Session plan: make your own soil sensor

Session overview

Students will be introduced to the importance of soil moisture, and build a kit that is capable of measuring soil moisture along with temperature and light level. They will undertake practical activities that show how the sensor can be used. A number of enquiries are suggested and students then design and carry out their own experiments.

These sessions should be split into two sections of around an hour each.

Session opener

Watch this short video about NASA's SMAP satellite: http://bit.ly/1xRGuHT. Launched in January 2015, SMAP scans the earth's surface to measure the levels of soil moisture in liquid or frozen form. Discussion: satellites cost millions of pounds to build and launch. Why spend that much money measuring soil moisture?

Objectives	Activities	Resources	Outcomes
Preamble Introduction to the soil moisture kit.	Assemble the kit in class. Introduce each element of the kit and their functions. Explore the science behind how the soil sensor works.	Kit components, guide and safety equipment as required. An H&S briefing may be required. Ask students to identify potential risks themselves. "How can two nails measure moisture?"	Introduce main principles of working scientifically. Understand risk and H&S requirements. Build a sensor and understand how it works.
Main activity (part 1) Learn how to use the kit to generate data. Design and set up an experiment.	Use the kit to make some observations and generate some basic data on the website. Choose a line of enquiry and design an experiment using the soil sensor.	Website: soil sensor experiment: http://bit.ly/soilexp "Experiments for your soil sensor" "Report checklist"	Collect data using the sensor and understand how it is displayed. Identify a suitable enquiry title and what data is needed to answer it. Set up an experiment.
Main activity (part 2) Collect results from the experiment and report back to the class. Design an experiment for potential use in a future session.	Collect results from experiments. Were they as expected? Report back to the class. Students to design further experiments that use the soil sensor.	Website: soil sensor experiment: http://bit.ly/soilexp "Report checklist"	Collect results and produce a report on the experiment that has been carried out. Create and design experiments using the kit and data.
Session close Exit tickets	Students to fill in an exit ticket that includes an action point to follow up on.	"Exit ticket"	Identify a follow-up activity that can be carried out without teacher supervision.

Discussion

The satellite's sensors can only penetrate about 5cm into the soil. What are the drawbacks with that?

Further learning

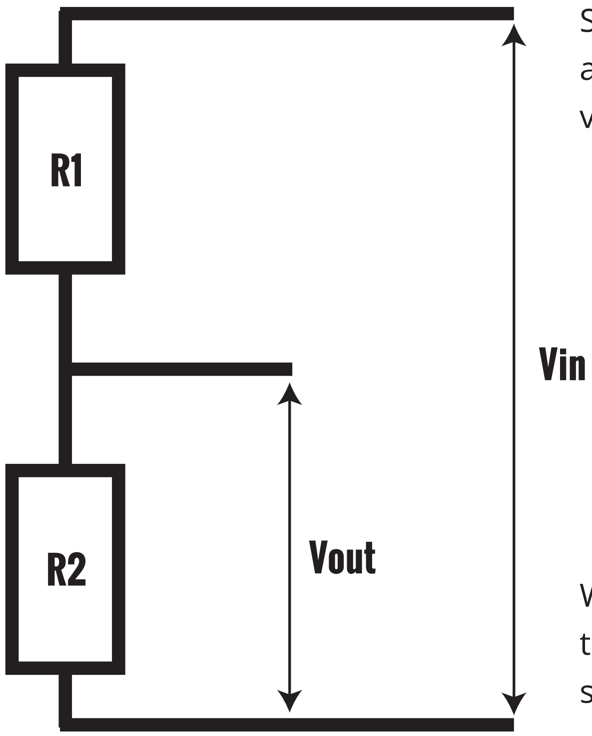
As data is released during NASA's SMAP satellite's mission, students could be given the opportunities to compare data for the local area with that provided by the kit. What local variations are there within the bigger picture? How valuable is data on this kind of micro-scale compared with data collected on a macro-scale?

Students could also be asked to plan out a sequence of questions and instructions that would use coding to automate the process of watering a plant.

How can two nails measure moisture?

Your Make Your Own Soil Sensor kit measures relative changes in soil moisture using resistance. When you put the two nails in soil, they measure the natural resistance of the soil. When the soil is very moist it will have a much lower resistance than when it is dry. Our Soil Sensor measures resistance by using a potential divider.

A potential divider is two resistors in series where one is known and fixed and the other changes. In your Soil Sensor, the 100KΩ (ohm) resistor is known and fixed and the two nails make up the resistor that changes depending on the moisture of the soil.



