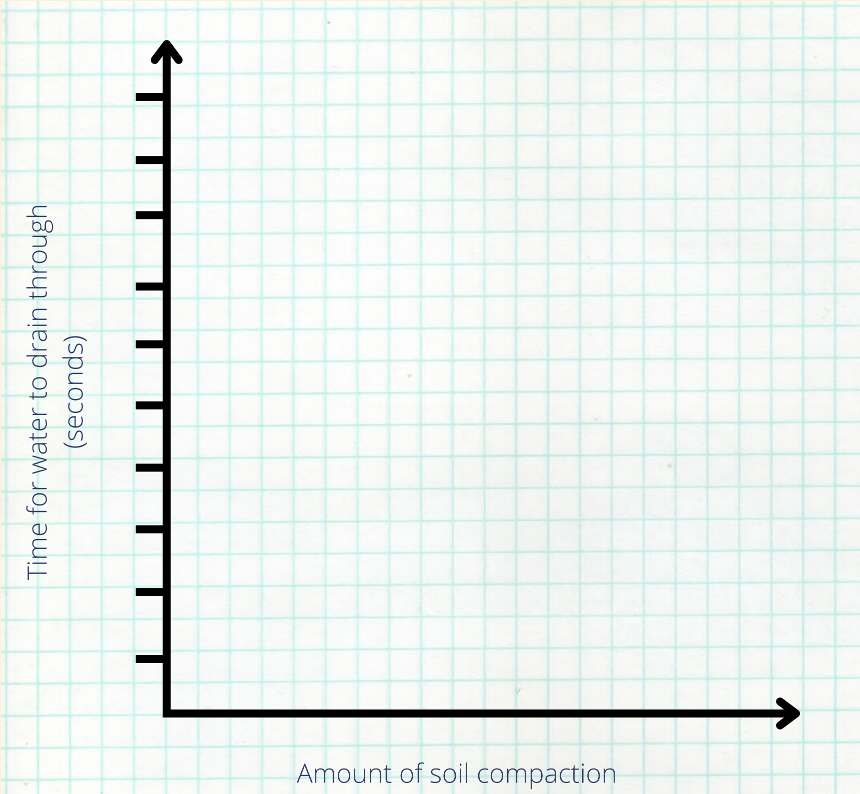
Analysis - bar chart



Does soil compaction affect the time it takes for water to drain through it?

Planning

Analysis - bar chart



Results

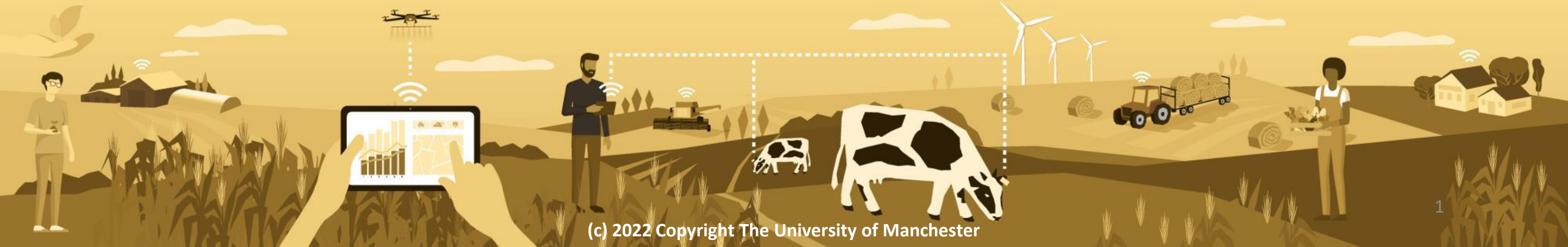
Amount of soil compaction	Time for water to drain through (seconds)
no compaction	
light compaction	
moderate compaction	
heavy compaction	

Conclusion

SOIL DEFENDERS

SESSION 2

Do farmers face problems with soil quality?



Listen & Match

Spraying artificial fertilisers

Spraying natural fertilisers

Soil compaction

Ploughing

Image credits: 1: Matt Fascione, /2: Aqua Mechanical,/3: Kenneth Allen/ 4: wfmillar

1

My soil becomes too compacted.

2

My soil needs extra nutrients to grow crops.

3

I know too much ploughing can damage the environment.

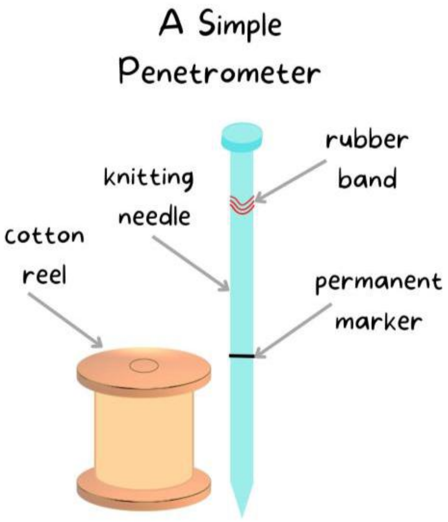
Image cr[illegible]ts: 1: Matt Fascione, /2: Aqua Mechanical,/3: Kenneth Allen/ 4: wfmillar

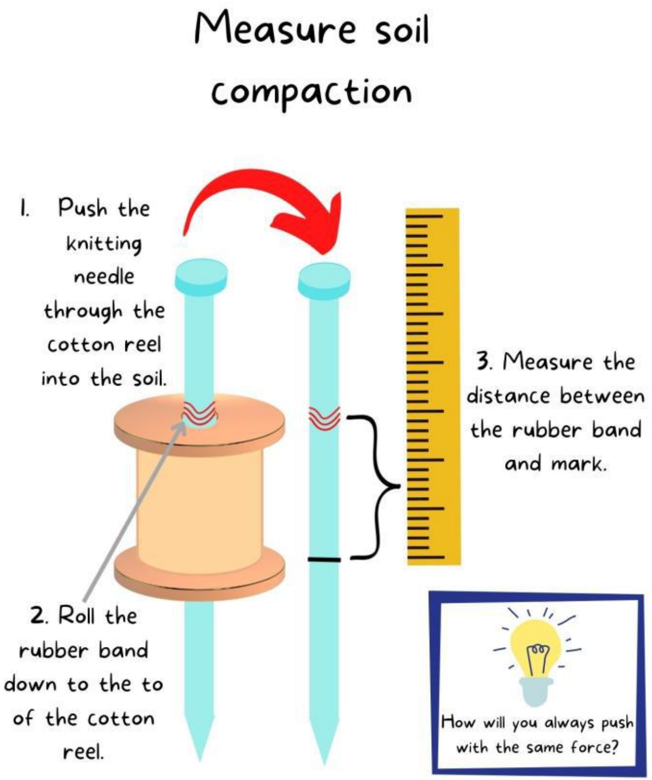
What did you find on your soil trail?

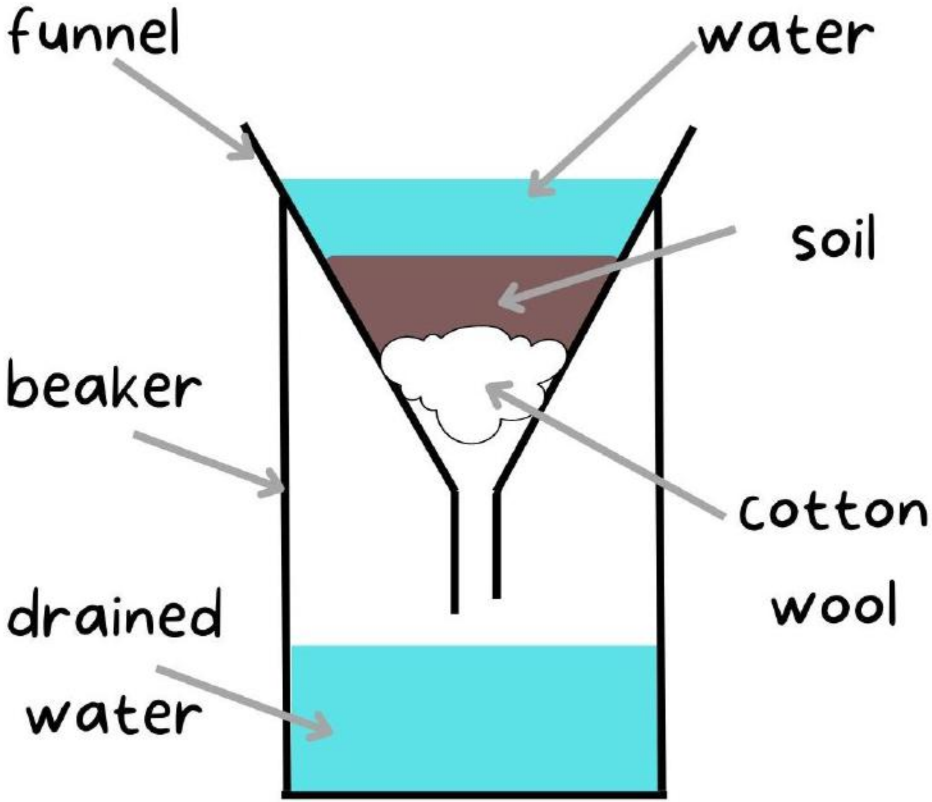
What is the soil like around our school?

Where is it most compact? Why do you think that is?

Where is the soil loose? Why do you think that is?







How does compaction of soil affect the time it takes for water to drain through it?

- What variable will we change? How will we change it?
- What variable will we measure to compare the soils? What equipment will we use?
- What variables will we need to keep the same so that they don't affect our results?

Have you found a problem to solve?

What conclusions have you drawn?

What link is there between what you've found out and what happens with machinery on arable farms?

What problem have you found that an agri-engineer can solve?

Image credit: James T M Towill

Scientists in China carried out a comparative test to find out the effect of soil compaction on soybean seedlings.

Which of these seedlings do you think grew in soil with no, moderate and high compaction?

Image credit: Wang et al. (2019)

Today we have been working like an engineering by **asking questions** to better understand the problems that farmers face with efficiency and sustainability.

Some of our questions have led to science enquiries where we have **worked scientifically** to gather evidence to answer them.

SOIL DEFENDERS

Soil Defenders - Session 3

How can we prevent pests eating the seeds?

Context:
Learners consider how they can help arable farmers protect cereal crops from pests so that more seeds can grow well and be harvested (the yield). Some learners apply their maths skills of fractions and percentages to find out more about the problem. They learn about the types of pests doing harm and the innovative ways that engineers create mechanisms to deter animals. They work in pairs to visualise their design ideas in response to a set design brief.

Engineering focus:
Learners will be working as an engineer by imagining and planning design ideas. They will take the thoughts and ideas in their heads and put it into drawings or words so someone else can respond to them (Visualising).

Learning time:
2 hours

Suggested age group:
7-9 years old

Curriculum links:
Design Technology
Learners will be:

- Using research and developing design criteria to inform the design of an innovative, functional and appealing animal deterrent that is fit for purpose and aimed at farmers.
- Visualising design ideas by generating, developing, modelling and communicating their ideas through discussion, annotated sketches, cross-sectional and exploded diagrams.

Keywords
seeds
crops
barley
oats
wheat
pest
deter
deterrent
sowing
harvest
yield

Resources:

- Soil Defenders Session 4 Presentation
- Samples of oat, wheat and barley seeds
- Sample foods made from oats, wheat & barley
- Hand lens
- NFU Farmer Video - Pest Problem
- Problem on a page - Animal Deterrent
- Laptops/electronic tablets/devices for research
- Paper, pencils, rulers etc

Optional (extension enquiry):

- A small bag of wheat seeds for planting -
- Soil/compost
- 4 x Seed Trays
- Ruler to measure the depth for planting.

Step-by-step plan

1

Spot and match it!
Pose a quick-fire challenge to learners to match the seed varieties grown on arable farms to their names and the products they make (Slide 2-6). Where possible, have real seeds and food samples available to handle and develop descriptive language to describe the seeds. Use a hand lens to support. Reveal the match using Slide 3 and continue to Slides 4-6 to identify the differences in the look of the crops when they are growing and ready for harvest. Encourage learners to use descriptive language to explain the differences they notice.

Extend: Have a variety of food stuff available to see and taste, to support pupils in connecting the crops to their everyday lives. This is important to enhance learners' awareness of food moving from farm to plate. Perhaps some learners with gluten allergies will be aware of products made from a variety of grains. Examples could include:

Oat	Wheat	Barley
flapjacks, oat porridge, muesli, oat cakes, oat milk	Weetabix, pasta, noodles, cookies and biscuits, beer, Worcestershire sauce	Barley sugar, barley flour, pearl barley e.g. Scotch Broth,

2

Introduce NFU Farmer Video - Pest Problem
In this video, the learners hear from a farmer who explains a regular problem of seed loss from fields. Explain that in this session they will be working like engineers, using their imagination to plan a mechanism that could reduce the problem of seed loss from fields resulting from rodents and birds.
Share an email to your young engineers from farmer Hannah about the problem she faces with seed loss due to pests (slide 7), you could work as a class to engage with this email further applying maths skills to exploring the questions in this optional extension maths challenge:

Extension: Maths Challenge

Posing the problem as a maths challenge will involve learners applying their knowledge of big numbers, fractions and percentages. Adapt this task to suit the ability of your class.

