Royal Academy of Engineering

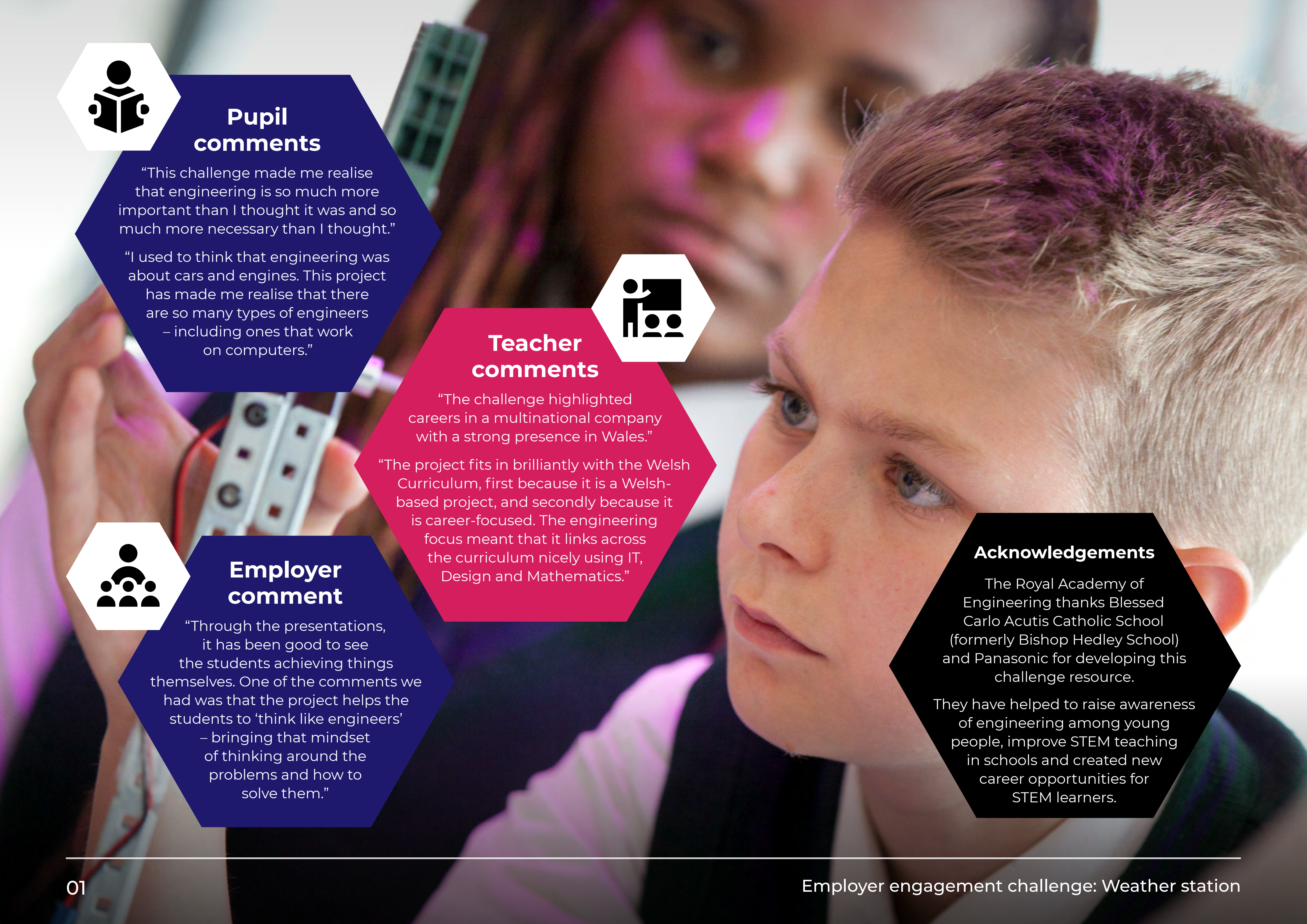
Employer Engagement Challenge

Weather station

How do you collect data to accurately forecast the weather?

Ariennir gan Lywodraeth Cymru
Funded by Welsh Government

THIS IS ENGINEERING



Pupil comments

"This challenge made me realise that engineering is so much more important than I thought it was and so much more necessary than I thought."

"I used to think that engineering was about cars and engines. This project has made me realise that there are so many types of engineers – including ones that work on computers."

Teacher comments

"The challenge highlighted careers in a multinational company with a strong presence in Wales."

"The project fits in brilliantly with the Welsh Curriculum, first because it is a Welsh-based project, and secondly because it is career-focused. The engineering focus meant that it links across the curriculum nicely using IT, Design and Mathematics."

Employer comment

"Through the presentations, it has been good to see the students achieving things themselves. One of the comments we had was that the project helps the students to 'think like engineers' – bringing that mindset of thinking around the problems and how to solve them."

Acknowledgements

The Royal Academy of Engineering thanks Blessed Carlo Acutis Catholic School (formerly Bishop Hedley School) and Panasonic for developing this challenge resource.

They have helped to raise awareness of engineering among young people, improve STEM teaching in schools and created new career opportunities for STEM learners.

Panasonic

Panasonic is a global electronics company with a long history in Wales. It first opened a factory in Cardiff in 1974, and has since expanded its operations to include several other sites across the country.

Panasonic develops and manufactures a range of products, including home appliances and computer technologies such as televisions, laptops and microwave ovens.

