Royal Academy of Engineering

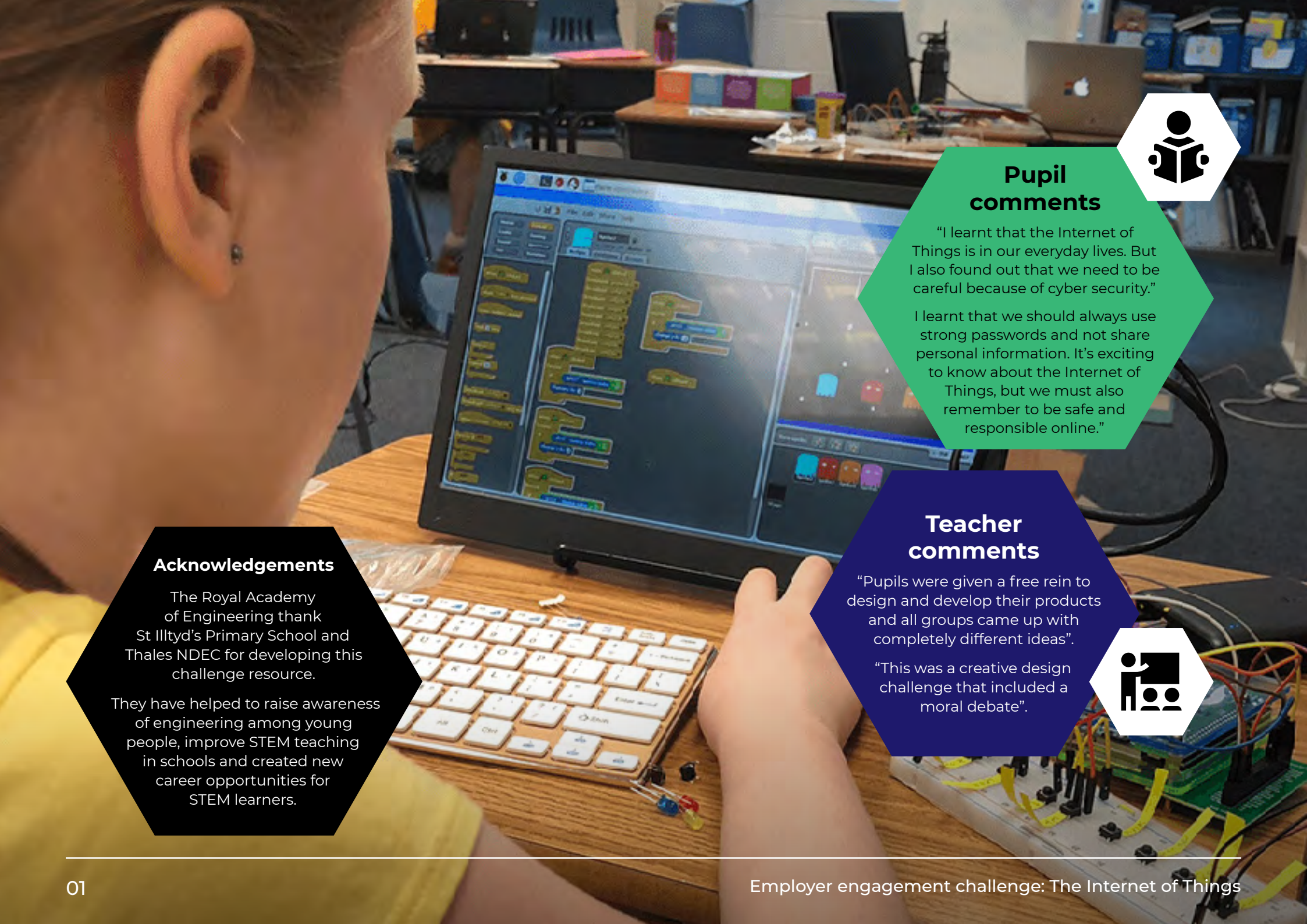
Employer Engagement Challenge

The Internet of Things

"Alexa, what is 'The internet of things?"

Ariennir gan Lywodraeth Cymru
Funded by Welsh Government

THIS IS ENGINEERING



Pupil comments

"I learnt that the Internet of Things is in our everyday lives. But I also found out that we need to be careful because of cyber security."