Task 1: What fraction or percentage of the farmers' wheat seeds are not turning into plants?

Answer: 345/460 = ¾ becoming plants ¼ being lost

Task 2: The typical area of a crop field in the UK is 800,000m^2. This farmer's field has 10 fields how many seeds are needed to plant wheat on all these fields?

Answer: The total area = 800,000m^2 x 10 = 80,000,000 m^2

The farmer plants 460 seeds per m^2

Total number of seeds = 80,000,000 m^2 x 460 seeds per m^2 = 36,800,000,000 seeds

Task 3: It takes between ½ m^2 and 1m^2 of wheat crop to make a loaf of bread. Can you estimate how many loaves of bread our farmer can produce from the wheat that is grown on the farm?

Answer: 80,000,000 loaves of bread from the 10 fields, if 1 loaf per 1m^2

40,000,000 loaves of bread from the 10 fields, if 1 loaf per ½ m^2

3

Understanding the problem we are trying to solve

Share the Problem on a page handout with learners. Provide time to do some initial research into the types of animals that may need to be deterred. The most common are rodents and birds on UK farms, including moles, wood mice, pigeons etc. (See slide 8 &9)

Stimulate some ideas by providing examples to guide thinking - how do we stop animals or pests in our daily life? E.g. stopping squirrels eating bird food using structural deterrents; bird spikes; security lights to stop intruders; sound deterrents; etc.

Use the design brief to gather learners' ideas about the types of deterrents they think could be used on a farm. Are they aware of anything that farms currently use to deter birds? The most common is of course a scarecrow!

4

What could save our seeds?

Launch the design challenge, with learners working into pairs. Remind them that they can adapt ideas from other devices or mechanisms. Access to whiteboards or flipchart paper and pens will allow them to visualise (sketch) ideas and encourage talk to describe how their device will work. The following top tips will help get them started:

- Decide which animal or animals you are going to try to deter.
- Do some research about existing devices that work as deterrents.
- List or sketch ideas that you think could deter the animals you are thinking about. Be open minded and have lots of ideas!
- Collaborate to decide which ideas to take further, and use sketching and annotations to visualise and communicate your ideas.

Discuss the ideas you consider to best meet the design criteria. Encourage peer-review by giving time for learners to go around the classroom looking at everyone else's designs. They could use sticky-notes to leave developmental and supportive comments, or questions for their peers as to how the design could be further improved.

5

Evaluate

How well will the engineered designs solve the farmer’s problem? Provide some time for learners to reflect on how well their designs have met the design brief using the table on the Problem on a page handout. Learners can score themselves out of 5 on meeting specific success criteria.

Why not share learners designs on Twitter or on social media to raise the profile of their engineering activities? @EngEduChallenge

Of course, learners may wish to create and test prototypes of their designs in your school grounds, although at this stage this is not a requirement of the challenge, if time allows the challenge could be developed further.

Want to take it further?

Consider how could you can further improve your device:
- To operate within certain hours of the day?
- To be programmable by the farmer?
- To move by itself?

How well did you do?

Success Criteria	Score /5
Weatherproof and portable	
Incorporating recycled and sustainable materials	
Incorporate moving parts	
Easy to operate and maintain	
Not harmful to animals or a nuisance to the public	

Take it further

Optional Science Investigation: Does the depth a seed is planted affect its growth?

Challenge learners to design a fair test that will answer the above question – they should work in small groups of 3 or 4 to plan their investigation. Learners should think about what depths they are going to use and how many different depths. They should also consider how they are going to measure the different depths in a precise and accurate manner and what variable they will measure to compare the plants.

Variable that will be changed	Depth of seed (mm)
Variable that will be measured	Height of plant after a fixed time (mm)
Variables that will be controlled	Type of seed, amount of water, soil/nutrients, light, temperature

Learners could sow several rows of seeds on a tray - not only would this better mimic crops growing in a field but would allow learners to gather multiple measurements and calculate the mean average of their data set. Learners will need to decide what their results table will look like in advance so they are clear about the data they are planning to gather.

Once sufficient growth has been achieved (probably after 3 or 4 weeks) learners will gather and record data. To analyse their findings, they can plot a line graph with depth of seed on the x-axis and average height of plant on the y-axis and then use this to identify trends and causal relationships.

Encourage learners to consider how their findings might impact agricultural engineers when they are designing machines to plant the seeds?

Seed Snatchers Challenge

What's the farmer's problem?

"Once I have sown my seeds, they need protecting so that my crop can grow without being damaged by birds or other animals."

Available resources:

- Internet access for research
- Large paper for visualising ideas, pens, rulers and drawing equipment

What is the design brief?

Use drawings and/or 3D models to imagine and design a device that will deter birds and small rodents from eating newly sown seeds or crops on a wheat field.

Your device will need to meet the following criteria:

- Be portable
- Be weatherproof
- Should incorporate recycled and sustainable materials
- Incorporate moving parts
- Easy to operate and maintain
- Autonomous (work by itself)
- Not harmful to the animals it deters or cause a nuisance to the public

The engineering design task

Can you devise a solution to stop crop damage caused by birds and rodents?

Birds are a major problem for farmers. They can quickly decimate an entire crop, leaving the farmer with nothing but empty fields and no income. Some birds, like pigeons and sparrows, will strip seeds from the ground. Other birds eat young plants and buds directly off the plant. The same can be true of rodents such as mice and voles. It is important therefore that farmers protect the crops they have worked so hard to produce whilst still considering the welfare of the animals.

Top tips to get started:

Think about the features and functions of the device:

- What animal(s) are you planning to deter?
- What type of deterrent best suits your purpose?
  - Auditory - what sounds would frighten the animals?
  - Visual – what sights might frighten the animals??
  - Repellents – what smells, feelings and tastes might deter animals?
- Which parts will be the moving parts of your device?
- Could your device incorporate a sensor to detect movement?
- How could the sensor be powered?
- Will your device be stationary or could it move to different parts of a field?

Background Information:

What might deter animals that eat seeds?

A gas gun creates a loud sound when the sensor is triggered.

Human figures can deter some animals.

Some animals don't like particular smells.

Some animals don't like super high pitch sounds (ultrasound).

Animals will keep away from model predators.

Materials that reflect sunlight will startle and deter animals.

Glossary:

Seeds – the grains of plants used for sowing.
Crops – a plant that is grown in a field on a large scale.
Pest – an insect or other small animal that harms or destroys plants.
Deter – to prevent or discourage someone from doing something.
Deterrent – a thing that discourages or is intended to discourage someone from doing something.
Sowing – to plant or scatter seeds for growing.
Harvest – the process or period of gathering in crops.
Yield – the amount produced of an agricultural or industrial product.

More information and inspiration!

You will probably want to research ideas to deter animals from eating seeds and seedlings. Explore some of these websites:

- 5 ways to protect crops from wold animals
- How to protect crops from birds

Want to take it further?

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Photo credits: Kolforn/Dschwen/Bird-be-gone/Nevin/Geographbot

Soil Defenders - Session 3

How can we prevent pests eating the seeds?

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Learners consider how they can help arable farmers protect cereal crops from pests so that more seeds can grow well and be harvested (the yield). Some learners apply their maths skills of fractions and percentages to find out more about the problem. They learn about the types of pests doing harm and the innovative ways that engineers create mechanisms to deter animals. They work in pairs to visualise their design ideas in response to a set design brief.

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Learning time:
2 hours

Suggested age group:
7-9 years old

Curriculum for Excellence links:

First Level:
I explore and discover engineering disciplines and can create solutions. TCH 1-12a
I can use exploration and imagination to solve design problems related to real-life situations. EXA 1-06a
I can explore and experiment with sketching, manually or digitally, to represent ideas in different learning contexts. TCH 1-11a

Second Level:
I can extend my knowledge and understanding of engineering disciplines to create solutions. TCH 2-12a
I can develop and communicate my ideas, demonstrating imagination and presenting at least one possible solution to a design problem. EXA 2-06a
I can use a range of graphic techniques, manually and digitally, to communicate ideas, concepts or products, experimenting with the use of shape, colour and texture to enhance my work. TCH 2-11a

Keywords
seeds
crops
barley
oats
wheat
pest
deter
deterrent
sowing
harvest
yield

Resources:
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- Laptops/electronic tablets/devices for research

Optional (extension enquiry):
- A small bag of wheat seeds for planting -
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Step-by-step plan

1

Spot and match it!

Pose a quick-fire challenge to learners to match the seed varieties grown on arable farms to their names and the products they make (Slide 2-6). Where possible, have real seeds and food samples available to handle and develop descriptive language to describe the seeds. Use a hand lens to support. Reveal the match using Slide 3 and continue to Slides 4-6 to identify the differences in the look of the crops when they are growing and ready for harvest. Encourage learners to use descriptive language to explain the differences they notice.

Extend: Have a variety of food stuff available to see and taste, to support pupils in connecting the crops to their everyday lives. This is important to enhance learners' awareness of food moving from farm to plate. Perhaps some learners with gluten allergies will be aware of products made from a variety of grains. Examples could include:

Oat	Wheat	Barley
flapjacks, oat porridge, muesli, oat cakes, oat milk	Weetabix, pasta, noodles, cookies and biscuits, beer, Worcestershire sauce	Barley sugar, barley flour, pearl barley e.g. Scotch Broth,

2

Introduce NFU Farmer Video - Pest Problem

In this video, the learners hear from a farmer who explains a regular problem of seed loss from fields. Explain that in this session they will be working like engineers, using their imagination to plan a mechanism that could reduce the problem of seed loss from fields resulting from rodents and birds.

Share an email to your young engineers from farmer Hannah about the problem she faces with seed loss due to pests (slide 7), you could work as a class to engage with this email further applying maths skills to exploring the questions in this optional extension maths challenge:

Extension: Maths Challenge

Posing the problem as a maths challenge will involve learners applying their knowledge of big numbers, fractions and percentages. Adapt this task to suit the ability of your class.

Task 1: What fraction or percentage of the farmers' wheat seeds are not turning into plants?

Answer: 345/460 = ¾ becoming plants ¼ being lost

Task 2: The typical area of a crop field in the UK is 800,000m^2. This farmer's field has 10 fields how many seeds are needed to plant wheat on all these fields?

Answer: The total area = 800,000m^2 x 10 = 8,000,000 m^2

The farmer plants 460 seeds per m^2

Total number of seeds = 8,000,000 m^2 x 460 seeds per m^2 = 3,680,000,000 seeds

Task 3: It takes between ½ m^2 and 1m^2 of wheat crop to make a loaf of bread. Can you estimate how many loaves of bread our farmer can produce from the wheat that is grown on the farm?

Answer: 8,000,000 loaves of bread from the 10 fields, if 1 loaf per 1m^2

4,000,000 loaves of bread from the 10 fields, if 1 loaf per ½ m^2

3

Understanding the problem we are trying to solve

Share the Problem on a page handout with learners. Provide time to do some initial research into the types of animals that may need to be deterred. The most common are rodents and birds on UK farms, including moles, wood mice, pigeons etc. (See slide 8 &9)

Stimulate some ideas by providing examples to guide thinking - how do we stop animals or pests in our daily life? E.g. stopping squirrels eating bird food using structural deterrents; bird spikes; security lights to stop intruders; sound deterrents; etc.

Use the design brief to gather learners' ideas about the types of deterrents they think could be used on a farm. Are they aware of anything that farms currently use to deter birds? The most common is of course a scarecrow!

4

What could save our seeds?

Launch the design challenge, with learners working into pairs. Remind them that they can adapt ideas from other devices or mechanisms. Access to whiteboards or flipchart paper and pens will allow them to visualise (sketch) ideas and encourage talk to describe how their device will work. The following top tips will help get them started:

- Decide which animal or animals you are going to try to deter.
- Do some research about existing devices that work as deterrents.
- List or sketch ideas that you think could deter the animals you are thinking about. Be open minded and have lots of ideas!
- Collaborate to decide which ideas to take further, and use sketching and annotations to visualise and communicate your ideas.

Discuss the ideas you consider to best meet the design criteria. Encourage peer-review by giving time for learners to go around the classroom looking at everyone else's designs. They could use sticky-notes to leave developmental and supportive comments, or questions for their peers as to how the design could be further improved.

5

Evaluate

How well will the engineered designs solve the farmer's problem? Provide some time for learners to reflect on how well their designs have met the design brief using the table on the Problem on a page handout. Learners can score themselves out of 5 on meeting specific success criteria.

Why not share learners designs on Twitter or on social media to raise the profile of their engineering activities? @EngEduChallenge

Of course, learners may wish to create and test prototypes of their designs in your school grounds, although at this stage this is not a requirement of the challenge, if time allows the challenge could be developed further.

Want to take it further?