The challenge

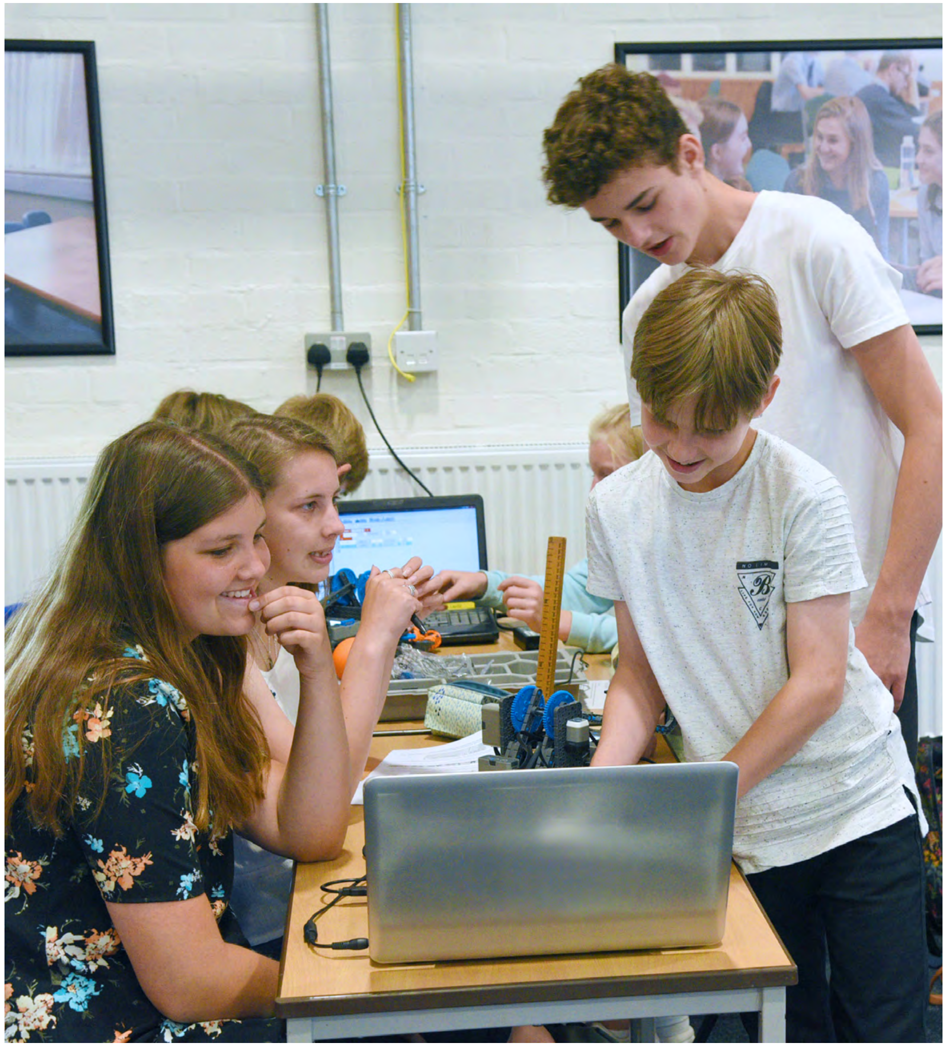
In this challenge, students will learn about the importance of climate conditions and the role that technology and engineering has in helping us live more sustainably. They will work in teams to create and program a low-cost, compact and portable weather station using coding, computer-aided design and manufacturing. This device will monitor and record temperature, pressure and humidity, both indoors and outdoors in various weather conditions. Students will use the collected data to identify patterns and trends in weather conditions and predict a forecast.

This challenge focuses on using technology to understand climate change patterns and make a positive impact on our ever-changing world. Students engage with real-world issues and develop solutions that contribute to a greener and more resilient future. They gain insights into the factors influencing the weather through a hands-on approach and apply their knowledge of climatology and technology to practical use.

The challenge culminates in a marketing campaign where each team showcases the features, advantages and distinctive selling points of their weather station.

This challenge is designed to support practitioners to follow Curriculum for Wales' careers and work-related experience guidance. It is supported by a set of videos that give an inside look at how engineers at Panasonic work, and introduces first-hand how the challenge is delivered in school.

The challenge is recommended for secondary school pupils and can be adjusted to match different age groups and abilities.



Here are some of the learning opportunities that the challenge provides:

- **Real-world environmental relevance**
- **Collaborative teamwork**
- **Data collection and analysis**
- **Creativity, design and building**
- **Persuasive presentation**

Challenge overview

Setting the class challenge

Design, build and program a forecasting gadget in this weather watch challenge.

This device should be small, affordable and easy to move around. It's like a mini weather station that checks temperature, pressure and humidity both indoors and outdoors, in all weather conditions.

This challenge combines geography and climate science with technology and engineering. You will work as a team to enhance your practical and programming skills, gather data and understand how it can contribute to predicting future weather patterns. This means you can discover interesting aspects about your surroundings and the environment.

Also, you'll have the opportunity to create a marketing campaign to showcase the features of your weather station.

By participating in this challenge, young learners will develop the skills and practices that engineers use every day in their professional lives.

Asking questions, imagining and planning ideas, creating and refining outcomes, while continuously reflecting on how things could be improved, are all 'Engineering Habits of Mind' as demonstrated in 'the Progressing to be an Engineer' cycle.

The Progressing to be an Engineer cycle

Learning opportunities	Core skills
■ Real-world environmental relevance ■ Collaborative teamwork ■ Data collection and analysis ■ Creativity, design and building ■ Persuasive presentation	**Literacy:** Reading and technical vocabulary. Selective research. Writing and reporting. Presenting and communication. **Numeracy:** Data collection and analysis. Pattern spotting. Measurements and calculation. **Scientific:** Problem-solving and experimenting. Visual and special awareness. Technical: Systems thinking and problem-solving. Communication and teamwork.

Engineering design process		Activity	Success will look like
0–1 hour	Research the challenge	**Watch the challenge videos** – engineers films **Time to investigate** – weather patterns and data collection **Time to present** – weather patterns and trends	Understand the aims and requirements of the challenge, as well as how engineering concepts relate to it. Gather relevant information and have a clear and comprehensive understanding of the challenge.
1–2 hours	Ask	**Time to problem solve** – building micro processing units **Time to question** – systems thinking	Identify problems and ask questions to understand how to resolve them. Explain how systems work while identifying ways they can be improved.
2–4 hours	Imagine Plan	**Time to imagine** – design and develop a CAD casing for the weather station **Time to plan** – modelling a card prototype of the weather station	Draw and label multiple design ideas, effectively communicating fitness for purpose and why certain ideas are better than others. Use simple annotated sketches to turn ideas into words and drawings. Plan a design that aims to solve a problem or task for a specific user, by transforming one idea in a better one.
4–6 hours	Create	**Time to code create** – data logging programming **Time to create** – computer-aided manufacture of the weather station **Time to deploy, install and test** – data collection and analysis	Use knowledge of how systems and components work and interact to create a product that achieves a specific purpose. Evaluate the product's fitness for purpose and look to find ways to improve this based on observation and improvement.
6–7 hours	Improve	**Time to reflect** – on experiences in relation to each stage of the challenge	Test the outcome for quality using a logical approach gathering evidence to make an informed decision. Evaluate how the product is working, identifying areas for improvement and describe possible changes that can enhance the design.
7–8 hours	Present the challenge	**Time to present** – create a marketing campaign for the weather station	Communicate ideas effectively and with confidence, making complex concepts understandable to the audience. Engaging interactions and making a lasting impression.