I learnt that we should always use strong passwords and not share personal information. It's exciting to know about the Internet of Things, but we must also remember to be safe and responsible online."

Teacher comments

"Pupils were given a free rein to design and develop their products and all groups came up with completely different ideas".

"This was a creative design challenge that included a moral debate".

Acknowledgements

The Royal Academy of Engineering thank St Illtyd's Primary School and Thales NDEC 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.

Thales NDEC

Thales and the National Digital Exploitation Centre (NDEC) is a cyber centre of excellence with a mission to protect Wales from cyber threats and develop the cyber experts of the future.

NDEC is the first research and development facility in Wales and provides local, regional and national organisations with the digital security infrastructure required in an increasingly complex technological world.

The 'internet of things' (IoT) refers to the interconnectivity of everyday objects, creating a network of smart devices that can communicate with each other online. It is a network of physical objects or 'things' embedded with sensors, software and other technologies that enable them to connect and exchange data with other devices or systems over the internet.

These 'things' range from simple household appliances like speakers and wearable tech to vehicle tracking systems and healthcare devices. This innovative technology has the potential to support our everyday lives, but it also comes with significant ethical and security implications.

In this challenge, Thales NDEC invites pupils to use their creativity to design new and innovative IoT devices. The focus is not only on the practical aspects of designing and making prototypes, but also on considering the ethical and security implications that arise with the creation of IoT technology. Pupils will be encouraged to think critically about the potential consequences of their designs and come up with solutions that prioritise the safety and privacy of users and society as a whole.

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 Thales NDEC work, and introduces first-hand how the challenge is delivered in school.

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

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

- **Collaborative teamwork**
- **Creativity, design and build**
- **Material testing and selection**
- **Problem finding and solving**
- **Ethical and security considerations**

Challenge overview

Setting the class challenge

Welcome to the exciting world of the Internet of Things (IoT). Thales NDEC would like you to join it on an engineering journey to learn about how digital devices talk to each other.

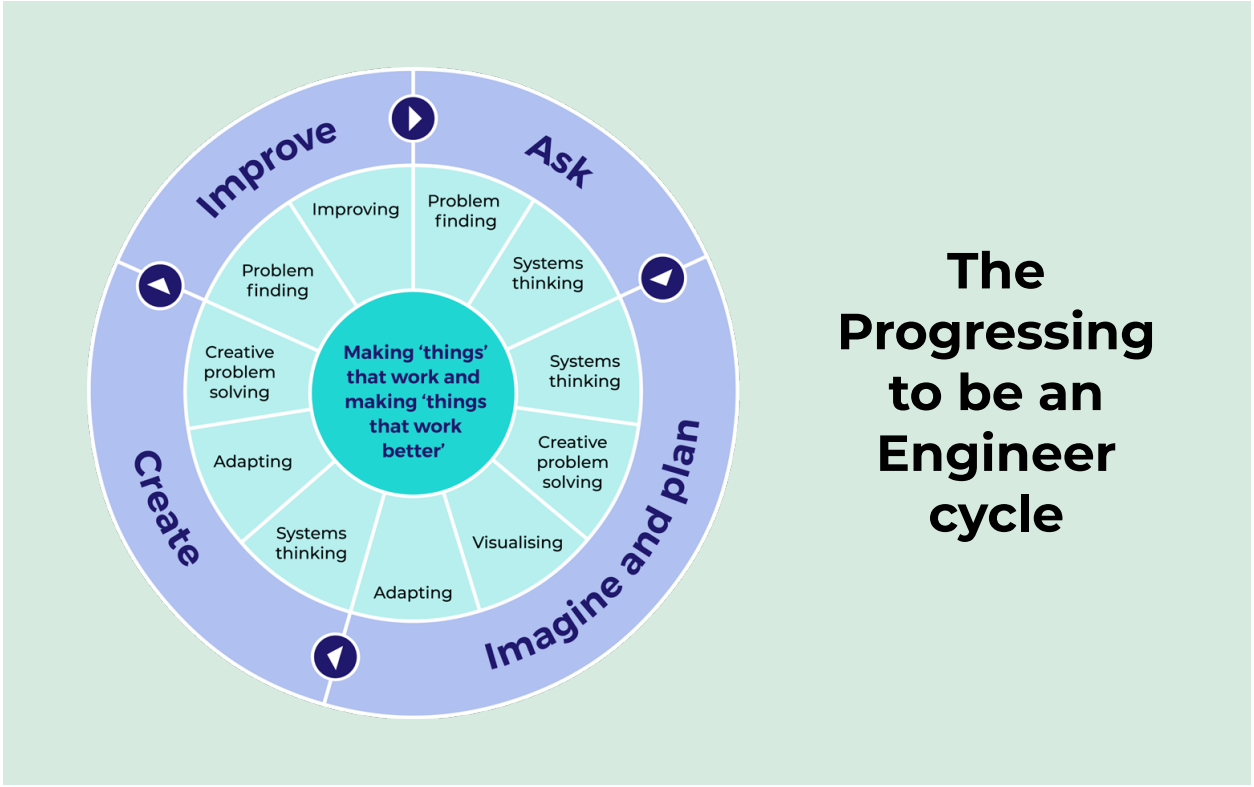
In this project, you will become tech-savvy problem-solvers. You will design a device that benefits your community using the power of the internet, all while ensuring it remains safe and secure from cyber threats.