Consider how could you can further improve your device:

- To operate within certain hours of the day?
- To be programmable by the farmer?
- To move by itself?

How well did you do?

Success Criteria	Score /5
Weatherproof and portable	
Incorporating recycled and sustainable materials	
Incorporate moving parts	
Easy to operate and maintain	
Not harmful to animals or a nuisance to the public	

Take it further

Optional Science Investigation: Does the depth a seed is planted affect its growth?

Challenge learners to design a fair test that will answer the above question – they should work in small groups of 3 or 4 to plan their investigation. Learners should think about what depths they are going to use and how many different depths. They should also consider how they are going to measure the different depths in a precise and accurate manner and what variable they will measure to compare the plants.

Variable that will be changed	Depth of seed (mm)
Variable that will be measured	Height of plant after a fixed time (mm)
Variables that will be controlled	Type of seed, amount of water, soil/nutrients, light, temperature

Learners could sow several rows of seeds on a tray - not only would this better mimic crops growing in a field but would allow learners to gather multiple measurements and calculate the mean average of their data set. Learners will need to decide what their results table will look like in advance so they are clear about the data they are planning to gather.

Once sufficient growth has been achieved (probably after 3 or 4 weeks) learners will gather and record data. To analyse their findings, they can plot a line graph with depth of seed on the x-axis and average height of plant on the y-axis and then use this to identify trends and causal relationships.

Encourage learners to consider how their findings might impact agricultural engineers when they are designing machines to plant the seeds?

Seed Snatchers Challenge

What's the farmer's problem?

"Once I have sown my seeds, they need protecting so that my crop can grow without being damaged by birds or other animals."

Available resources:

- Internet access for research
- Large paper for visualising ideas, pens, rulers and drawing equipment

The engineering design task

Can you devise a solution to stop crop damage caused by birds and rodents?

Birds are a major problem for farmers. They can quickly decimate an entire crop, leaving the farmer with nothing but empty fields and no income. Some birds, like pigeons and sparrows, will strip seeds from the ground. Other birds eat young plants and buds directly off the plant. The same can be true of rodents such as mice and voles. It is important therefore that farmers protect the crops they have worked so hard to produce whilst still considering the welfare of the animals.

What is the design brief?

Use drawings and/or 3D models to imagine and design a device that will deter birds and small rodents from eating newly sown seeds or crops on a wheat field.

Your device will need to meet the following criteria:

- Be portable
- Be weatherproof
- Should incorporate recycled and sustainable materials
- Incorporate moving parts
- Easy to operate and maintain
- Autonomous (work by itself)
- Not harmful to the animals it deters or cause a nuisance to the public

Top tips to get started:

Think about the features and functions of the device:

- What animal(s) are you planning to deter?
- What type of deterrent best suits your purpose?
  - Auditory - what sounds would frighten the animals?
  - Visual – what sights might frighten the animals??
  - Repellents – what smells, feelings and tastes might deter animals?
- Which parts will be the moving parts of your device?
- Could your device incorporate a sensor to detect movement?
- How could the sensor be powered?
- Will your device be stationary or could it move to different parts of a field?

Background Information:

What might deter animals that eat seeds?

A gas gun creates a loud sound when the sensor is triggered.

Human figures can deter some animals.

Some animals don't like particular smells.

Some animals don't like super high pitch sounds (ultrasound).

Animals will keep away from model predators.

Materials that reflect sunlight will startle and deter animals.

Glossary:

Seeds – the grains of plants used for sowing.
Crops – a plant that is grown in a field on a large scale.
Pest – an insect or other small animal that harms or destroys plants.
Deter – to prevent or discourage someone from doing something.
Deterrent – a thing that discourages or is intended to discourage someone from doing something.
Sowing – to plant or scatter seeds for growing.
Harvest – the process or period of gathering in crops.
Yield – the amount produced of an agricultural or industrial product.

More information and inspiration!

You will probably want to research ideas to deter animals from eating seeds and seedlings. Explore some of these websites:

- 5 ways to protect crops from wold animals
- How to protect crops from birds

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Photo credits: Kolforn/Dschwen/Bird-be-gone/Nevin/Geographbot

SOIL DEFENDERS

SESSION 3

How can we prevent pests eating the seeds?

Match the name of the **arable crop** to the **seed** and then the **product**

barley

wheat

oats

Image credits: H. Zell/epicbeer/CIMMYT/insatiablemunch/Didriks/avlxyv/NSW DPI Schools program oats

Porridge, flapjacks, oatcakes

wheat

Bread, pasta

barley

Beer, barley water, scotch broth

Image credits: H. Zell/epicbeer/CIMMYT/insatiablemunch/Didriks/avlxyv/NSW DPI Schools program

oats

Image credits: H. Zell/insatiablemunch/sebilden

wheat

Image credits: CIMMYT/NSW DPI Schools program/born1945

barley

Image credits: epicbeer/avlxyv/Yoshimai

To youngengineer@engineeringeducates.org

Bcc

Cc

Add a subject I need your help!

Dear Young Engineers,

Every year I sow around 460 wheat seeds per every square metre of my fields, and I need at least 400 of these seeds to grow into mature plants if I am going to get the yield I need.

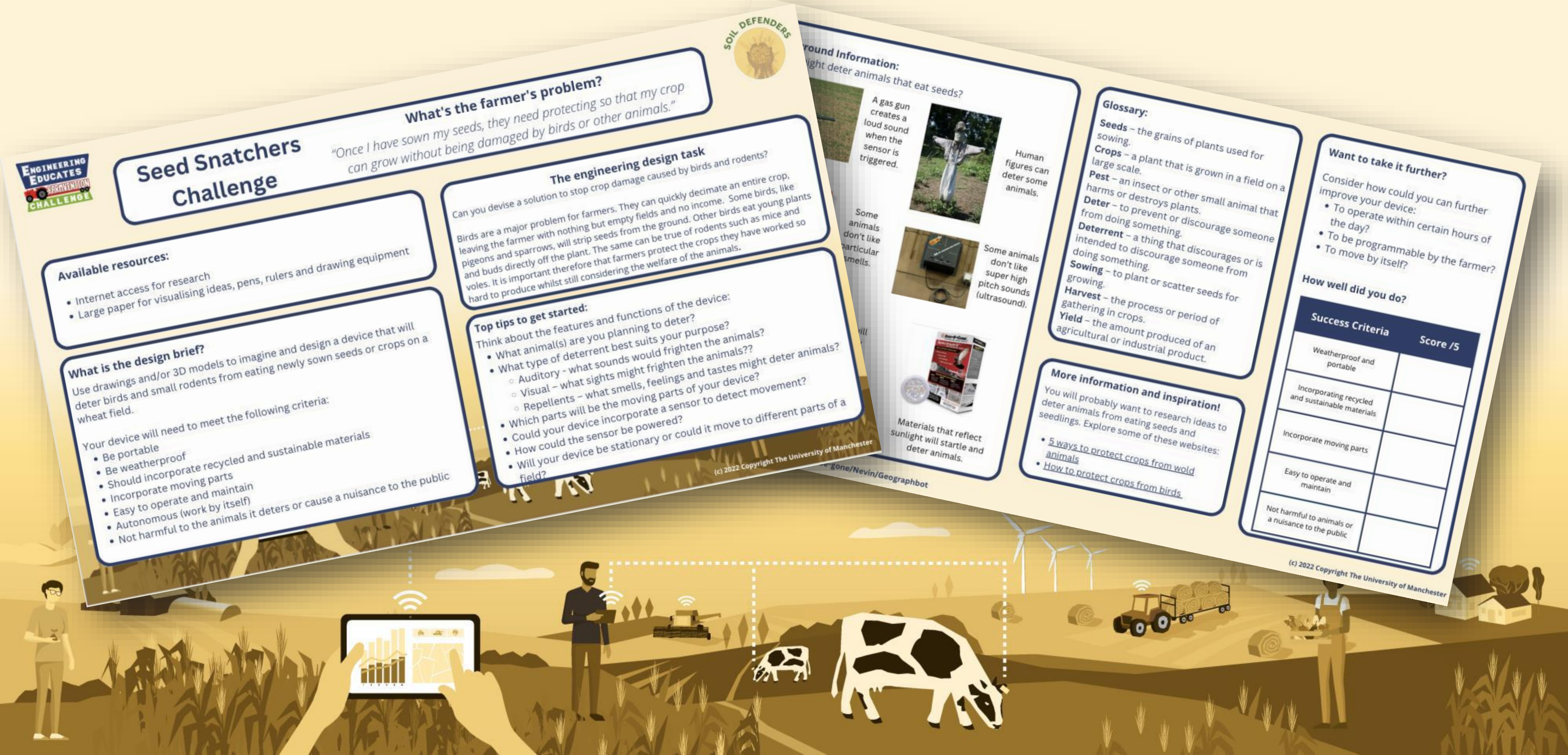
In the last few years, I have seen a rise in pests, like small rodents such as rats and field mice as well as birds like seagulls and crows, eating my newly planted seeds before they germinate. My crop yield is as low as 345 plants per square metre which is a problem.

Although these animals are all important to the ecosystem and I have done a lot to increase biodiversity on my farm. I am seeking solutions to deter them from ruining my crop.

Any suggestions?

Farmer Hannah

Seed Snatchers Challenge




mice
rats
seagulls
crows
Image credits: Kentish Plumber/Sergey Yeliseev/Szoki Adams/TruShu

Today we have been working like an engineer by **imagining and planning** possible solutions to the problem of pests eating freshly sown seeds.

SOIL DEFENDERS

Soil Defenders - Session 4

How could we sow seeds without compacting the soil?

Context:
Pupils continue to work within the engineering design cycle, with a focus on creating prototypes for a machine for seed sowing that avoids soil being damaged and compacted. In their design, they consider the different steps within the seed sowing process and how to respond to the farmers' need to make sure that seeds are dispersed evenly and in a straight line.

They learn about how the Small Robot Company engineers are innovating robots to support farmers in becoming more sustainable in the way they work on arable farms.

Engineering Focus: Working like engineers by creating a simple machine to sow seeds, thinking about the parts of a system and how they work together.

Learning time:
2 hours

Suggested age group:
7-9 years old

Curriculum links:
Pupils will be:
- Selecting from and using a wider range of materials and components, including construction materials, according to their functional properties.
- Applying understanding of how to strengthen, stiffen and reinforce more complex structures as well as understanding and using simple mechanical systems in the products they create.

Keywords
ploughing
planting
fertilising
harvesting
transporting
soil compaction
sowing
seed drill
hopper
pipe
coulter
tines
prototype
system

Resources:
- Soil defenders Session 4 PPT
- 5mm thick strong corrugated card (from a recycled box)
- 3mm skewers/dowel/straws
- Seeds/beads/marbles
- PVA glue/Glue gun/Masking tape
- Scissors/craft knife/cutting mat
- cardboard tubes
- recycled boxes
- A4 sheet of light card to make templates
- Problem on a Page: Soil Saver Challenge handout

Step-by-step plan

1

Recap what we know about the processes that take place on an arable farm over the year.
Support pupils in matching photos of processes on the arable farms to their place in the cycle of 'a year on a farm'. Begin by checking their understanding of each key word in the cycle (Slide 2) and then ask children to talk in pairs about what they can see the heavy machinery is being used to do and what process this might be. Key questions:

- From the photos - What have all these processes got in common? (All use heavy machinery)
- What problems do heavy machinery cause? (Soil compaction, pollution)

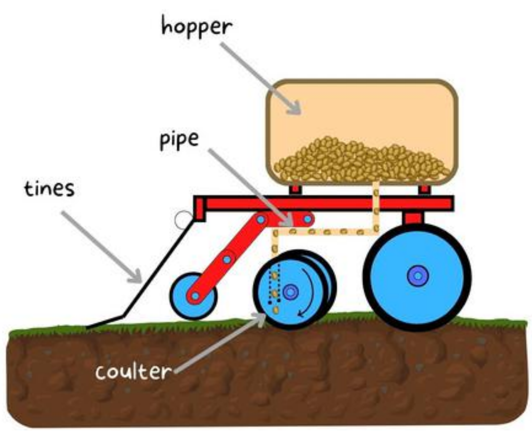
2

How are agricultural engineers inventing solutions to common problems on arable farms? A case study.
Watch the NFU 'Agricultural Video' through the link on our website.
In addition, you can watch the video about how an engineering company called the **Small Robot Company** have developed **three small robots Tom, Dick and Harry** to solve some of the problems with arable farming. This introduces the pupils to how agricultural engineers are finding creative solutions to avoid using heavy machines that cause soil compaction and making the most of modern technology. Encourage pupils to discuss how the small robots solve some of the problems they have learnt about.

3

Innovating sowing seeds
Support pupils in looking at how seeds are planted today using larger machinery by watching a **video of a seed drill in action** and then taking a closer look at the parts of the system and their jobs (Slides 3 and 4).

Explain that engineers are experts at making things and making things work better by reducing or solving problems. Explain that in this session the pupils will be thinking as engineers to come up with ways that seeds could be sown without the use of heavy machinery.