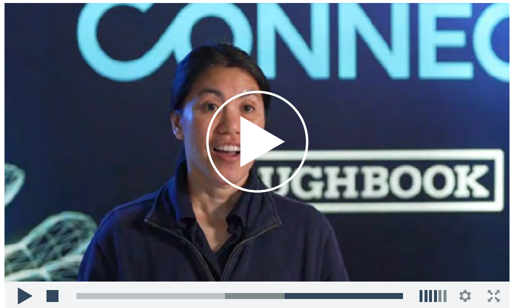
Time to start

Begin by showing the class the set of three engineer videos that showcase the diverse range of engineering roles within the company. Each video is approximately three minutes long.

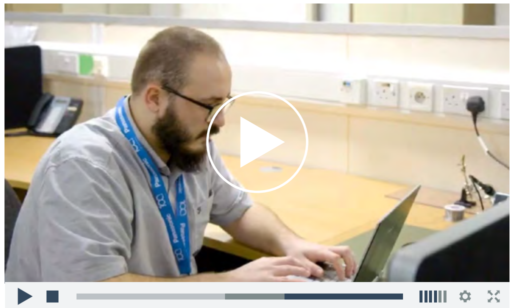
Go to **raeng.org.uk/wvep** or scan the QR code to watch the videos.

Thomas: Mechanical design engineer

Joy: Quality assurance engineer



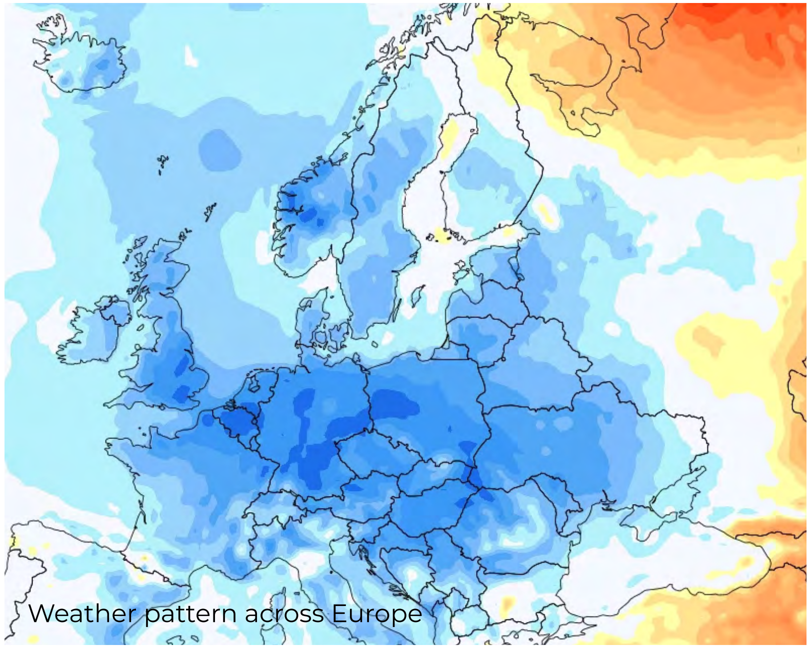
Connor: Software engineer



The aim of this first activity is to learn how to collect data about the weather and describe weather patterns.

Begin by explaining that meteorologists measure and record different elements from our weather system and put this information together to calculate a forecast.

These elements include temperature, humidity (the amount of water vapour in the air) and pressure. When pressure is high, we normally expect clear skies. When the pressure is low, the weather is often wet and windy.



Weather pattern across Europe

Time to investigate weather patterns and data collection

Start with a brief discussion about the importance of weather prediction in our daily lives and its impact on various activities.

Divide students into teams of three or four.

Assign each team one of the weather elements: temperature, pressure or humidity.

Ask the science department for thermometers, barometers and hygrometers. Provide each team with a weather instrument corresponding to their assigned element.

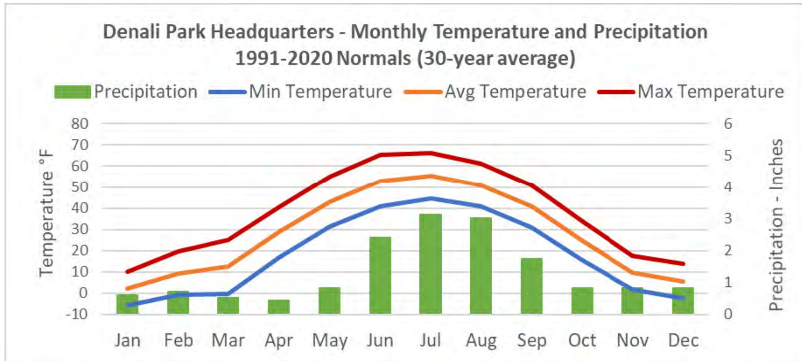
Demonstrate and explain the process of collecting weather data using these instruments.

Provide each team with a weather data sheet that includes space to record temperature, pressure and humidity readings over a specific time period (e.g. morning, noon and evening).

Ask teams to work together to collect data at different times of the day and record their observations on the data sheet.

After data collection, each team should analyse their data and identify any patterns or trends in temperature, pressure and humidity changes throughout the day.

Teams create a visual representation (charts, graphs, etc) of their data to present to the class.