Along the way, you will discover the different roles and responsibilities of cyber professionals and how they safeguard our digital world.

You will also explore how to protect your digital profile and prevent cyber crime, while learning about cutting-edge technology.

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
■ Collaborative teamwork ■ Creativity, design and building ■ Material testing and selection ■ Problem finding and solving ■ Ethical and security considerations	**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 research** – the Internet of Things **Time to consider** – benefits to life styles	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 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 an IoT eco-friendly smart device **Time to plan** – identify stages of manufacture	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 into a better one.
4–6 hours	Create	**Time to code** – Scratch platform programming **Time to create** – build a prototype of the Eco-Connect smart IoT device	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** – outline the learning journey and highlight the successes of the challenge	Communicate ideas effectively and with confidence, making complex concepts understandable to the audience. Engaging interactions and making a lasting impression.

Research the challenge

Ask

Imagine

Plan

Create

Improve

Present the challenge

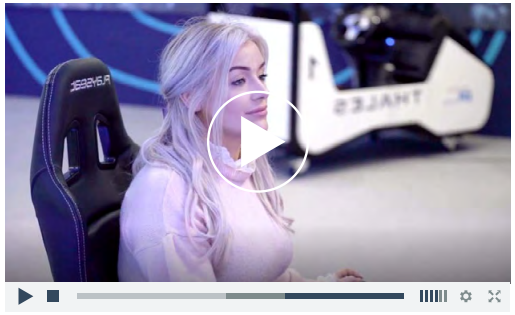
Time to start

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.

Dean: Operational technology engineer

Kirsty: Network cybersecurity engineer



Lisa: NDEC trainer

Time to explain

The aim of this first activity is to learn about the IoT and how we benefit from smart devices that interconnect with each other globally online.

Begin by explaining what the IoT is. Relate this to their everyday lives.

For example: IoT is like a big network where machines and smart devices can talk to each other using the internet. These devices can be things like smart watches, speakers and toys.

