Royal Academy of Engineering

THIS IS ENGINEERING

IN THE NATURAL WORLD

Teacher Guide

INTRODUCTION

WELCOME TO THIS IS ENGINEERING (TIE), A SERIES OF STEM RESOURCES CREATED BY THE ROYAL ACADEMY OF ENGINEERING TO SUPPORT TEACHING AND LEARNING IN PRIMARY AND SECONDARY SCHOOLS.

Teachers and engineers have co-developed these resources, which offer practical, hands-on experiences that integrate the sciences, computing, mathematics, and the design/technology curriculum.

Students can explore the world of engineering while developing essential transferable skills such as problem-solving, teamwork, communication, and social conscience.

Each TIE resource includes a set of interdisciplinary activities and one **Sustainable Futures Innovation Challenge**.

We have designed activities to be delivered by non-specialists, as well as teachers. They are not sequential, which means you choose activities that align with schemes of work and suit students' interests.

As an engineer you use

- Creativity
- Teamwork
- Open-mindedness
- Social conscience
- Communication
- Determination
- Problem-finding and solving
- Innovation

UN SUSTAINABLE DEVELOPMENT GOALS

Some of the biggest challenges we face stem from how we interact with our environment. Engineering is at the heart of finding sustainable solutions.

Our resources align with the **United Nations Sustainable Development Goals**, focusing on addressing global challenges and connecting students with authentic, real-world experiences that bring the curriculum to life.

Engineers play an important role in tackling these challenges, our interactions with the environment and finding solutions to climate change and biodiversity.

CLIMATE CHANGE AND SUSTAINABILITY IN EDUCATION

Our aim is to support teaching for a sustainable future, putting young people at the centre of climate responsible education and the environment. We aim to inspire more students to engage with STEM subjects and broaden their awareness of the exciting and diverse opportunities in engineering, while helping to foster the skills needed for the next generation of engineers.

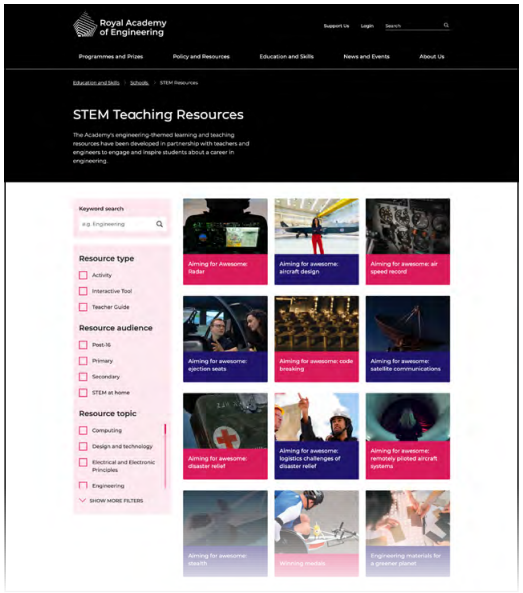
Royal Academy of Engineering

RESOURCE LIBRARY

All Academy STEM school resources are available to download from the education website library.

These resources cover a wide range of activities designed to inspire and engage students in STEM subjects.

Several of the resources are accompanied by video introductions that provide an overview of the activities and offer guidance on how to use them effectively in the classroom.



Explore and download from our **resource library**

THIS IS ENGINEERING

This is Engineering is a campaign to inspire young people to consider careers in engineering. The campaign is led by the Royal Academy of Engineering and features a series of short videos that showcase the work of real engineers. The videos cover a wide range of engineering disciplines, from civil engineering to software engineering.

The engineers featured in the videos are from all walks of life, and they share their passion for engineering and their advice for young people who are considering a career in the field.

Our resources spotlight these engineers, revealing why they chose engineering and how they turned their passions into rewarding careers.

WHAT'S IN THE BOX?

Each resource box contains items and materials to deliver activities for a class of up to 30 students. The box also includes a teacher guide and photocopiable activity and innovation challenge booklets.

Benefits to teaching

- Supports pupil-centred practical learning, linked to the curricula in England, Scotland, Northern Ireland, and Wales.
- Aligns with Gatsby benchmarks, providing engineering careers information and work-related guidance.
- Based on real-world challenges – learners apply their knowledge and skills to the world around them.
- Open ended and experience driven – exploring different solutions, finding unique ways to complete activities.