See the diagram on the left for a representation of a potential divider. Calculate the value of the output voltage from a potential divider with the formula:

Vout = (R2 / R1+R2) x Vin

Vout is the output voltage in volts

R1 is the value of resistor R1 in ohms

R2 is value of resistor R2 in ohms

Vin is the input voltage in volts

Water has a much lower natural resistance than the soil around it so when you water your soil the sensor detects a sharp reduction in resistance.

The Make Your Own Soil Sensor kit is just one way that you can measure soil moisture. It is a cheap, simple way of putting together a kit that measures relative changes in soil moisture using resistance. There are many other ways of measuring soil moisture that you can look into, ranging from cheap gizmos for gardeners that are not particularly accurate, to expensive systems that control irrigation of crops. Aside from resistance sensors, soil sensors can use frequency domain sensors, heat dissipation sensors, neutron moisture gauges amongst others.

Look into the technology behind NASA’s SMAP satellite. How does it measure soil moisture and why do you think they have chosen to do it in that way?

Experiments for your soil sensor

We have suggested six different experiments you can carry out as a class or as part of a group. Choose what you are going to do, then design your experiment using the “experiment checklist”.

Think carefully about controlling variables for each experiment. For example, if you choose experiment four, “Plant or no plant”, make sure you use the same size pots with consistent amounts of the same type of soil, that you add the same amount of water, that temperature and light levels are the same for both pots and so on.

1. Different soils

Compare the levels of soil moisture over time in a pot with one type of soil to a pot with a significantly different type of soil.

You can try altering the type of soil (e.g. sandy, loamy, clay) and/or the content of the soil (e.g. gravel or bark).

2. Temperature

Compare the levels of soil moisture over time in a pot at a colder temperature (e.g. outside or by an open window) to a pot at a warmer temperature (e.g. in a greenhouse or by a radiator).

Your soil sensor kit has one sensor that records temperature, so you will need at least two kits for this experiment.

3. Watering

Add different amounts of water to a number of pots. You could use incremental amounts of water (10ml, 20ml, 30ml) or exponential amounts (10ml, 20ml, 40ml).

Does the soil moisture increase in a linear way? At what amount of added water does the moisture level max out?

4. Plant or no plant

Compare the levels of soil moisture over time in a pot with no plant to a pot with a plant.

You could consider using herbs, succulents or cacti. How might different types of plant affect this experiment?

5. Mulch or no mulch

Compare the levels of soil moisture over time in a pot with no mulch to a pot with mulch.

Mulch is any type of material that is spread or laid over the surface of the soil as a covering. You can use bark chippings, leaves, straw or newspaper.

6. Light levels

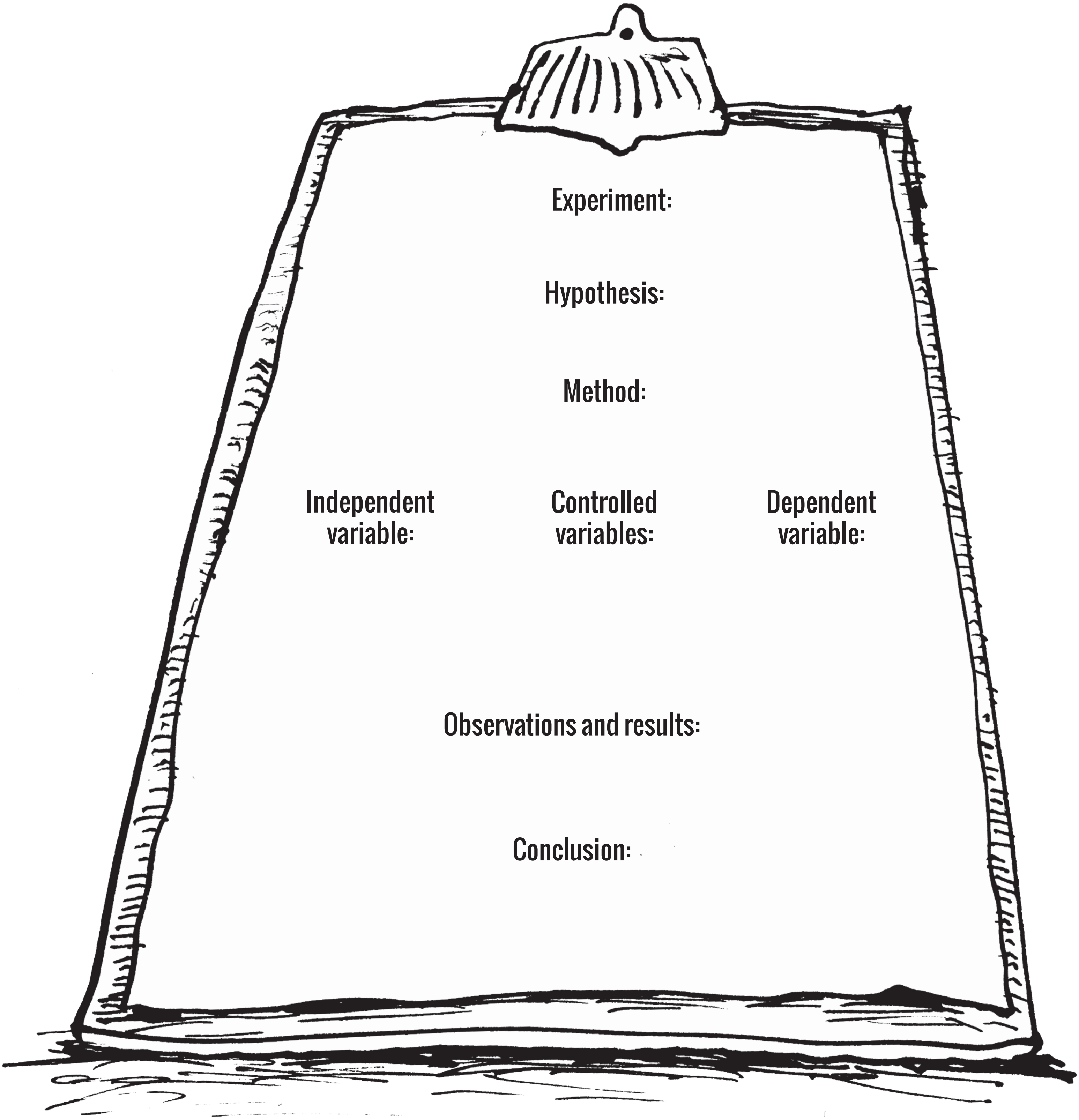
Compare the levels of soil moisture over time in a pot with higher light levels (e.g. by a window) to a pot with lower light levels (e.g. in a cupboard).