Step-by-step plan

4

Creating prototypes for a seed dropping device

Pupils work in pairs to create a prototype seed dropping device. Provide them with the 'Problem on a page' handout that clearly outlines their challenge and design brief (slide 5).

Provide materials listed in the resources section of these teacher notes and challenge your pupils to develop a small prototype device that drops seeds/beads/marbles as it rolls along.

Try to limit guidance to that provided on the 'Problem on a page' to encourage your pupils to think creatively and come up with their own unique solution to the problem.

5

Evaluate as an engineer

Once pupils have made, tested and tinkered with their prototype they should evaluate how well they have met the design brief.

Encourage them to explain:

- What are the essential parts of the system in their seed dropper?
- How well their seed dropper meets the design criteria?
- How their seed dropper might help solve the problem of soil compaction?

If the opportunity arises pupils can share their prototype with a farmer, engineer or a family member to practice communicating their ideas with an audience.

Revisit the Engineering Design Cycle for learners to reflect on how they have been working as an engineer through the Soil Save Challenge (slide 6).

Take it further

Adapting a design to match the needs of the farmer (Slide 7)

Should you want to allocate more classroom time for pupils to work on their prototypes you could challenge them to **adapt** their designs to meet the specific needs of a particular farmer:

- I need the drill to hold bigger seeds.
- I need the seeds to be dropped further apart.
- I need the seed drill to carry more seeds for larger fields.

Soil Saver Challenge

What's the farmer's problem?

"I need to sow my seeds evenly without compacting the soil too much, as this can mean the plants don't grow as well."

Available resources:

For wheels & axles – cardboard, straws, dowel, skewers;
For the body and hopper – tissue box, cardboard tubes, plastic bottles/box;
For the seeds – seeds/rice/marbles/beads.
Other useful materials:
corrugated cardboard, craft sticks, paper cups, masking tape, glue, scissors, rubber bands.

What is the design brief?

Use drawings and/or 3D models to create a prototype of a seed dropping device that reduces the chance of soil compaction.

Your design will need to meet the following criteria:

- Seeds should be dropped automatically (not by hand)
- It should touch the ground when seeds are being dropped
- Should be operated by only one person
- Seeds should be dropped or 'planted' in a straight line
- Seeds should be a similar distance apart

The engineering design task

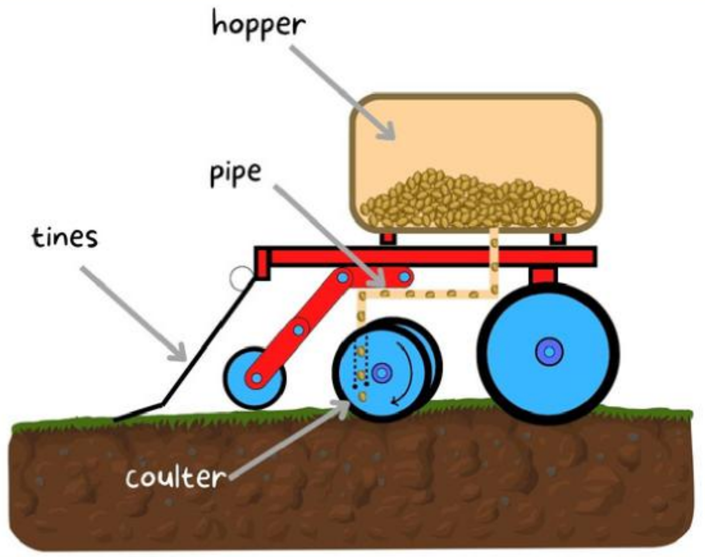
Can you find a way to make a simple seed dropping device which helps the farmer to solve his compaction problem?

Farmers use special machines called seed drills to make sure that the seeds are planted evenly. These machines can be very heavy and cause the soil to become compacted which can make it hard for a plant's roots to reach enough oxygen and water. The heavier the machinery the more likely that compaction will happen. Your challenge is to come up with an idea for a lightweight alternative.

Top tips to get started:

Think about the component parts of a seed drill system:

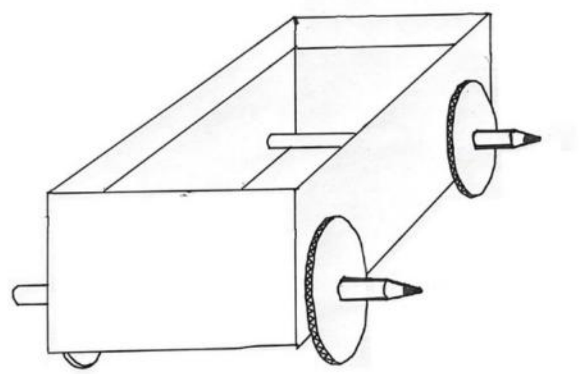
- What does the hopper and pipe do?
- What could you use for these parts of the system?
- Where will you have seed storage?
- What will stop seeds falling out?



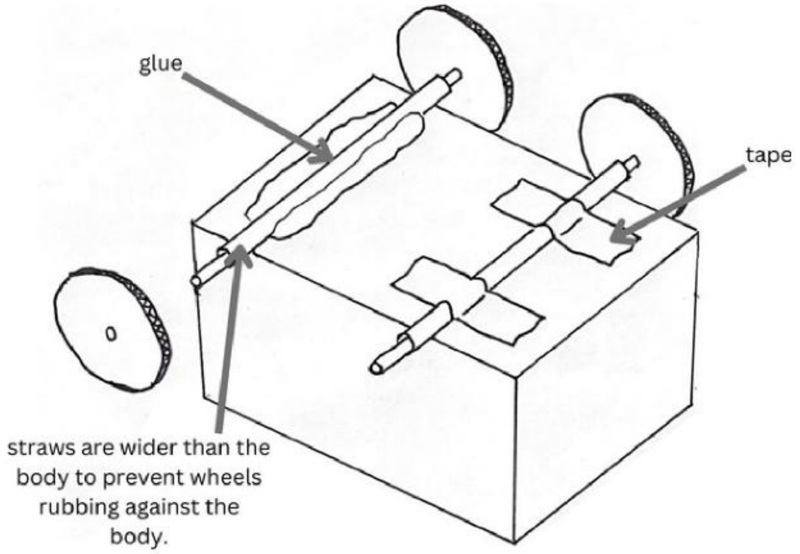
Background Information:

How will you make a moving vehicle?

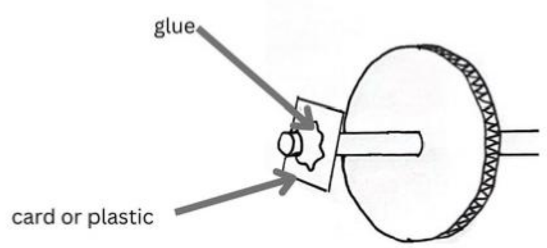
There are different ways to fix wheels.

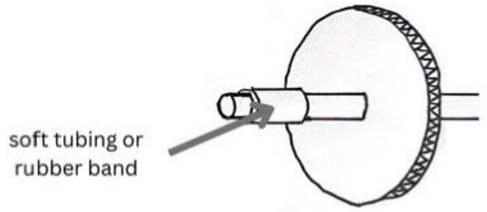


You could use pencils, chopsticks, doweling or skewers as axles.



Placing your axles through a straw can help stop the wheels rubbing.





Wheels can be attached to the axle with card, plastic, tubing, glue or rubber bands.

Think about the system used in a seed drill. How could you adapt your vehicle so that it drops seeds as it moves along?

If you are stuck for ideas take a look at the **Soil Saver Challenge Get Yourself Unstuck Guide**.

Glossary:

Seed Drill - a device used to sows seeds for crops by positioning them in the soil and burying them to a specific depth while being dragged by a tractor.

Hopper – stores the seeds to be planted above the rest of the machine so that the force of gravity helps them fall through to be planted.

Pipe – a shoot for the seeds to travel through, from the hopper to the soil.

System – a set of related parts or components that work together to produce an outcome.

Axle – a rod on which one or more wheels can rotate, either freely or be fixed to and turn with the axle.

Axle holder – the component through which an axle fits and rotates.

More information and inspiration!

Take a look at these videos of other people's solutions to the problem to get some ideas:

- Loo Roll Roller
- Tissue Box Triumph

Want to take it further?

Can you consider how you can improve your machine to:

- hold more seeds?
- drop seeds further apart?
- plant larger seeds?

How well did you do?

Use the problem-solving score card to evaluate how well you performed in this design and make/create task?

Success Criteria	Score /5
Device drops seeds	
Seeds are evenly spread	
Easily operated by one person	
Made from recycled materials	
Seeds fall in a straight line	

Soil Defenders - Session 4

How could we sow seeds without compacting the soil?

Context:
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Engineering Focus: Working like engineers by creating a simple machine to sow seeds, thinking about the parts of a system and how they work together.

Learning time:
2 hours

Suggested age group:
7-9 years old

Curriculum for Excellence links:

First Level:
I explore and discover engineering disciplines and can create solutions. TCH 1-12a
I can use exploration and imagination to solve design problems related to real-life situations. EXA 1-06a
I can explore and experiment with sketching, manually or digitally, to represent ideas in different learning contexts. TCH 1-11a

Second Level:
I can extend my knowledge and understanding of engineering disciplines to create solutions. TCH 2-12a
I can develop and communicate my ideas, demonstrating imagination and presenting at least one possible solution to a design problem. EXA 2-06a
I can use a range of graphic techniques, manually and digitally, to communicate ideas, concepts or products, experimenting with the use of shape, colour and texture to enhance my work. TCH 2-11a

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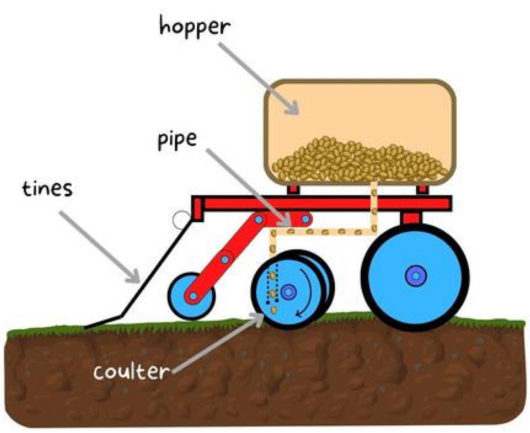

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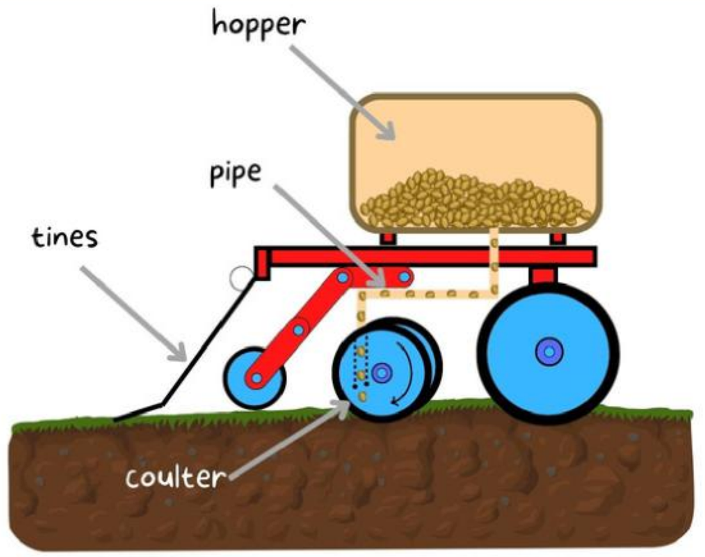

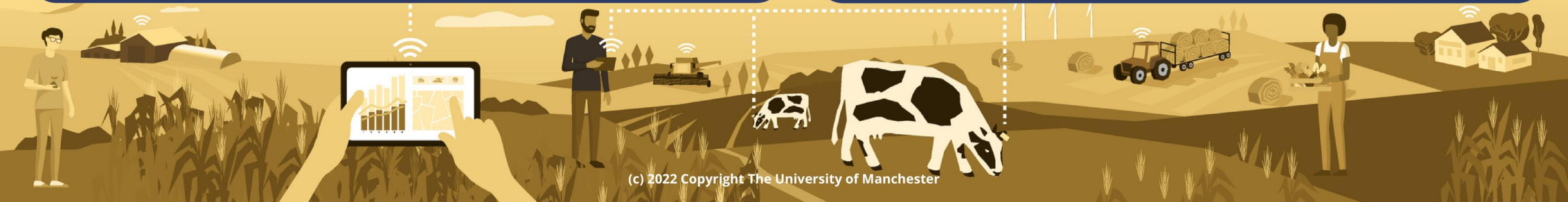

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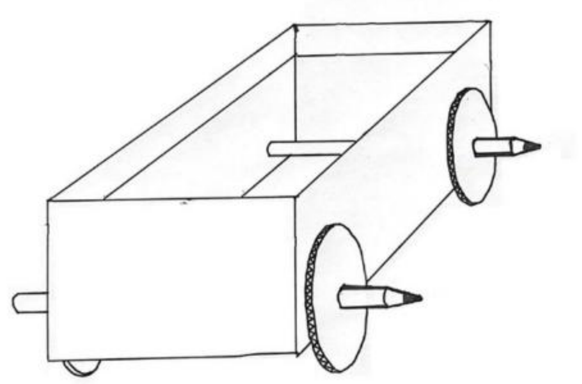