Time to present

Give each team an opportunity to present their findings

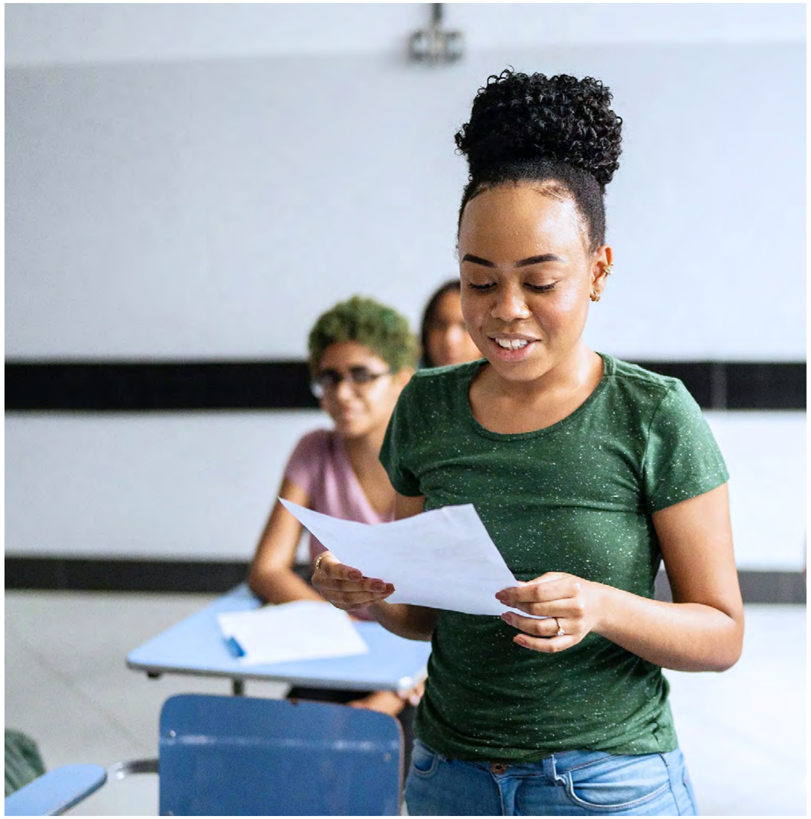
to the class and emphasise the importance of each team member's involvement in some aspect of the presentation.

Ask the students to share what they have learned and

any insights they have gained about patterns and trends observed within their assigned weather element.

They can use presentations, drawings or verbal explanations to share the data they have found.

Encourage the other students in the class to ask questions and engage in discussions after each presentation.



Time to problem solve

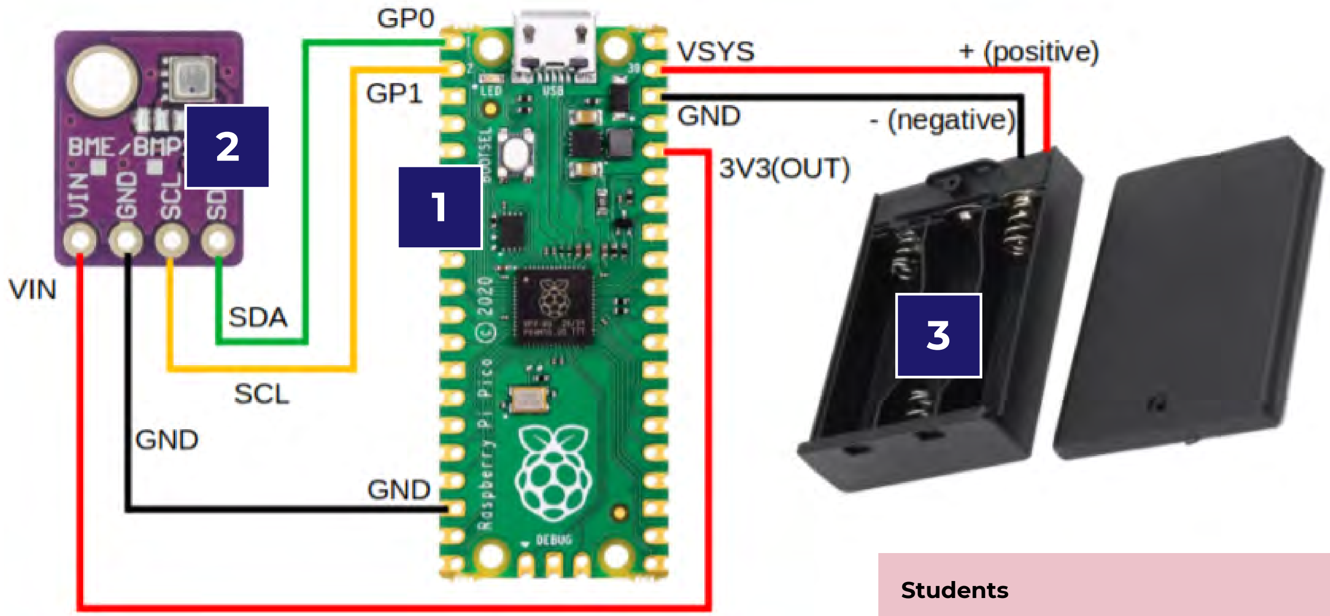
The aim of this activity is to use problem-solving skills and hands-on experience to connect electronic components using the diagram provided.

Ask teams to carefully study the diagram and identify the connections between the micro-controller (Raspberry Pi Pico), environmental sensor (Bosch BME280), battery holder and cables.

These electronic components are recommended for this activity. However, your school may have alternative components that work equally well.

After connecting the components, ask each team to test their setup to ensure that the connections are correct and working. Encourage students to troubleshoot any issues that may arise during testing.

Electronic components
1. Raspberry Pi Pico (microcontroller) **2.** Bosch BME280 (environmental sensor) **3.** Battery holder with batteries (2xAA) **4.** Dupont cables **5.** Micro USB cables



Teachers: please note that alternative microprocessors and supporting components are available for use in this challenge and they work equally as effectively.

Students

Carefully study the diagram and identify the connections between the microcontroller (Raspberry Pi Pico), environmental sensor (Bosch BME280), battery holder and cables.

Handle these electronic components with care to prevent damage.

After connecting the components, test the setup to ensure that the connections are correct and working.