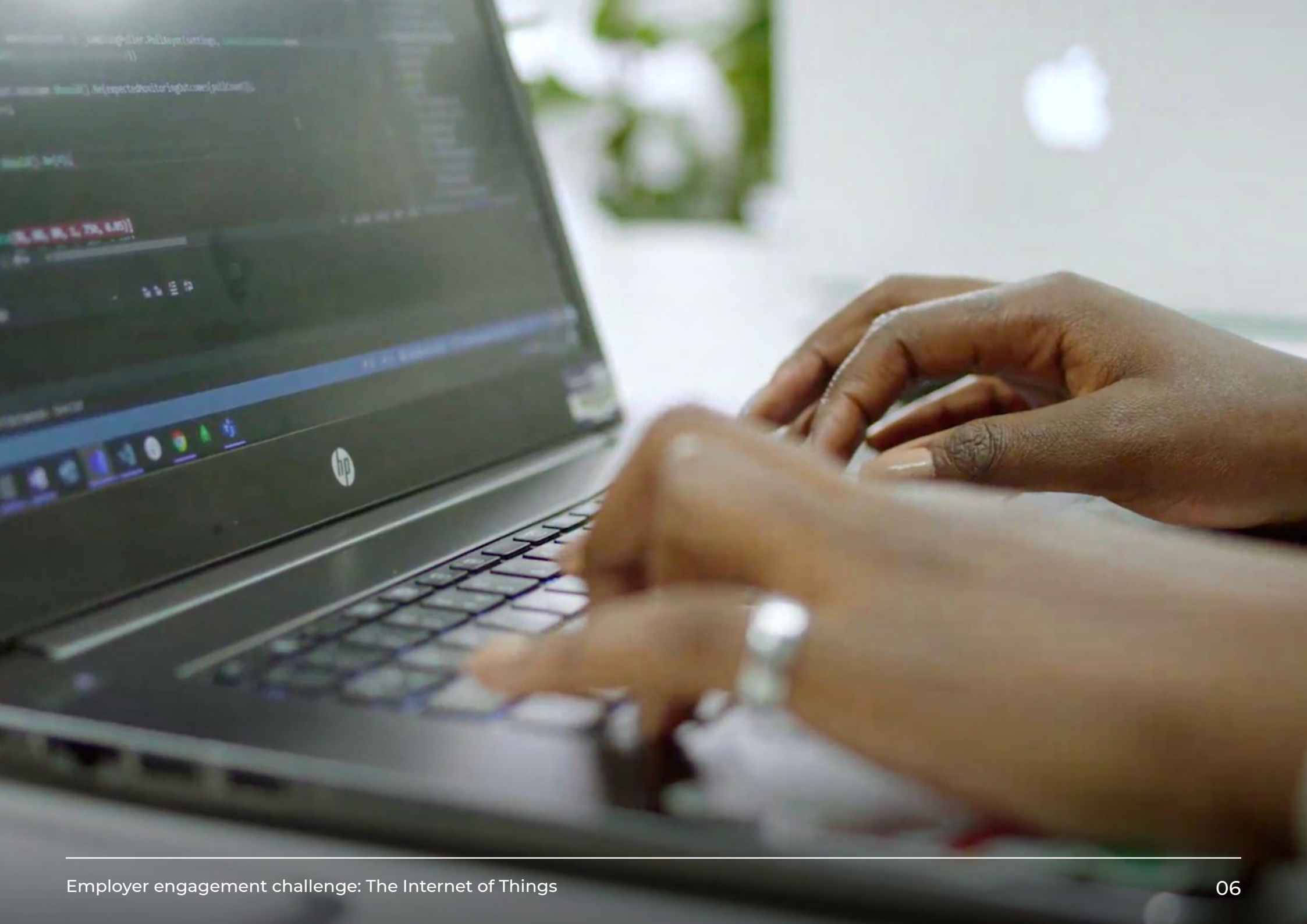
They talk to each other and share information via computer language. This information can includes personal details and contact information such as username and passwords.

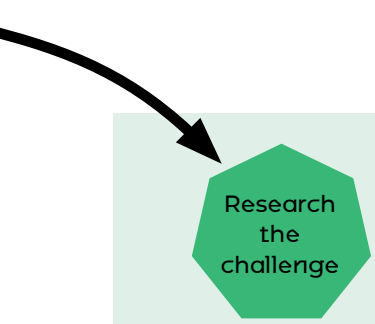
Time to research

Divide the class into groups of three or four pupils.

Assign each group a specific IoT smart device category from the list below. Ask each group to conduct research on their assigned category.

Smart		
Cat 1	**Speaker**	voice-controlled assistants that can control other smart devices
	Wearable devices	smartwatches – capable of tracking health and fitness data
	Fitness trackers	monitor physical activities and health-related information
Cat 2	**Lighting**	controllable and programmable lighting systems
	Locks	internet-enabled locks that can be controlled remotely
	Thermostats	remotely control home heating and cooling systems
Cat 3	**Cameras**	internet-connected cameras for home security
	Cars	connectivity for navigation, diagnostics, and entertainment
	Vehicle tracking systems	monitor vehicle location and performance





Ask

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Time to research – *continued*

Ask each group to create a presentation or make a list of at least three IoT devices they have found, along with the following details for each device:

- Device name
- Where it is commonly used
- Function, or what it does
- Reason for being linked to the internet

Time to present

Give each group an opportunity to present their findings to the class. They can use posters, drawings, or verbal explanations to share the information they have found.