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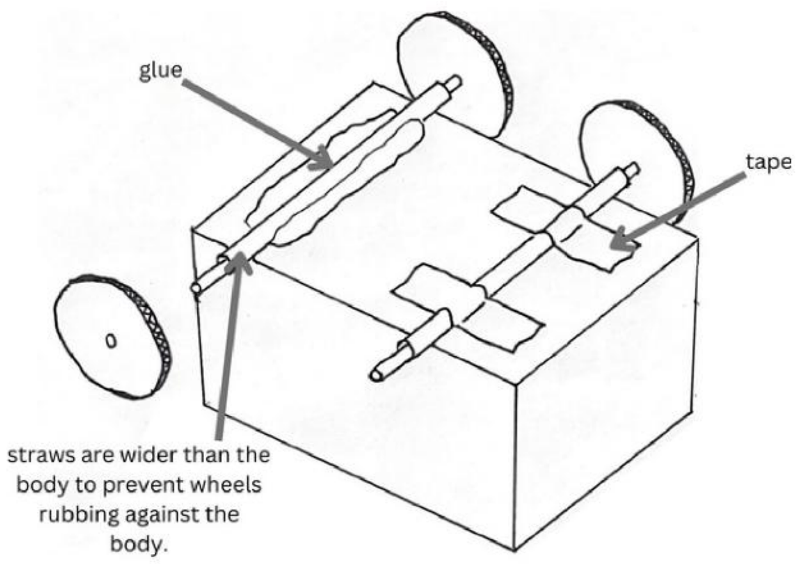
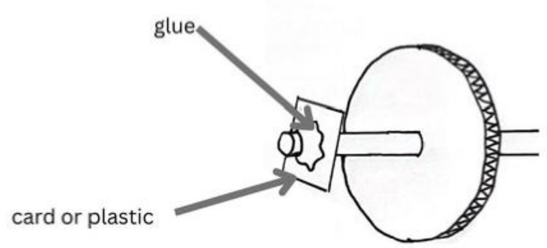
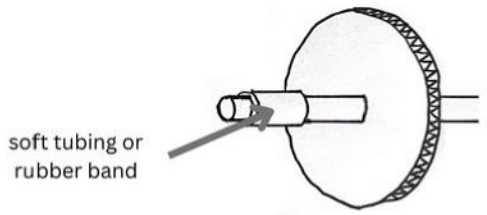


Placing your axles through a straw can help stop the wheels rubbing.





Wheels can be attached to the axle with card, plastic, tubing, glue or rubber bands.

Think about the system used in a seed drill. How could you adapt your vehicle so that it drops seeds as it moves along?

If you are stuck for ideas take a look at the **Soil Saver Challenge Get Yourself Unstuck Guide**.

Glossary:

Seed Drill - a device used to sows seeds for crops by positioning them in the soil and burying them to a specific depth while being dragged by a tractor.

Hopper – stores the seeds to be planted above the rest of the machine so that the force of gravity helps them fall through to be planted.

Pipe – a shoot for the seeds to travel through, from the hopper to the soil.

System – a set of related parts or components that work together to produce an outcome.

Axle – a rod on which one or more wheels can rotate, either freely or be fixed to and turn with the axle.

Axle holder – the component through which an axle fits and rotates.

More information and inspiration!

Take a look at these videos of other people's solutions to the problem to get some ideas:

- Loo Roll Roller
- Tissue Box Triumph

Want to take it further?

Can you consider how you can improve your machine to:

- hold more seeds?
- drop seeds further apart?
- plant larger seeds?

How well did you do?

Use the problem-solving score card to evaluate how well you performed in this design and make/create task?

Success Criteria	Score /5
Device drops seeds	
Seeds are evenly spread	
Easily operated by one person	
Made from recycled materials	
Seeds fall in a straight line	

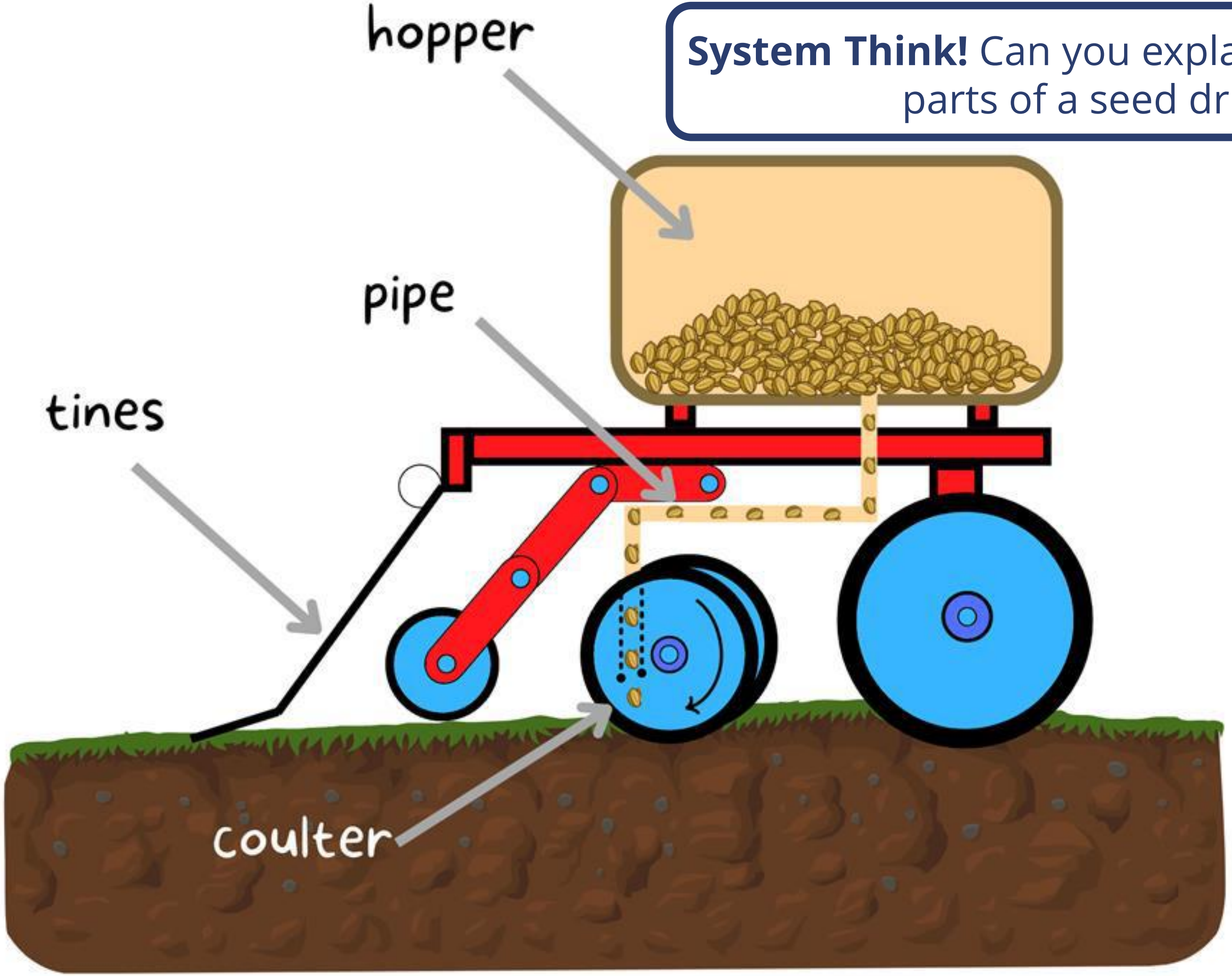
SOIL DEFENDERS

SESSION 4

How can we engineer solutions to protect the soil?

Which is which?

System Think! Can you explain how the component parts of a seed drill make up the system?



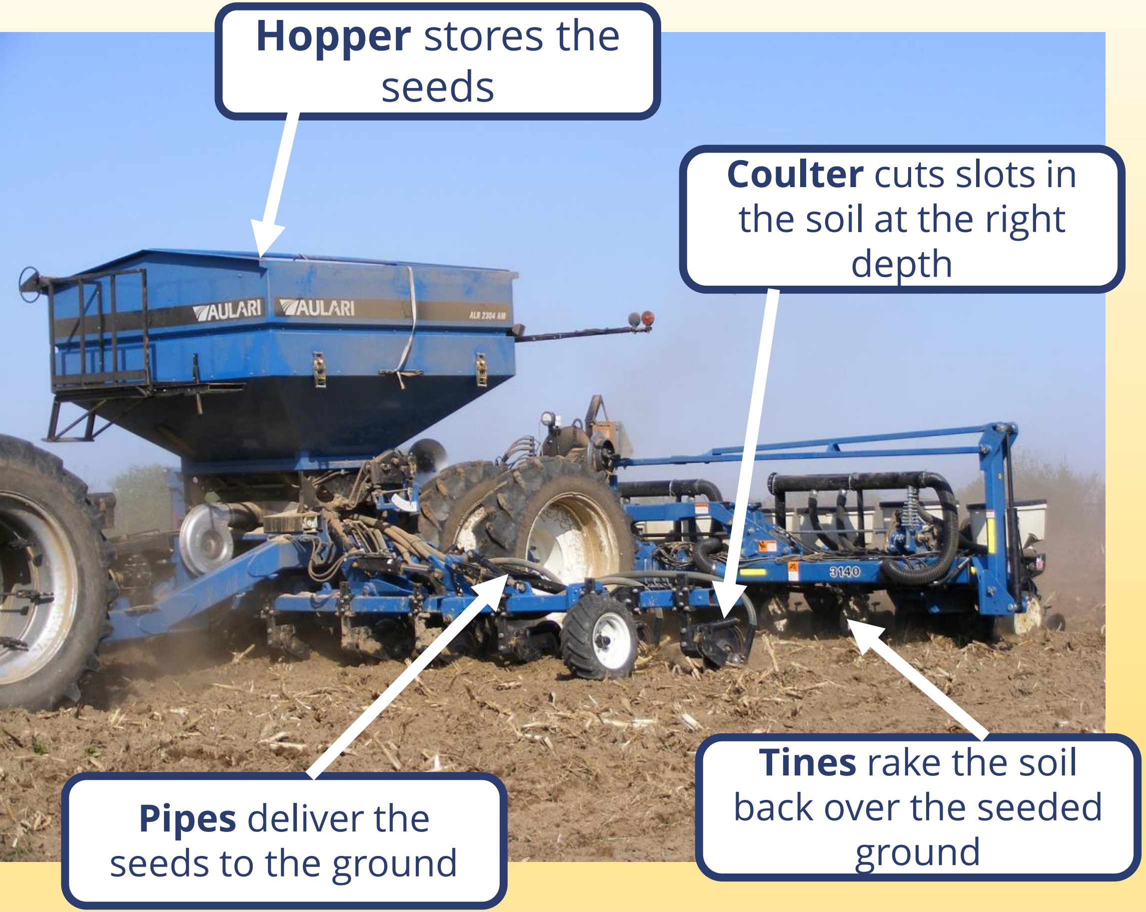
Hopper: Stores the seeds to be planted above the rest of the machine so that the force of gravity helps them fall through to be planted.

Pipe: A shoot for the seeds to travel through, from the hopper to the soil.

Coulter: Cuts a slot in the soil at just the right depth for the seeds to fall into.

Tines: Always at the back of the seed drill to rake the soil back over the soil when the seeds are dropped.

How do arable farmers sow seeds?



Seed drills: are pulled behind tractors and cut a trench in the soil. They drop seeds into the trench and then cover them over with soil.

Why might the soil on top be good for the seeds to grow?

Image credits: L P Guertin

Soil Saver Challenge

What's the farmer's problem?

"I need to sow my seeds evenly without compacting the soil too much, as this can mean the plants don't grow as well."

Available resources:

For wheels & axles – cardboard, straws, dowel, skewers;
For the body and hopper – tissue box, cardboard tubes, plastic bottles/box;
For the seeds – seeds/rice/marbles/beads.
Other useful materials:
corrugated cardboard, craft sticks, paper cups, masking tape, glue, scissors, rubber bands

The engineering design task

Can you find a way to make a simple seed dropping device which helps the farmer to solve his compaction problem?

Farmers use special machines called seed drills to make sure that the seeds are planted evenly. These machines can be very heavy and cause the soil to become compacted which can make it hard for a plant's roots to reach enough oxygen and water. The heavier the machinery the more likely that compaction will happen. Your challenge is to come up with an idea for a lightweight alternative.

What is the design brief?

Use drawings and/or 3D models to create a prototype of a seed dropping device that reduces the chance of soil compaction.