Your soil sensor kit has one sensor that records light, so you will need at least two kits for this experiment.

Experiment checklist

Once you have chosen an experiment to do, you need to design it carefully. What do you predict will happen? What will be the fairest and most accurate way to test this hypothesis? Make sure you think carefully about your variables and how they might relate to your experiment and your results.

After you have designed and set up your experiment, you will need to collect and analyse the data from the soil sensor, using the website [Intel short url]. Were your results what you expected? Is there enough data to come to a conclusion? Present your findings to the class.



Exit tickets

Name:

What has stuck with me from today is:

I forecast that I am going to:

I will submit a brief report of the results by:

Name:

What has stuck with me from today is:

I forecast that I am going to:

I will submit a brief report of the results by:

Name:

What has stuck with me from today is:

I forecast that I am going to:

I will submit a brief report of the results by:

Name:

What has stuck with me from today is:

I forecast that I am going to:

I will submit a brief report of the results by:

KS3 Science Curriculum links

Key Aims

All pupils:
> develop understanding of the nature, processes and methods of science through different types of science enquiries that help them to answer scientific questions about the world around them
> are equipped with the scientific knowledge required to understand the uses and implications of science, today and for the future.

Working Scientifically

This involves the students carrying out investigations, which have the following characteristics:
> ask questions and develop a line of enquiry based on observations of the real world, alongside prior knowledge and experience
> make predictions using scientific knowledge
> select, plan and carry out the most appropriate types of scientific enquiries to test predictions, including identifying independent, dependent and control variables, where appropriate
> use appropriate techniques, apparatus, and materials during fieldwork and laboratory work, paying attention to health and safety
> make and record observations and measurements using a range of methods for different investigations; and evaluate the reliability of methods and suggest possible improvements.

Detail from KS3 Science Curriculum (2013)

http://bit.ly/1r0zQYk

KS3 Computing Curriculum links

Key aims

All pupils:
> can understand and apply the fundamental principles and concepts of computer science, including data representation
> can evaluate and apply information technology, including new or unfamiliar technologies, analytically to solve problems
> are responsible, competent, confident and creative users of information and communication technology.

Key attainment targets

Pupils should be taught to:
> understand the hardware and software components that make up computer systems, and how they communicate with one another and with other systems
> understand how data of various types (including text, sounds and pictures) can be represented and manipulated digitally
> undertake creative projects that involve selecting, using, and combining multiple applications, preferably across a range of devices, to achieve challenging goals, including collecting and analysing data and meeting the needs of known users
> create, re-use, revise and re-purpose digital artefacts for a given audience, with attention to trustworthiness, design and usability.

Detail from KS3 Computing Curriculum (2013)

http://bit.ly/1ffIM67