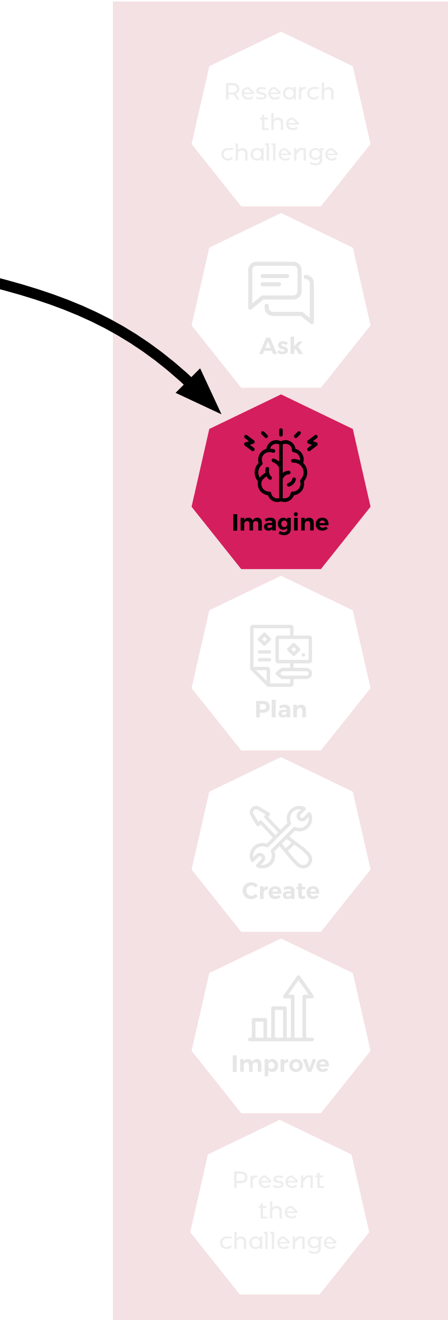
Time to question

Systems thinking is "explaining how things work together and why each part is there".

The questions below encourage students to think about the various interconnected aspects of designing, programming and logging data in a portable weather station.

Discuss these questions as a group and facilitate the conversations in class.

Systems thinking questions	
1	How frequently should the weather station log weather data? What factors might influence this decision?
2	How might the data interval affect the accuracy and detail of the recorded weather information?
3	What factors influence the choice of where to deploy the weather station? Can you identify potential challenges related to placing the weather station in different environments?
4	What methods will be used to transfer data from the weather station to a data storage device? What considerations are needed to ensure data security and integrity during transfer?
5	How can weather data be analysed to identify trends or patterns? What kind of graphs or charts could help visualise this data effectively?
6	How might you protect the electronic components from various weather conditions and physical impact?
7	Can you think of ways to ensure that a protective casing is sustainability sourced?
8	How can you ensure that the data collected by the weather station is reliable and accurate?



Time to imagine

The aim of this activity is to design the casing for a weather station that protects and is robust in all weather conditions.

Start by asking teams to brainstorm ideas and sketch rough designs on paper. Encourage them to consider aspects like ventilation, access points, component layout and compactness.

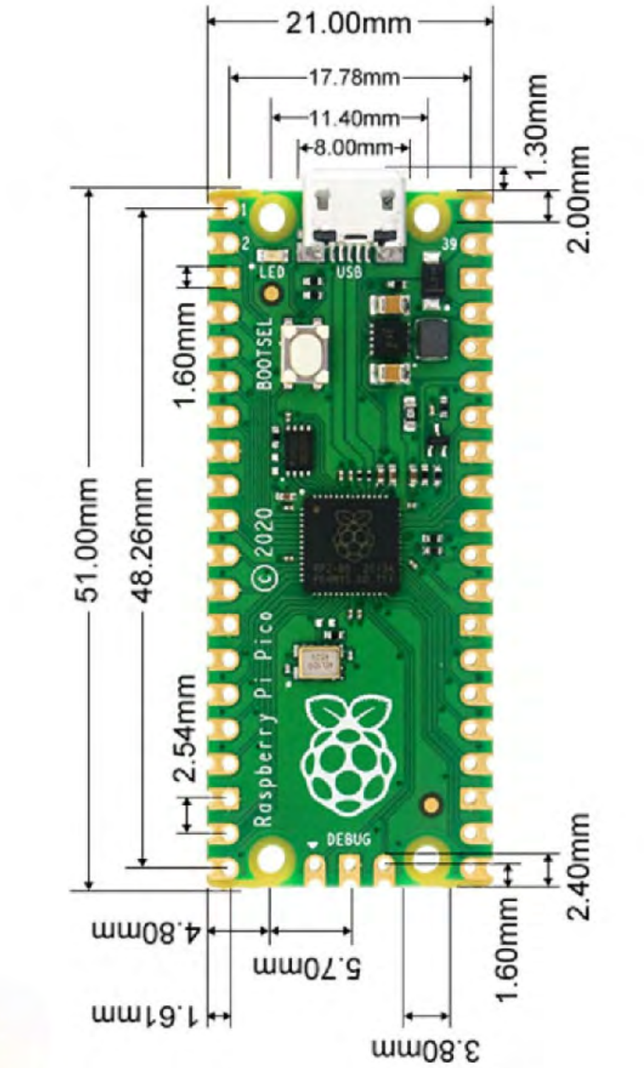
Emphasise the importance of annotating designs with explanations for each idea.

Introduce students to the basic principles of computer-aided design (CAD). Ask each team to design a three-dimensional model of their casing, refining details based on feedback.

Teams should examine the working drawing on this page closely. This drawing defines the dimensions of the microprocessor encased within the weather station. It is important to observe these measurements while creating the CAD drawing for the casing.