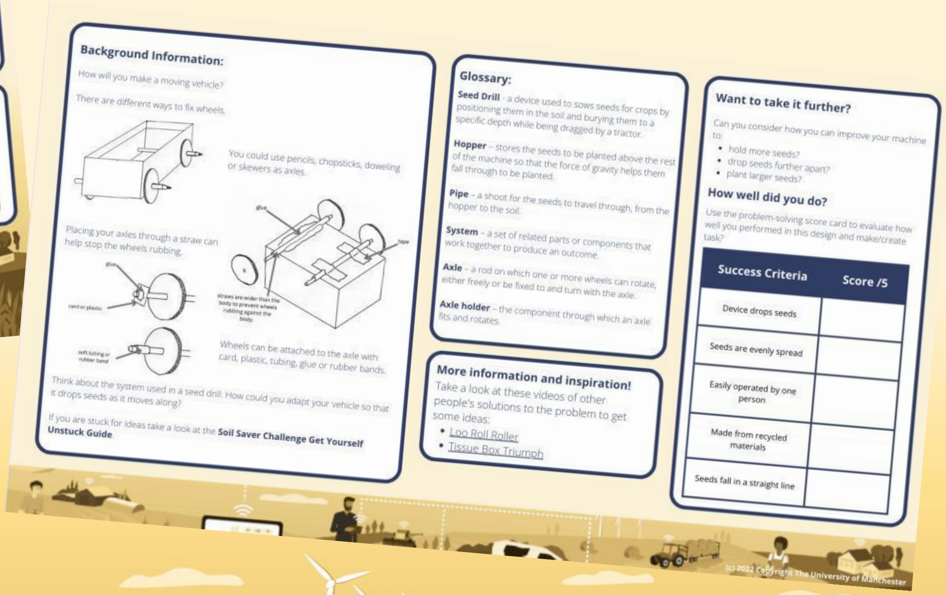
Your design will need to meet the following criteria:

- Seeds should be dropped automatically (not by hand)
- It should touch the ground when seeds are being dropped
- Should be operated by only one person
- Seeds should be dropped or 'planted' in a straight line
- Seeds should be a similar distance apart

Top tips to get started:

Think about the component parts of a seed drill system:

- What does the hopper and pipe do?
- What could you use for these parts of the system?
- Where will you have seed storage?
- What will stop seeds falling out?



Background Information:

How will you make a moving vehicle?

There are different ways to fix wheels.

You could use pencils, chopsticks, doweling or skewers as axles.

Placing your axles through a straw can help stop the wheels rubbing.

Wheels can be attached to the axle with card, plastic, tubing, glue or rubber bands.

Think about the system used in a seed drill. How could you adapt your vehicle so that it drops seeds as it moves along?

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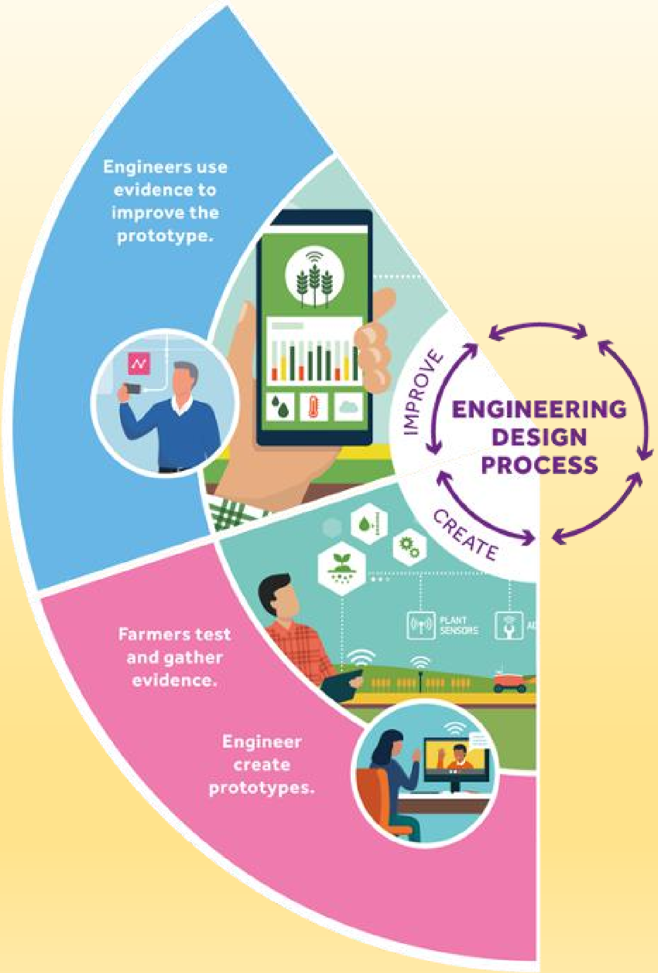


Today we have been working like an engineer by **creating and improving** a prototype seed dropper to reduce the problem of soil compaction.

Can adapt your prototype to meet these farmers' needs?

SOIL DEFENDERS

Soil Defenders - Session 5

How can automation make fertilising fields more efficient?

Learning time:
2 hours

Suggested age group:
7-9 years old

Context:
Learners think about how technology can improve new innovations in arable farming. After harvesting, the soil is depleted of nutrients, and farmers use slurry to add nutrients back into the soil, ready for new crops. Learners create a program on the micro:bit which simulates turning the slurry spray on and off so that waterways or neighbouring properties are protected from excess slurry going over the field boundaries.

Engineering focus:
Learners will be working as an engineer by improving design ideas. They will take the thoughts and ideas in their heads and put it into drawings or words so someone else can respond to it.

Keywords
automation
efficiency
fertiliser
nutrients
slurry
Microbit
program
algorithms
debug
sequence
input
output

Curriculum links: *Computing*
Learners will be:

- designing, writing and debugging programs that accomplish specific goals, including controlling or simulating physical systems
- using sequences in programs
- working with various forms of input and output device.

Resources:

- Challenge Instruction Video
- computer with access to the internet for MakeCode
- micro:bits (or micro:bit simulator at MakeCode)
- servos (optional)

If you don't have micro:bits in your school, you can still complete this lesson using the online micro:bit simulator at https://makecode.microbit.org/

Step-by-step plan

1

Understanding the problem

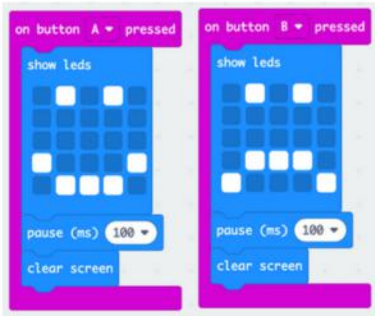
Ask learners to talk about and share what might have happened in the photo on slide 2. Explain that the first picture is of a car which was parked too close to a field when a farmer was spraying the field with slurry to fertilise the soil.

Explain that farmers spray their fields with fertiliser and their challenge will be to create a technological solution to prevent the spray going beyond their field (slide 3). The task is to engineer a solution to turn off the spray as the tractor turns at the boundary of the field, and then automatically turn it on again. Explain that the micro:bit is a small computer that will simulate whether the tractor is spraying or not (slide 4 & 5).

2

Code Exploration

Explain to learners that we will be using the micro:bit's buttons to explore how these work with some simple code. Display the code on slide 6 and ask the learners what they think the commands might do when the program is run. Why do they think this?



MakeCode commands are quite easy to read as they use clear language terms. When run, this code will display a smiling face on the LEDs when button A is pressed and a sad face when button B is pressed. Both faces will disappear after 100ms and the screen will be clear again. Give learners time to add the above code to their micro:bits. Ask learners to run the code to see if their predictions were correct.

Challenge the learners to:

- change what is displayed by clicking on the individual LEDs
- add another 'on button pressed' command and get the micro:bit to display something different when buttons A+B are pressed together
- change the time the LEDs display for before the screen is cleared.

Then lead a class discussion to consolidate key learning about the code, namely:

- When a button is pressed this triggers the LEDs to display the pattern chosen.
- The 'pause' command can be used to change the duration the LEDs display for before the screen is cleared.
- The 'clear screen' command sets all the LEDs to off.

Image Credit: Andy Harris/Graham Horn

3

Using the Microbit to solve a problem:

Remind learners of our problem: *we want to create a technology solution to prevent the manure being sprayed beyond the field when the tractor reaches the boundary*. Explain to learners that the micro:bit's LEDs will be used to simulate whether the tractor is spraying or not. When it is spraying, the LEDs will look as shown below and will be off when it is not spraying (slide 7).

LEDs to show tractor is spraying

Ask learners to consider how we could use what we have just learnt to tackle this challenge. Lead a discussion to arrive at the following ideas:

- the manure spray could be turned off by pressing a button on the Microbit
- the spray could automatically resume after an amount of time using the 'pause' command
- different buttons could pause the spray for longer - if the tractor had to cross a road between fields for example.

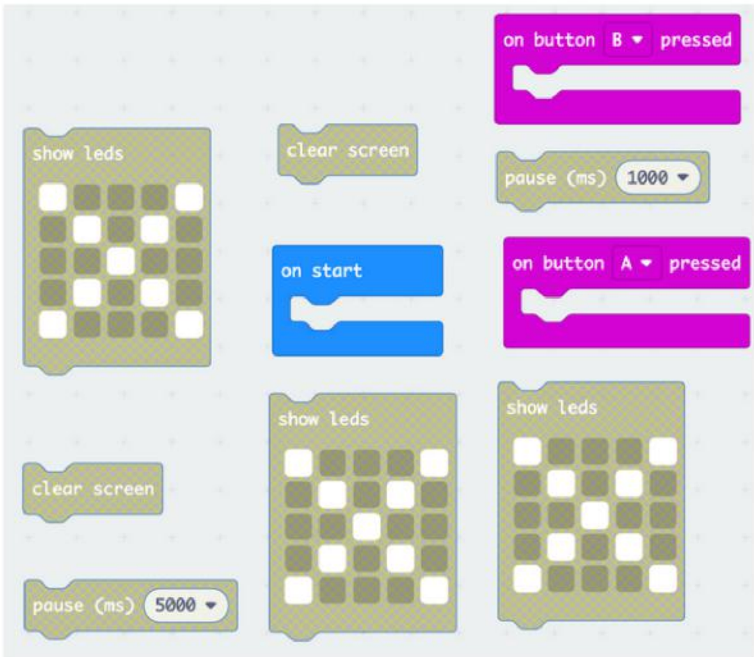
4

Support learners' programming: Parson's Problem

A Parson's problem scaffolds programming tasks by providing learners with all the code they need to complete a problem but doesn't show how the code should be combined (slide 8).

Ask learners to add the following commands to their micro:bit project and task them to combine the code to complete our challenge: for instance,

- spraying starts when the program is run.
- spraying is paused for different amounts of time when either the A or B button is pressed and then automatically resumes.

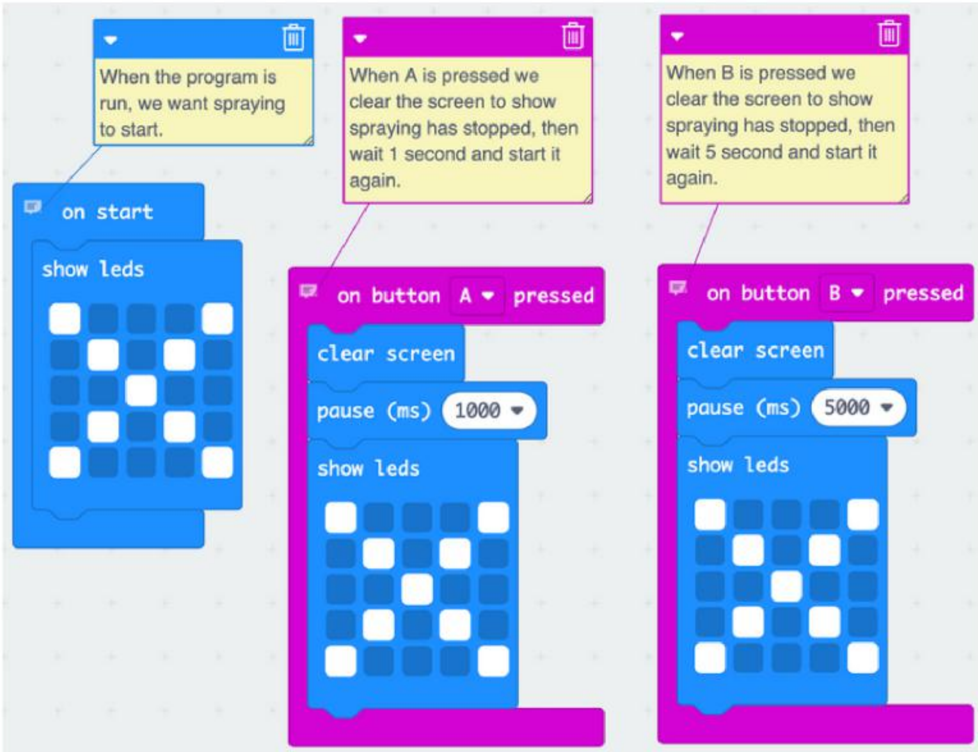


5

Share the solution to the problem (slide 9)

Do learners think the time the spraying is paused for is enough? Can they change their code to increase it?