Example of the items and materials you will find in a TIE resource box

PROGRESSING TO BE AN ENGINEER FRAMEWORK

Each TIE resource presents students with a real world **Sustainable Futures Innovation Challenge**.

These challenges are designed to teach engineering concepts in a practical, hands-on way using the '**Progressing to be an Engineer**' framework. This framework integrates problem-solving, creativity and systems thinking through the engineering cycle. Students are encouraged to apply engineering principles to develop innovative solutions that contribute to a sustainable future.

It is progressive by outlining learning outcomes for 5 to 7 years, 7 to 11 years and 11 to 4 years. The age boundaries are not discrete or limiting, and teachers should consider the ability of their pupils as the key driver for planning.

It is aligned to the curricula in England, Scotland, Northern Ireland, and Wales which means that teachers can capitalise on pupils' prior learning and skills and integrate engineering education into mainstream curriculum lessons.

It is incremental – the framework is carefully structured to provide a developmental programme of learning to fit within curriculum requirements.

The Progressing to be an Engineer cycle enables teachers to embed STEM knowledge, skills and understanding reflective of real-world engineering. The process is iterative, meaning that the steps may be repeated in order to refine the solution until it meets all the requirements.

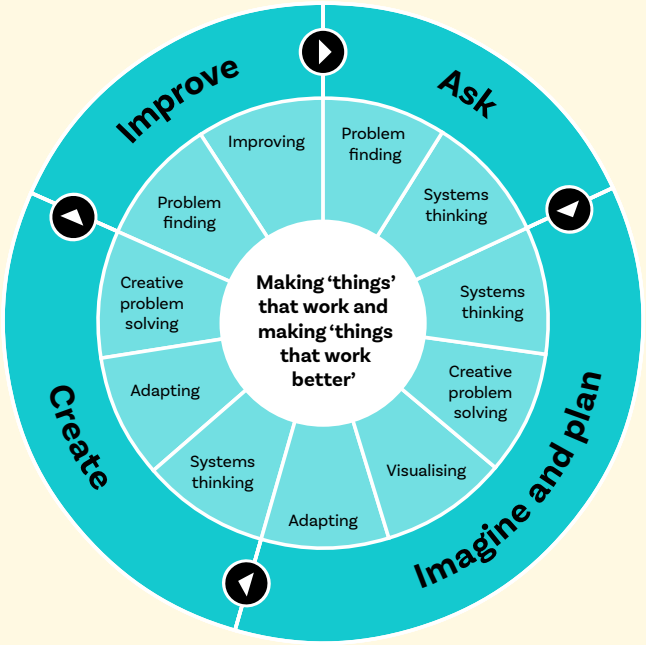
ENGINEERING HABITS OF MIND (EHOM)

Engineering Habits of Mind (EHoM) refer to the set of six skills and practices that engineers use when engaging in the engineering process. The framework develops the work on EHoM by linking them with the engineering design process.

The cycle shows how the engineering habits: *Problem finding*, *systems thinking*, *creative problem solving*, *visualising*, *adapting and improving* are embedded within the stages of the engineering design process: *Ask*, *Imagine and plan*, *Create*, and *Improve*.

The cycle may not encompass the practices of all engineering disciplines, but it has been shown to be accessible and relevant to teachers planning for engineering in school contexts.

THE PROGRESSING TO BE AN ENGINEER CYCLE



EHoM applied to the engineering design process	
PEng	**EHoM**
Ask	Problem finding | Systems thinking
Imagine and plan	Systems thinking | Creative problem solving Visualising | Adapting
Create	Systems thinking | Adapting Creative problem solving
Improve	Problem finding | Improving

To read more about this area download Bianchi, L. & Wiskow, J (2023) Progressing to be an Engineer.