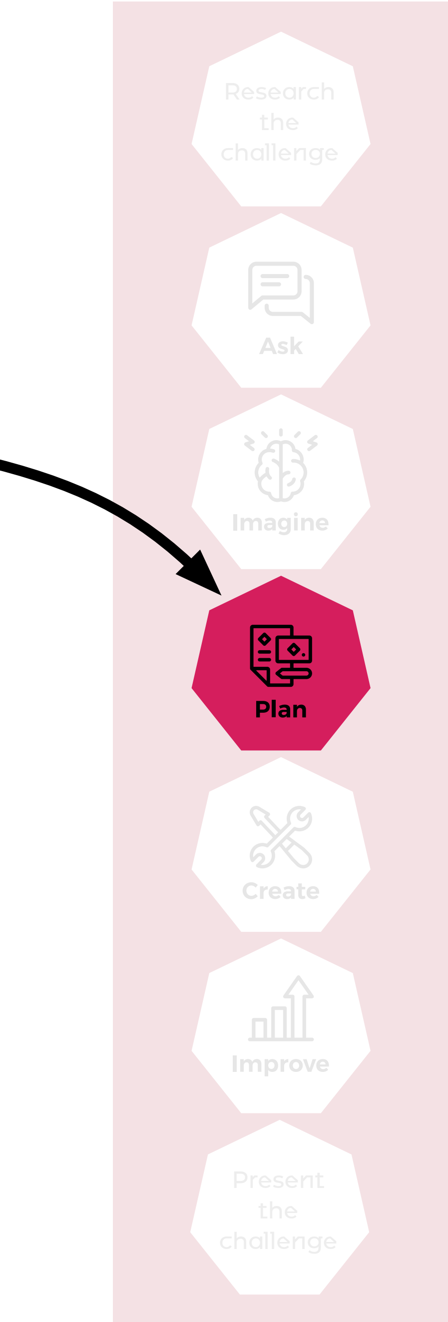
Ensure there is appropriate clearance around the microprocessor to guarantee a comfortable fit. Also, consider the need for access points for any wiring or connections linked to the microprocessor.

Introduce the concept of iteration – refining and enhancing designs through multiple drafts. Place a strong emphasis on accuracy, neatness and attention to detail.



Units: mm

Working drawing of a Raspberry Pi Pico [Outline dimensions]



Time to plan

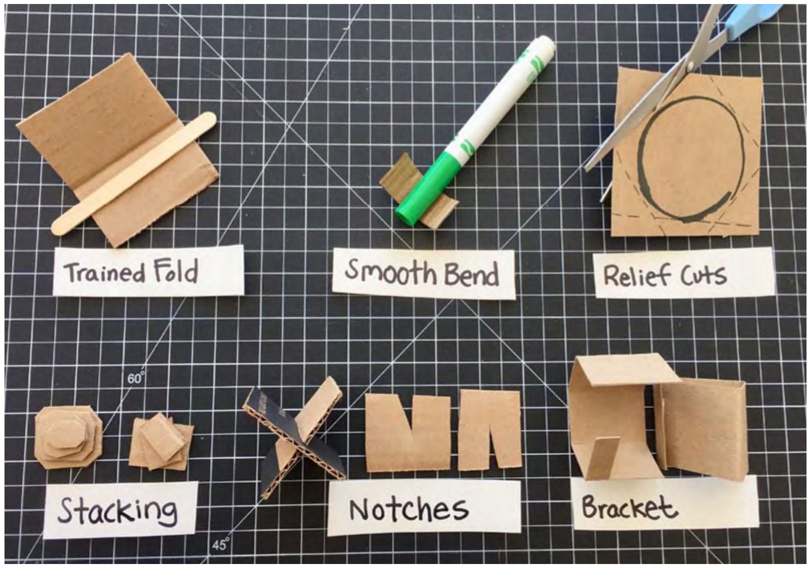
The aim of this practical activity is to use recycled card and repurposed materials to construct a scale model of the casing for a weather station.

Begin by informing students that modelling (or prototyping) allows designers and engineers to visualise the product concept in a physical form. It provides a clear representation of the intended product, making it easier to understand and evaluate.

Teams start prototyping by sketching a rough design of the chosen casing on the recycled card, marking areas for ventilation and connection ports.

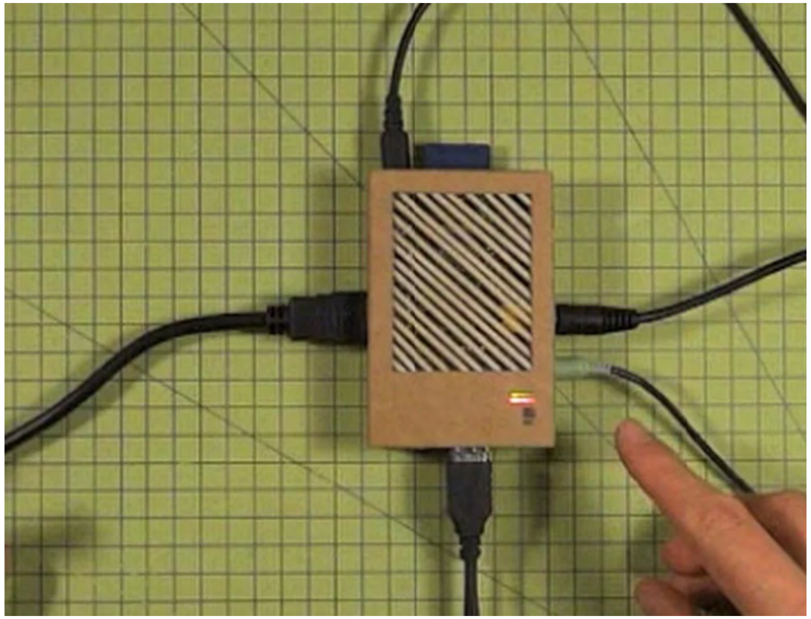
Once this is complete, students cut and shape the card to create the basic structure of the casing. Remind them to refer to the working drawing for accurate dimensions.

Assemble the card pieces using glue and tape, considering the placement of components and the need for a comfortable fit.