Allow plenty of time for learners to tinker with their code to improve their solution to the problem.



6

Evaluate:

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

- Turn the spray off when the buttons were pressed on the micro:bit (tractor)?
- Turn the spray back on automatically after different lengths of time?

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

Further links:

- Micro:bit Education Foundation
- Information about the new (2022) micro:bit V2
- Information about micro:bit accelerometer
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Soil Defenders - Session 5

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Curriculum for Excellence links:
First Level:
I explore and discover engineering disciplines and can create solutions. TCH 1-12a
I can demonstrate a range of basic problem solving skills by building simple programs to carry out a given task, using an appropriate language. TCH 1-15a
Second Level:
I can extend my knowledge and understanding of engineering disciplines to create solutions. TCH 2-12a
I can create, develop and evaluate computing solutions in response to a design challenge TCH 2-15a

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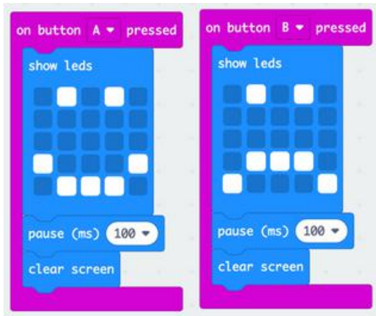

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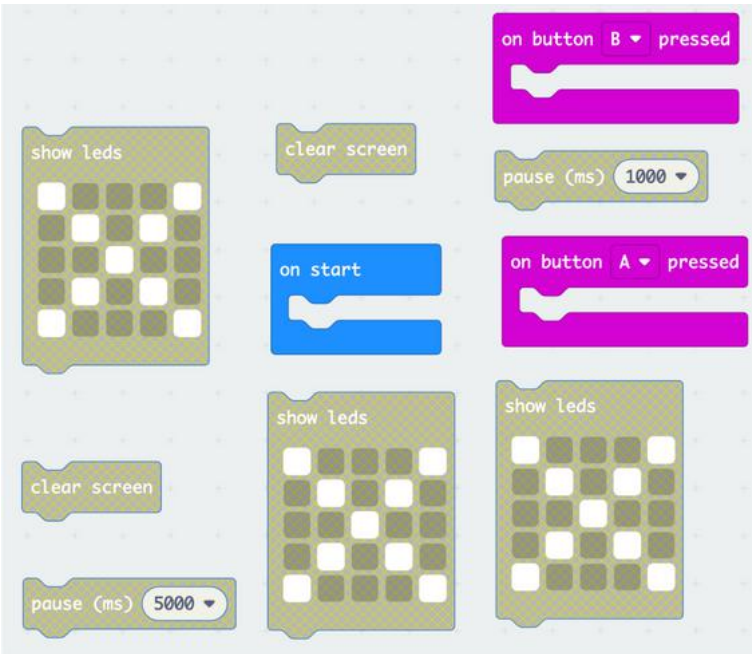

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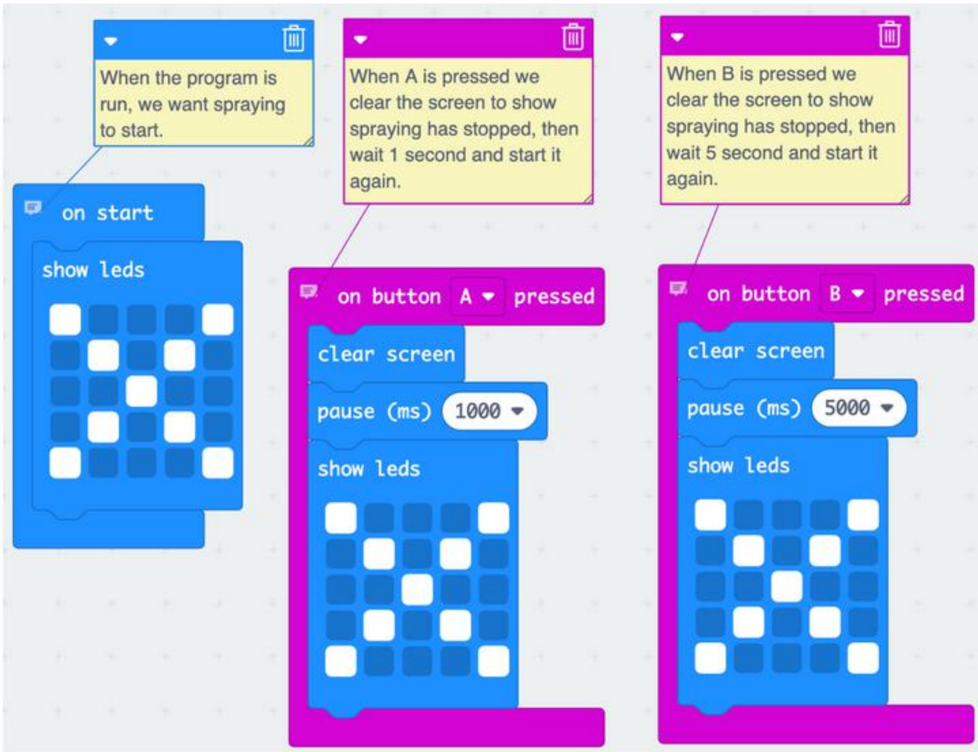

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SOIL DEFENDERS

SESSION 5

Spray-Stop-Spray

Oh no! What's happened here!?

Could we use technology to find a solution to farmers spraying beyond their fields by turning off the spray as the tractor turns at the boundary and then automatically turning it back on again?

Image credits: Andy Harris / Graham Horn

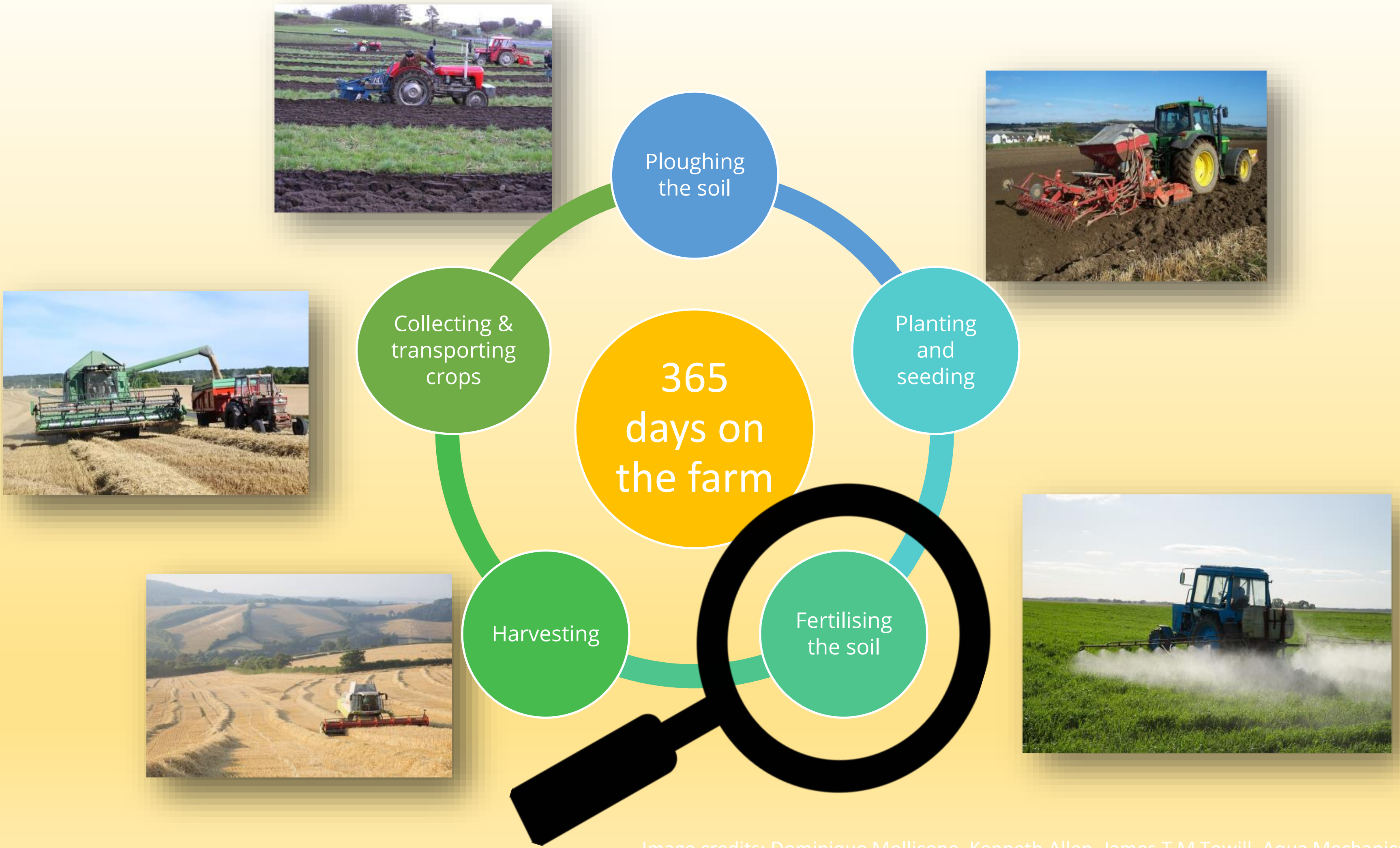
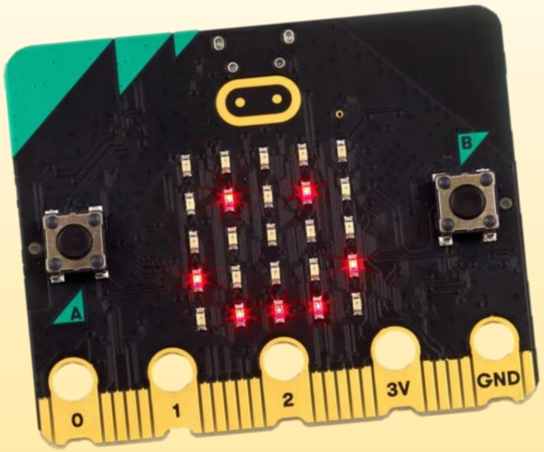
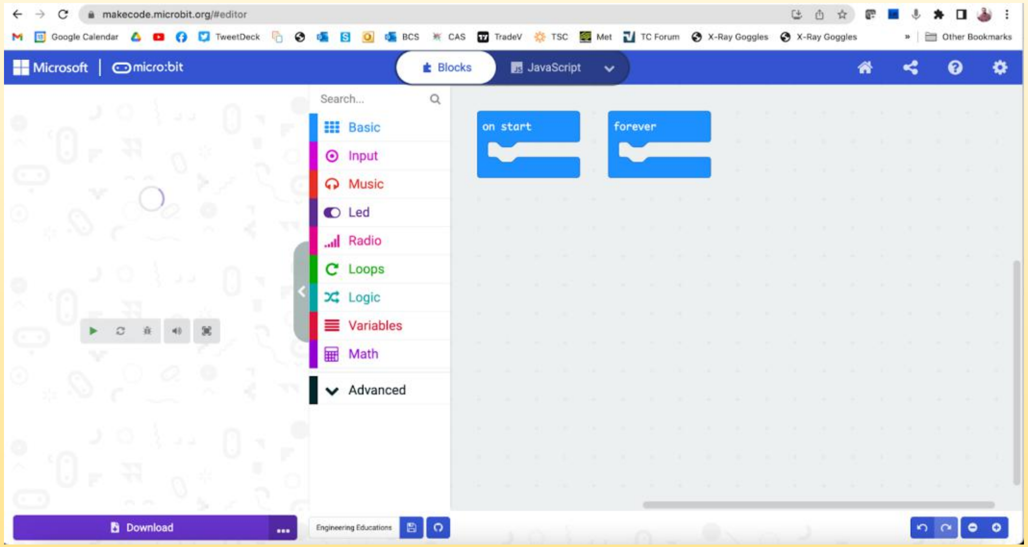