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

Time to consider

Discuss the benefits of IoT devices being connected to the internet. Facilitate a class discussion and encourage the class to think about how these devices make our lives easier, more convenient and efficient. Highlight some of the following benefits:

1. **Remote control:** controlled and monitored from a smartphone, making it more convenient for users
2. **Automation:** automate tasks, such as adjusting the thermostat based on the weather, which saves energy and money
3. **Enhanced functionality:** being online to receive updates and new features, improving their performance over time
4. **Data collection and analysis:** gather data about their usage, which can help users make better decisions and improve their overall experience

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Time to question

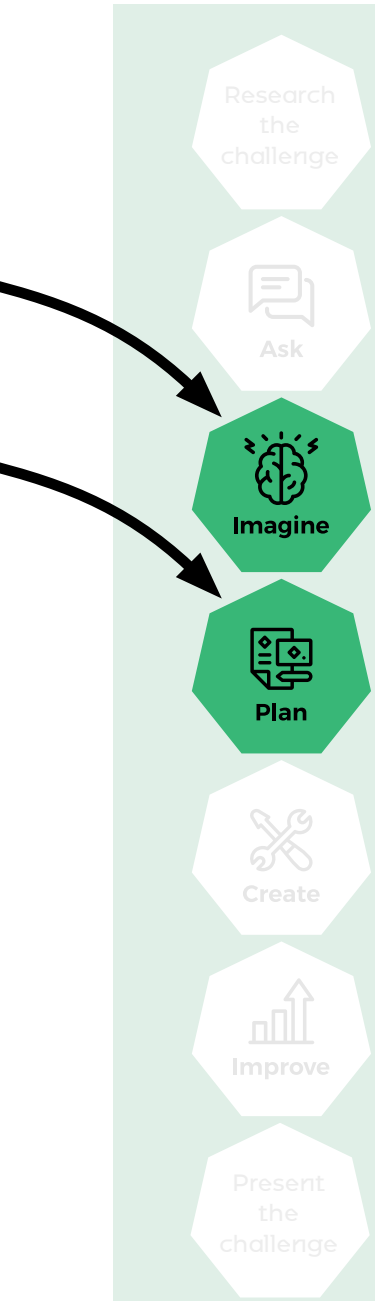
Systems thinking is "explaining how things work together and why each part is there".

Now the benefit of IoT devices have ben established, it's time to look at some of the potential drawbacks.

Discuss the following questions about cyber safety and cybersecurity as a group. Facilitate the conversations in class.

Systems thinking questions	
1	How do smart devices (IoT) make our lives and community better?
2	If you had a smart device at home, what kind of personal information would it collect? How can you keep that information safe from hackers?
3	Why is it important to keep our smart devices (IoT) safe from cyber-attacks? How can we do that?
4	How should we use smart devices (IoT) in a way that respects others' privacy and keeps our community safe?
5	What could happen if smart devices (IoT) were not protected properly? How might this affect our daily lives and the community?

Teacher: emphasise that cybersecurity is to inform and empower pupils about online safety and potential cyber threats. It is not to create fear or alarm among them.



Time to imagine

The aim of this activity is to design a new IoT eco-friendly smart device to enhance people's lives.

Divide the class into small groups of three to four pupils.

Teams use their collective creativity and knowledge of the IoT to design a smart device called **Eco-Connect**.

The purpose of Eco-Connect is to enhance people's lives at home and in the community, with a strong emphasis on prioritising online safety and security. Think about ways to make the device user-friendly, sustainable and visually appealing.

As a team, ask pupils to draw and label several design ideas for what the device could look like, including its features and dimensions. Be as creative as possible and use colour to present the decorative aspect of each design.

Each team should demonstrate and explain how the device will be constructed, illustrating its physical structure.

They should discuss the materials that will be used and give reasons for their selection. Encourage them to consider how the device can promote eco-friendliness and the use of recycled materials.