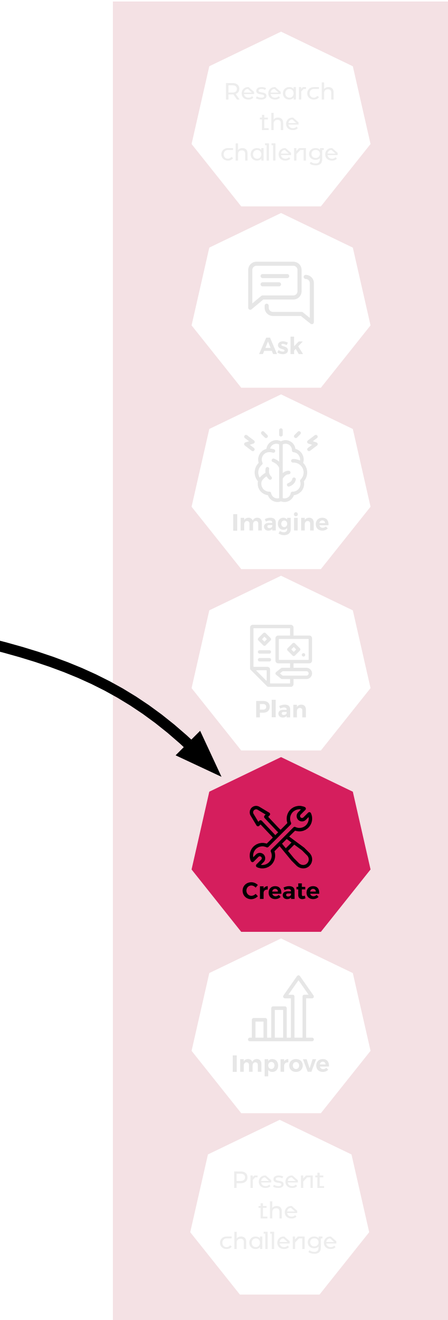
Materials

- Recycled cardboard and repurposed materials
- Craft knives, cutting mats, masking tape and glue guns
- Rulers, markers and pencils
- Working drawing of the weather station (from the previous activity)



Ask teams to evaluate their prototypes once completed, identifying areas for improvement and refinement based on the following questions:

- Were there any sizing issues that prevented neat component arrangement?
- Did the prototype provide adequate ventilation for the microprocessor?
- Were the connection ports easily accessible?
- Were there any unexpected challenges encountered during the modelling process?



Time to code create

The aim of this activity is to learn the basics of programming to enable environmental data logging and collection.

Software code examples

This section includes some Python examples for use with the Raspberry Pi Pico and BME280 sensor. Thonny Python editor is recommended for editing the software.

1. BME280 Read Temperature, Humidity and Pressure

This example uses the BME280 driver to read the temperature humidity and pressure from the sensor and print the results on serial output.

```
from machine import Pin, I2C
import BME280

i2c_bus = 0
i2c_sda_pin = 0
i2c_scl_pin = 1
i2c_freq = 400000
i2c = I2C(i2c_bus,sda=Pin(i2c_sda_pin), scl=Pin(i2c_scl_pin), freq=i2c_freq)

bme = BME280.BME280(i2c=i2c)
temp = bme.temperature
hum = bme.humidity
pres = bme.pressure

print('Temp: ', temp + 'C')
print('Humi: ', hum + '%')
print('Pres: ', pres + 'hPa')
print('\n')
print(temp + 'C', hum + '%', pres + 'hPa')
```

2. BME280 Read Integer Temperature, Humidity and Pressure

This example uses the BME280 int driver to read the temperature humidity and pressure from the sensor and print the results on serial output.

```
from machine import Pin, I2C
import bme280_int as bme280

i2c_bus = 0
i2c_sda_pin = 0
i2c_scl_pin = 1
i2c_freq = 400000
i2c = I2C(i2c_bus,sda=Pin(i2c_sda_pin), scl=Pin(i2c_scl_pin), freq=i2c_freq)
bme = bme280.BME280(i2c=i2c)

values = bme.values
print('Values:     ', values)
```

Teachers: please note that there are alternative programming languages and platforms available. These are compatible with other microprocessors and work just as effectively for this challenge.

3. BME280 Read Float Temperature, Humidity and Pressure

This example uses the BME280 float driver to read the temperature humidity and pressure from the sensor and print the results on serial output.

```
from machine import Pin, I2C
import bme280_float as bme280

i2c_bus = 0
i2c_sda_pin = 0
i2c_scl_pin = 1
i2c_freq = 400000
i2c = I2C(i2c_bus,sda=Pin(i2c_sda_pin), scl=Pin(i2c_scl_pin), freq=i2c_freq)
bme = bme280.BME280(i2c=i2c)

values = bme.values
print('Values:     ', values)
```

4. Raspberry Pi Pico Write to File

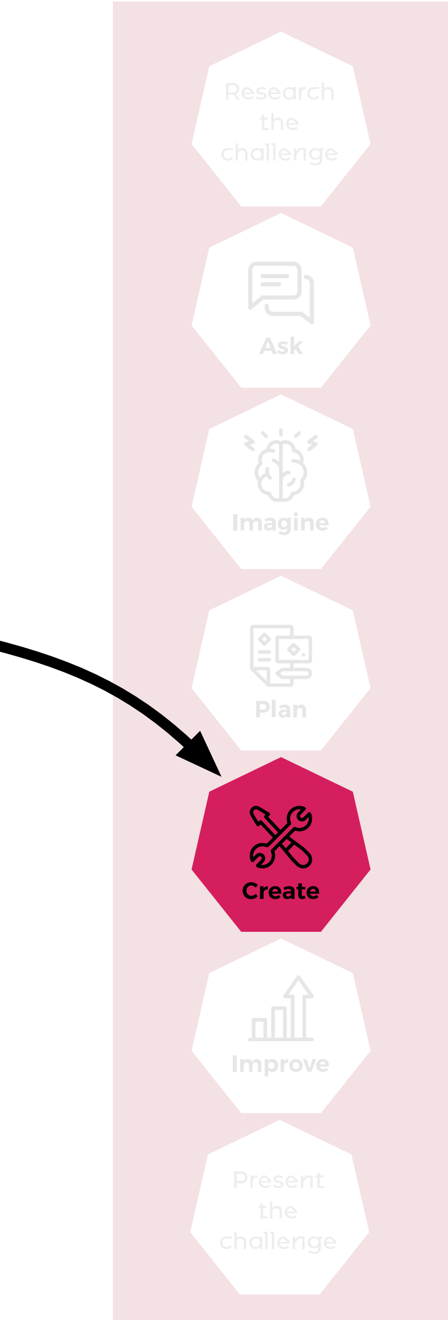
This example 1 reads the internal temperature of the Raspberry Pi Pico and writes the results to a file called temps.txt

```
import machine
import utime

sensor_temp = machine.ADC(machine.ADC.CORE_TEMP)
conversion_factor = 3.3 / (65535)

file = open("temps.txt", "w")

for i in range(0, 10):
    reading = sensor_temp.read_u16() * conversion_factor
    temperature = 27 - (reading - 0.706)/0.001721
    file.write(str(temperature) + "\n")
    file.flush()
    print('Data write to file')
    utime.sleep(1)

file.close()
```