PROGRESSING TO BE AN ENGINEER FRAMEWORK

Purpose	Making 'things' that work and making 'things' work better										
Engineering design process	Ask		Imagine and plan				Create			Improve	
Engineering Habit of Mind	Problem-finding	Systems thinking	Systems thinking	Creative problem-solving	Visualising	Adapting	Systems thinking	Adapting	Creative problem-solving	Problem-finding	Improving
5–7 years	Make observations to inspire the asking of simple questions, finding out more information about how things work.	Explain how simple systems work.	Draw and label a design with different parts, showing how they connect together.	Come up with and describe how different ideas can solve a problem.	Communicate ideas in words and simple sketches.	Observe a range of mechanisms (how things are made to work), suggesting ideas for how they could be used for a different purpose.	Use components to create a product with multiple parts.	Take an existing product and repurpose it by using it in a different way.	Create a prototype by taking a 2D design into 3D.	Check things work by testing.	Identify areas for improvement in a product and suggest changes to make it work better.
7–11 years	Identify problems and ask questions to better understand their cause.	Explain how simple systems work, identifying how each part depends on another and predicting what would happen if there is a missing piece or link.	Draw and label a design that uses a system, explaining the role of each part.	Generate multiple ideas, effectively communicating their 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 an existing mechanism (natural or man-made).	Use knowledge of how components work and interact to create a product that achieves a specific purpose.	Repurpose an existing product so that it can be used in a different way, tailored to the needs of a specific user or purpose. Evaluate its fitness for purpose.	Create and evaluate a series of prototypes, taking 2D designs into 3D, making improvements based on observations and feedback.	Test that things work using a logical approach, gathering evidence to make an informed decision.	Evaluate how the product is working, identifying areas for improvement in a product and describing possible changes that can enhance the design.
11–14 years	Critically examine problems, asking questions to understand their cause and how they impact different users.	Explain complex systems, including subsystems, describing how they depend on each other and predicting what can happen if there is a missing piece or link.	Draw and label a design that includes a system, justifying why each part is there, and how it best suits a user.	Use research and experience to come up with designs to solve a problem, justifying choices by applying scientific knowledge and evidence.	Use detailed annotated sketches to turn ideas into words and drawings to create a design specification.	Plan and evaluate designs that aim to solve a problem or tasks by transforming existing mechanisms (natural or man-made), suggesting alternatives and trade-offs with due regard for criteria such as cost and safety.	Create a product for a specific purpose, justifying the suitability of choices based on local and global issues – e.g. sustainability, energy, circular economy.	Repurpose an existing product, tailored to the needs of a specific user or purpose. Evaluate based on ethical, social and economic aspects.	Create a series of prototypes, taking 2D designs into 3D. Use cycles of self and peer-evaluation to identify and make improvements based on testing, observations and feedback.	Test and evaluate products against a specification reacting to the views of intended or specific user groups.	Identify areas for improvement in a product and describe changes to enhance the design, recognising the ideas that are most feasible and desirable.

ENGINEERING HABITS OF MIND

THE ACTIVITIES PRESENTED IN OUR RESOURCES ARE DESIGNED TO BE INTERACTIVE, OPEN-ENDED, ENCOURAGE DISCUSSION AND PROMOTE THE ENGINEERING HABITS OF MIND (EHOM).

The EHoM encourage the use of a pedagogical approach that cultivates problem-solving skills, creativity, making mistakes, reviewing, and planning.

There is no prescriptive teaching method, and it is up to you as a teacher, educator or STEM club leader to decide on which direction you wish to take each activity and where you may wish to spend more time.

Read the full report Thinking like an engineer here.

Engineering habits quiz

Students can take the engineering habits quiz to identify what engineering habits they are using, and perhaps ones they would like to work on.