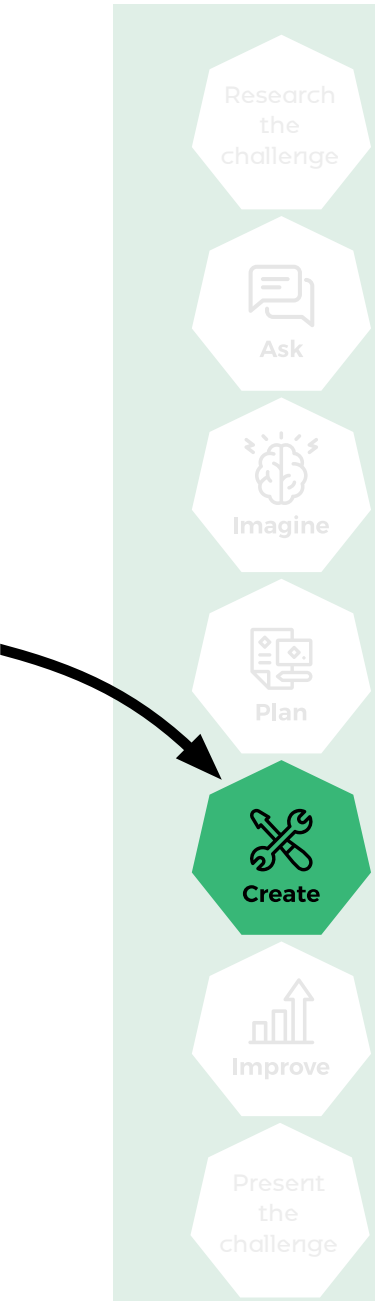
Time to plan

The aim of this activity is to identify each stage of manufacturing a IoT device prototype.

In the same teams, ask pupils to work together to plan out how their Eco-Connect device will be built. These stages may include:

- **Prototyping:** creating a small-scale model to test the concept
- **Material gathering:** collecting the necessary materials and components
- **Assembly:** putting the device together using materials and basic tools
- **Testing:** checking if the prototype works as intended
- **Refinement:** making any necessary improvements based on the results of testing
- **Packaging:** creating a presentable packaging for the device

Allow pupils to assign themselves specific goals they are working towards while also being part of a broader team unit.



Time to code

The aim of this activity is to learn the basics of coding and how to create animations and simple games using Scratch.

Start by introducing the concept of coding and Scratch. Show examples of simple animations and games created using code building blocks.

1. Basic Scratch animation

- Working in pairs, ask pupils to open the Scratch website and create a new project.
- Guide them through creating a simple animation using sprites and backdrops.
- Encourage pupils to make their sprite move across the screen using simple code blocks.

2. Creating a simple game

- Introduce the idea of a game with scores and obstacles.
- Demonstrate how to create a basic game using Scratch, like a “catch the falling objects” game.
- Show pupils how to keep track of scores using variables and add obstacles to make the game challenging.