5. Raspberry Pi Pico Read from File

This example reads a file called temps.txt (generated from the previous section) and displays the results on serial output

```
file = open("temps.txt")
print(file.read())
file.close()
```



6. Raspberry Pi Pico Check Power Input

This example* checks if the Raspberry Pi Pico is powered by the USB port or external power (e.g. batteries). The Raspberry Pi Pico onboard light emitting diode (LED) will bling as follows:

- USB port = fast blink (once every 1/4 of a second)
- External power (VSYS (pin 39)) = slow blink (once every second)

```
from machine import Pin
from time import sleep

pico_pin = 25
usb_power_pin = 24

pico_led = machine.Pin(pico_pin, machine.Pin.OUT)
usb_power = machine.Pin(usb_power_pin, machine.Pin.IN)

while True:
    if usb_power() == 1:
        pico_led.value(1)
        sleep(0.25)
        pico_led.value(0)
        sleep(0.25)
    else:
        pico_led.value(1)
        sleep(1)
        pico_led.value(0)
        sleep(1)
        pico_led.value(0)
```

**Python uses indentation rules to indicate blocks of code. It is very important these rules are followed.*

Time to create – *continued*

Using computer-aided manufacturing to build a weather station casing

In this activity, teams will manufacture and assemble their weather station, creating a functional product ready for installation and testing at their respective homes.

Instruct students to carefully consider the combination of the successful outcomes achieved throughout the challenge activities so far, which encompass:

- Creating a three-dimensional CAD model
- Developing a card prototype
- Successfully programming microprocessors

Computer-aided manufacturing

Familiarise students with the processes of 3D printing and laser cutting. Each team will need to prepare their CAD model for the manufacturing of their weather station casing.

Teams then assemble the casing with the microprocessor and sensor. Once the casing is assembled, ask students to install the weather station in their home area for a testing period lasting one to two weeks in total.

During this time, students should collect weather data on temperature, humidity and pressure.

Time to deploy, install and test

The aim of this activity is to collectively log weather data, analysing the results in a spreadsheet and answer questions related to observations.

Instruct teams to create a schedule (rota) for data logging and collection from the weather station. Explain the importance of selecting an appropriate location for precise data collection. This involves ensuring the station is placed away from heat sources, direct sunlight and any obstructions.

Allow the weather stations to accumulate data for the specified time period. It is recommended to have a duration of 1–2 weeks. Instruct students to perform regular checks and record the collected data. Provide computers equipped with spreadsheet software to each team in school. Encourage teams to create tables and graphs to visually represent the data on temperature, humidity, and pressure across the specified time frame.

Assemble the teams and provide them with the following analysis questions.

1. Did the weather station work as you expected?
2. What does the data show about temperature over the time period?
3. What does the data show about humidity over the time period?
4. What does the data show about pressure over the time period?
5. Can you see any patterns?
6. Do you have enough information to form a conclusion?
7. Could you make any improvements to your weather station?

Within their respective teams, students should engage in discussions and provide answers to each question based on their data analysis.

Time to reflect

Success can be based on the skills students develop and the practices they acquire throughout each stage of the challenge.

These include the ability to ask questions, imagine and plan ideas, create and refine outcomes, while continuously reflecting on how things could be improved.

Engineers also demonstrate the following practices as part of their day-to-day activities.

- Problem finding and creative problem-solving
- Systems thinking and visualising
- Adapting and improving
- Teamwork and collaboration
- Project and time management

At the end of the challenge, gather teams for a post-challenge debrief. Encourage them to reflect on their experiences and assess their personal growth in relation to the skills they have developed and practised throughout the challenge.

Present the challenge

Time to present

The aim of this final activity is to create and present a marketing campaign for the sale of the weather station.

In their teams, ask students to brainstorm and discuss the following aspects of their weather station product:

- Who should the weather station be aimed at?
- What are the advantages of using the weather station?
- What makes their weather station better than others?

Ask teams to discuss and plan the pricing of their weather station. Encourage them to consider effective marketing strategies for their product and create a basic outline of their marketing plan.

Then, instruct the teams to create their marketing presentation. Why not develop a TV commercial or a radio ad? Alternatively, they can create a website or social media posts.

Encourage each team member to participate in some way and let each team decide on their preferred method of presentation.

Allow time for questions and feedback after each team has presented their marketing campaign to the class.


RM

Royal Academy of Engineering

The Royal Academy of Engineering is harnessing the power of engineering to build a sustainable society and an inclusive economy that works for everyone.

In collaboration with our Fellows and partners, we're growing talent and developing skills for the future, driving innovation and building global partnerships, and influencing policy and engaging the public.

Together we're working to tackle the greatest challenges of our age.

What we do

Talent & diversity

We're growing talent by training, supporting, mentoring and funding the most talented and creative researchers, innovators and leaders from across the engineering profession.

We're developing skills for the future by identifying the challenges of an ever-changing world and developing the skills and approaches we need to build a resilient and diverse engineering profession.

Innovation

We're driving innovation by investing in some of the country's most creative and exciting engineering ideas and businesses.

We're building global partnerships that bring the world's best engineers from industry, entrepreneurship and academia together to collaborate on creative innovations that address the greatest global challenges of our age.

Policy & engagement

We're influencing policy through the National Engineering Policy Centre – providing independent expert support to policymakers on issues of importance.

We're engaging the public by opening their eyes to the wonders of engineering and inspiring young people to become the next generation of engineers.

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