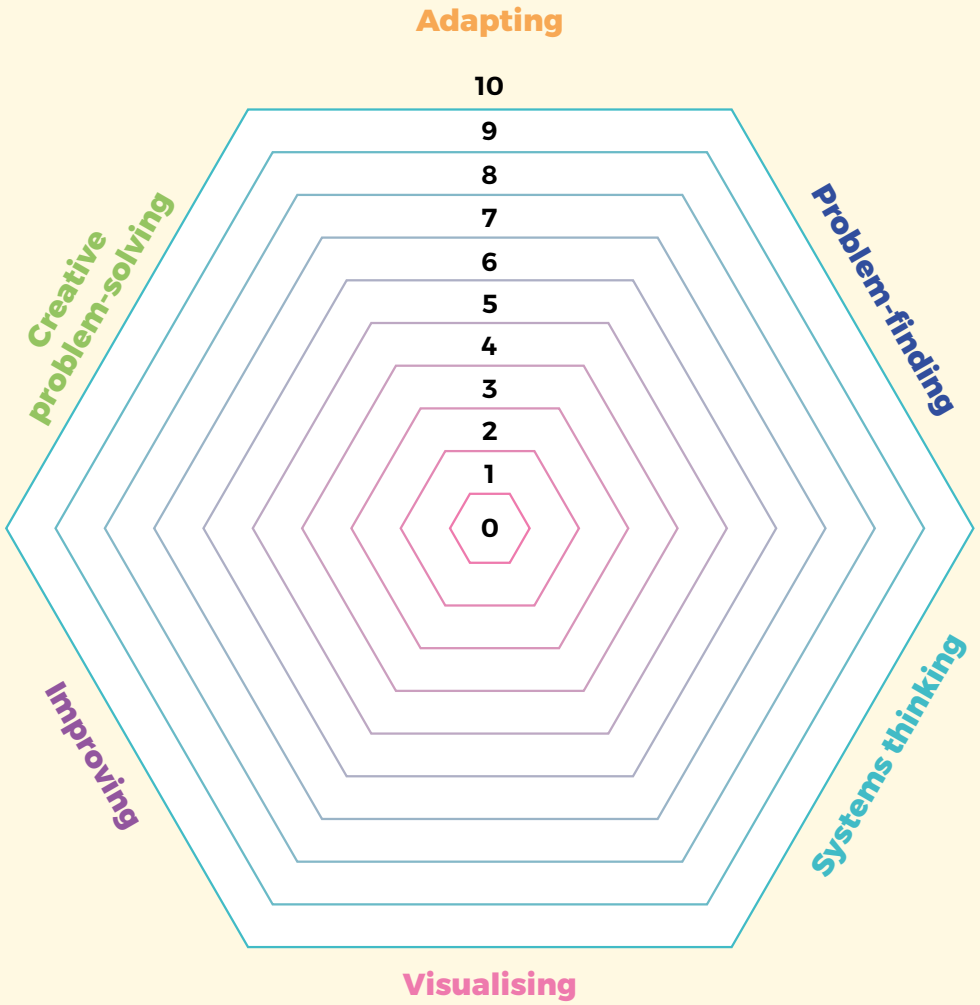
Once students complete the quiz, they can see their results on the EHoM spider diagram and can easily pick out their engineering strengths.

Results are not fixed! We encourage young learners to complete the quiz several times.

They might find that different engineering habits are stronger depending on the type of activity or challenge they are doing.

We have included all the EHoM student statements for both you and young learners for reference and to use in different lessons and activities.

Find the engineering habits quiz on the Royal Academy of Engineering website on our resource hub.



ENGINEERING HABITS – STUDENT STATEMENTS

I AM GOOD AT...

Creative problem-solving

- Coming up with lots of new and good ideas
- Working successfully in a group
- Taking on board other people's ideas and using them
- Making detailed mind maps
- Thinking first before doing something

Improving

- Making what I have done better
- Experimenting with things just to see what happens
- Working hard and practising to get better, even when it's tricky
- Working out what I need to do to improve
- Sticking at doing something until it's the best it can be

Problem-finding

- Thinking about the world around me and how it could be better
- Finding out why something does not work
- Finding mistakes in mine and other people's work
- Checking and checking again until I am happy
- Asking lots of questions to make sure I understand

Adapting

- Deciding how something could be done differently
- Explaining how well I am doing to my teachers or friends.
- Evaluating how good something is
- Behaving appropriately in different settings
- Sticking up for what I think when talking with other people

Visualising

- Thinking out loud when I am being imaginative
- Making a plan before I start work
- Practising something in my head before doing it for real
- Explaining my ideas to other people so they understand
- Making models to show my ideas

Systems thinking

- Spotting patterns and working out what comes next
- Using ideas from one subject in another
- Putting things together to make something new
- Spotting similarities and differences between things
- Working out the possible consequences of something before they happen

The quiz and student statements are based on EHoM research supported by the Royal Academy of Engineering and published in Hanson, J., Hardman, S., Luke, S., Maunders, P. & Lucas, B. (2018) **Engineering the future: training today's teachers to develop tomorrow's engineers**. London: Royal Academy of Engineering.

Thank you

This STEM teaching and learning resource has been developed by the Royal Academy of Engineering as part of its This is Engineering: School Engagement Programme.

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Boeing, the Royal Air Force and the estate of the late Mr John Gozzard.

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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