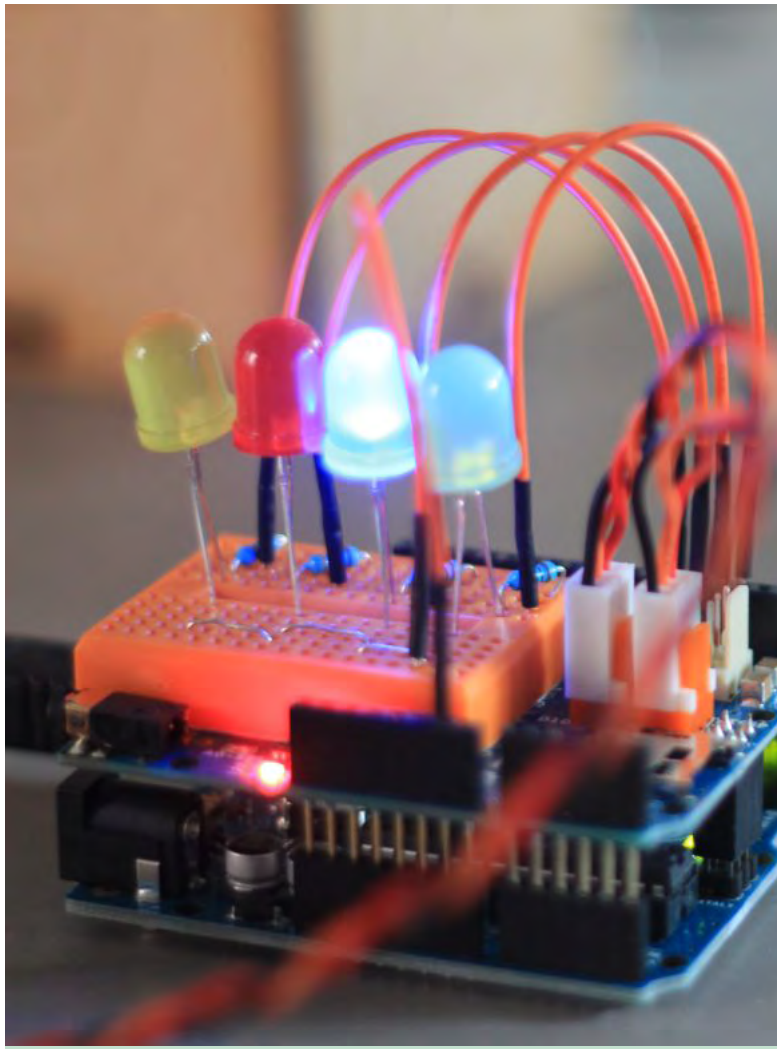
3. Intermediate game development

- Guide pupils with increasing levels of difficulty to their games, such as increasing the speed of falling objects or adding more obstacles.

Extension activity

For teams who complete their projects early or show a deeper interest in coding, provide additional activities such as creating more complex games of varying difficulty levels.

Incorporate sound effects or explore other Scratch extensions. You can also suggest real-life scenarios where the IoT can be applied, sparking creativity and critical thinking.



Did you know using Scratch software is like building code for an IoT device. Scratch is a visual programming language that allows users to create interactive stories and games. When building code for an IoT device, developers use programming languages like C++, Python or JavaScript, but the principles and concepts are similar.

Research the challenge

Ask

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Time to create

The aim of this activity is to build a 'functional' or 'non-functional' prototype of the Eco-Connect device.

Teams start building their prototypes using the materials and designs they have planned for. Provide guidance and support as needed, encouraging experimentation and creativity.

What is the difference between a functional and non-functional prototype?

Functional prototypes have working parts and interactive elements that demonstrate operational features. These could include electronic components that detect light, produce sound, or incorporate sensors.

Non-functional prototypes do not have working parts and interactive elements; they focus on visual design and overall user experience.

Remember that teams should demonstrate how the device's function benefits the user when interconnected through the internet network.

Throughout the process, ask teams to share their progress and any difficulties they faced during the build process. Discuss potential solutions and collaborative ideas for overcoming these problems.

Once the build is complete, give teams some time to test and make adjustments to their prototype if necessary.

Materials for 'non functioning' prototype
■ Cardboard or shoeboxes (for the device casing) ■ Craft supplies (coloured paper, markers, glue, scissors, etc.) ■ Recycled materials (bottle caps, cardboard tubes, etc.)
Additional materials for 'functioning' prototype
■ Microcontroller board (e.g. MicroBits or Crumbles) ■ Sensors (e.g. temperature, light, motion sensors, etc.) ■ LEDs or small bulbs ■ Connecting wires ■ Batteries and battery holders ■ CAD software installed (e.g. Tinkercad)