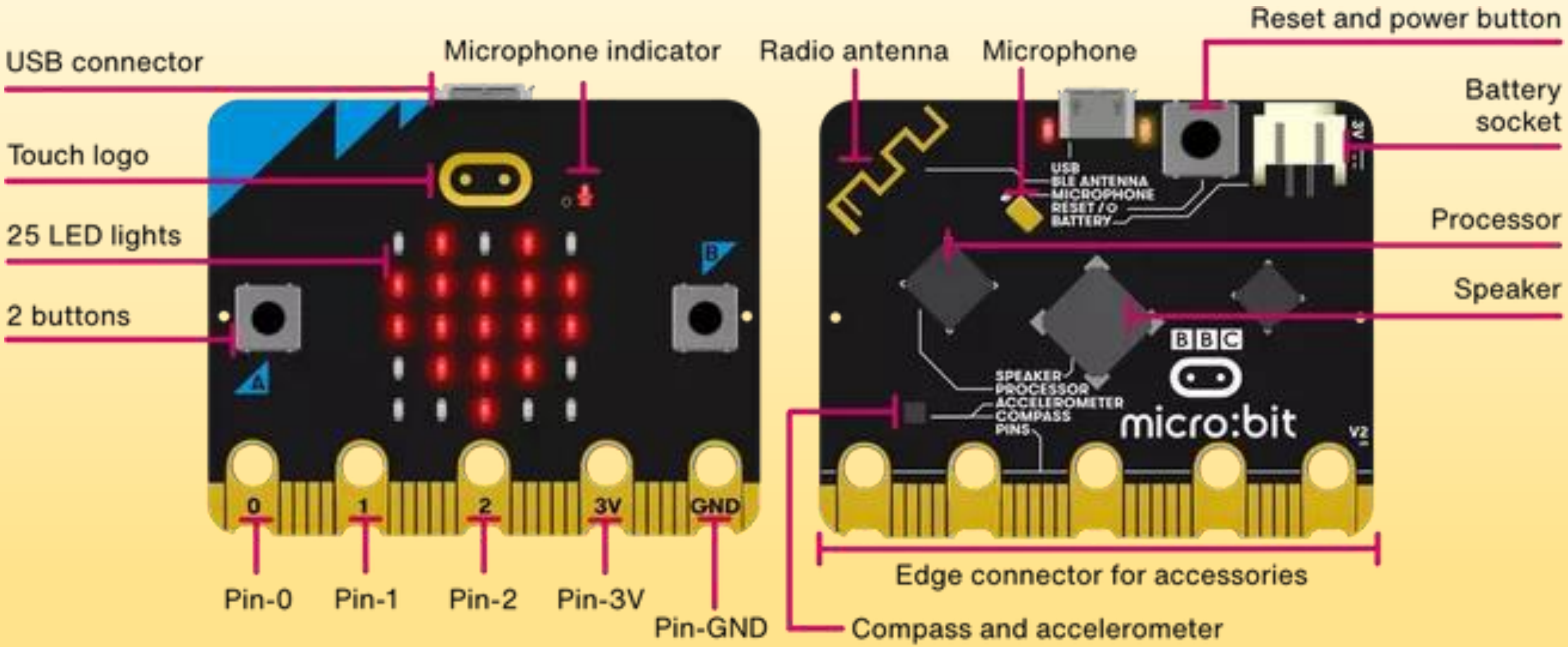
Image credits: Dominique Mollicone, Kenneth Allen, James T M Towill, Aqua Mechanical, RRayner

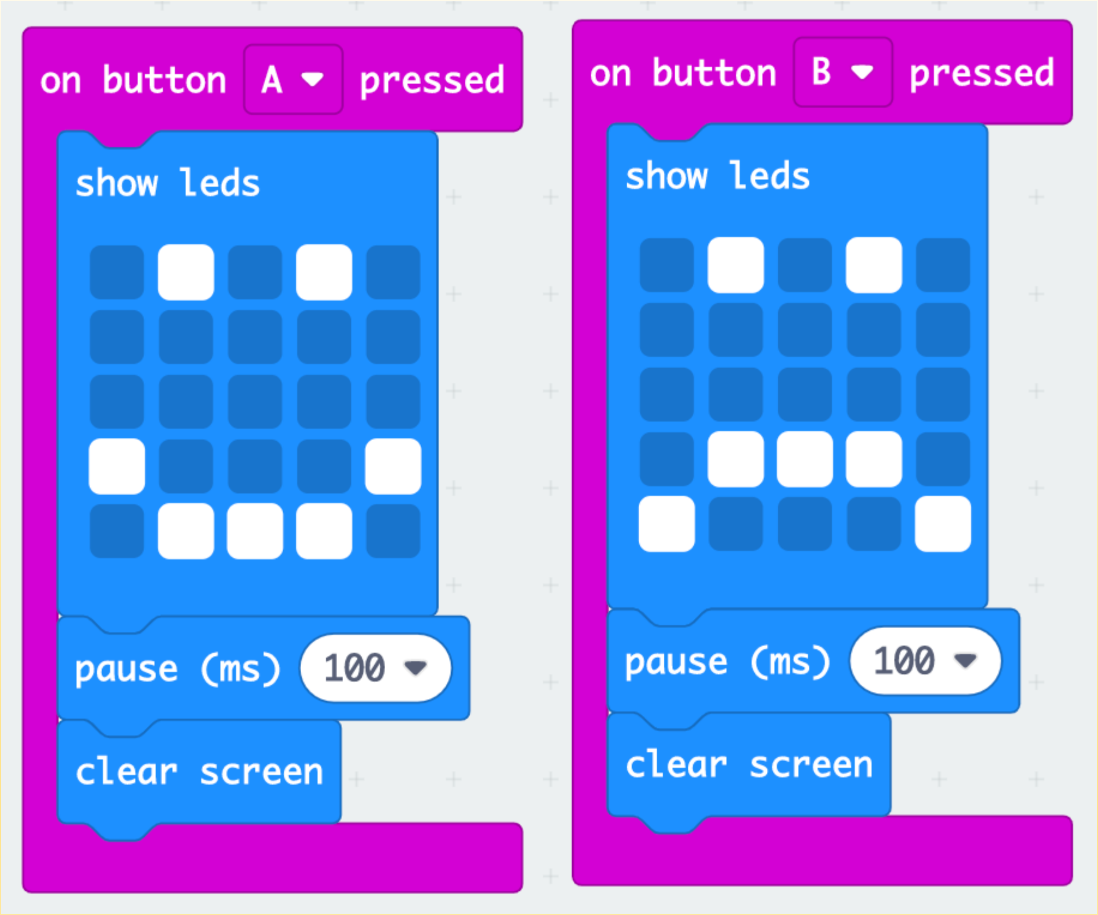


Micro:bit



Make Code Editor


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
USB
BLE ANTENNA
MICROPHONE
RESET / O
BATTERY
SPEAKER
PROCESSOR
ACCELEROMETER
COMPASS
PINS
BBC
micro:bit
V2
Edge connector for accessories
Compass and accelerometer



Challenge yourself

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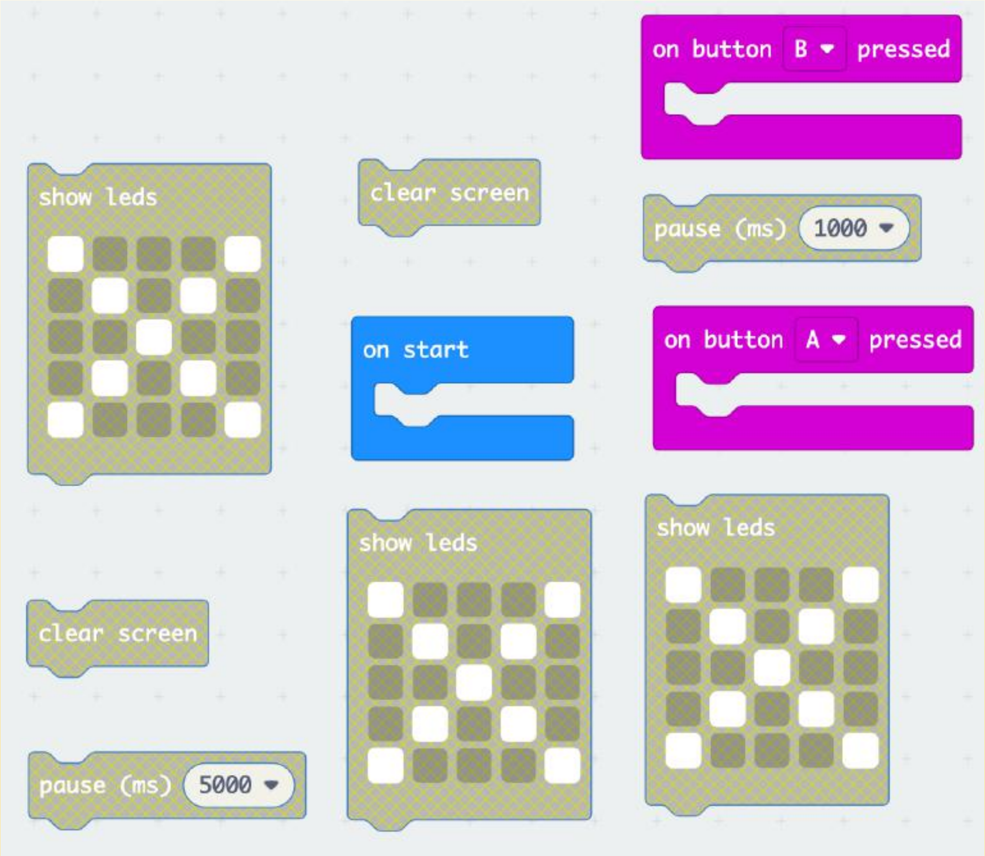
LEDs to show
tractor is spraying

How could we use the Micro:bit to tackle this challenge?

Parson's Problem

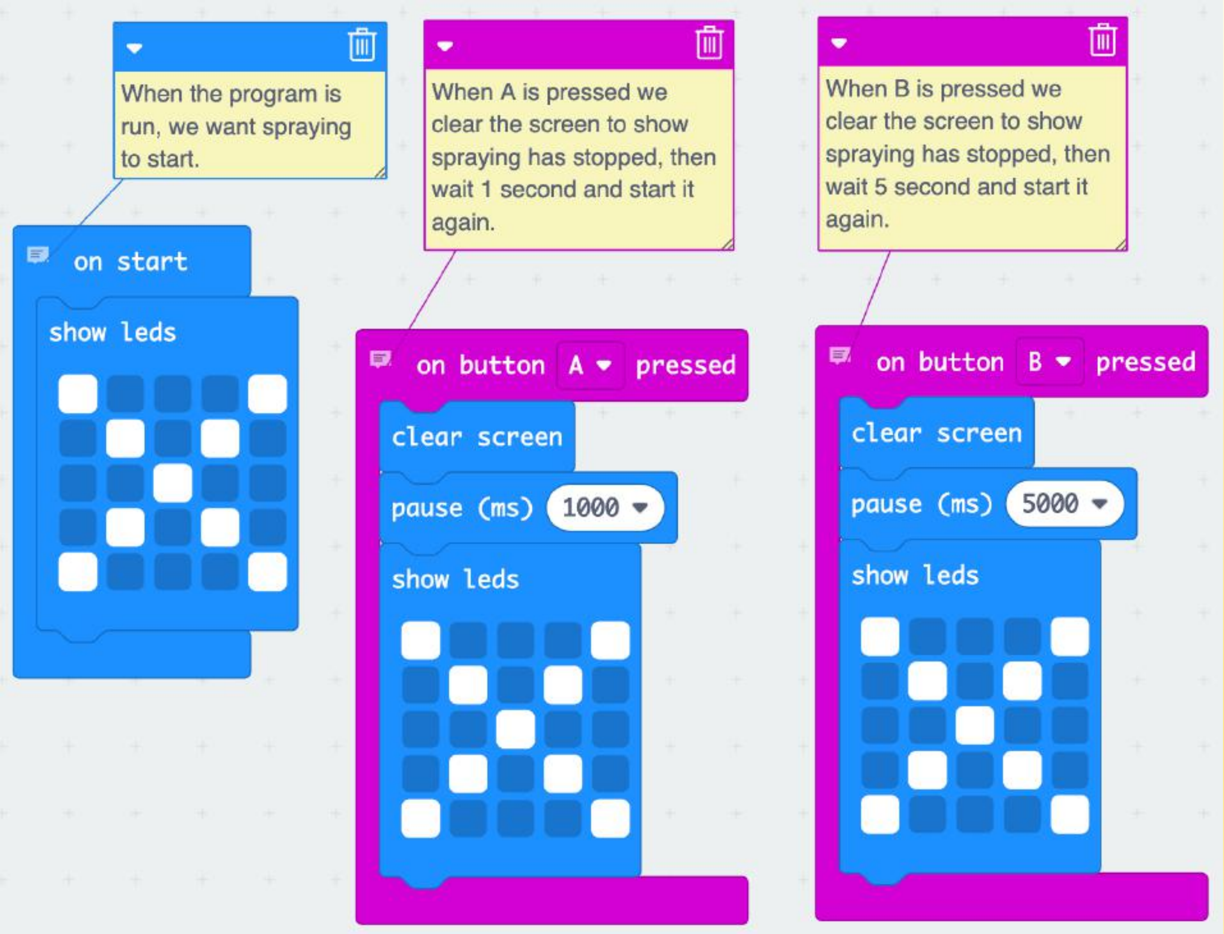


Add these commands to your micro:bit project.

Combine the code to complete the challenge:

- Spraying starts when the program is run.
- Spraying is paused for different amounts of time when either the A or B button is pressed and then automatically resumes.

How did you solve the challenge?



Think about!

- Is the time the spraying is paused for long enough?
- Can you change their code to increase it?

SOIL DEFENDERS