Time to reflect

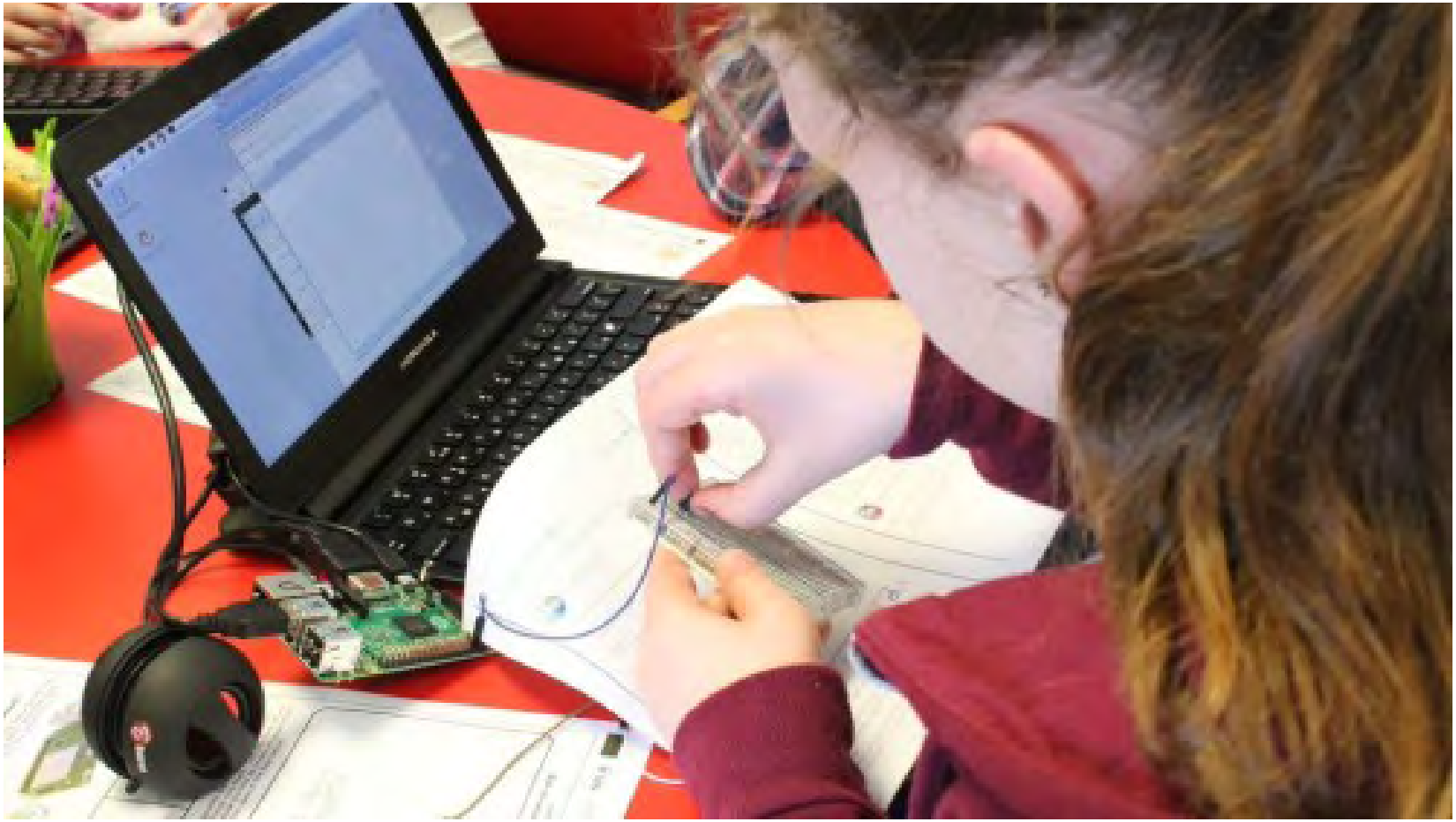
Success can be based on the skills pupils develop and the practices they acquire throughout each stage of the challenge.

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.



Research the challenge

Ask

Imagine

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Improve

Present the challenge

Present the challenge

Time to present

The aim of this final activity is to present outcomes, explain choices throughout the challenge and highlight what went well and what could be improved.

This should be a group task where every member of the team contributes to the presentation in some way.

The presentation can be divided into the following sections.

1. A summary of the final IoT device and its features
2. What went well during the design and building process
3. What challenges they faced and how they overcame them
4. How the outcome could be improved or enhanced

In addition, each team could create a sales pitch to convince others to buy and use their IoT device. The pitch should highlight the following aspects:

- The problem the product solves or the need it fulfils
- The unique features and benefits of the product
- How their product is better or different from other similar products
- Why people should buy and use their IoT device, enhancing people's lifestyles and maintaining cybersecurity

Royal Academy of Engineering

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

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