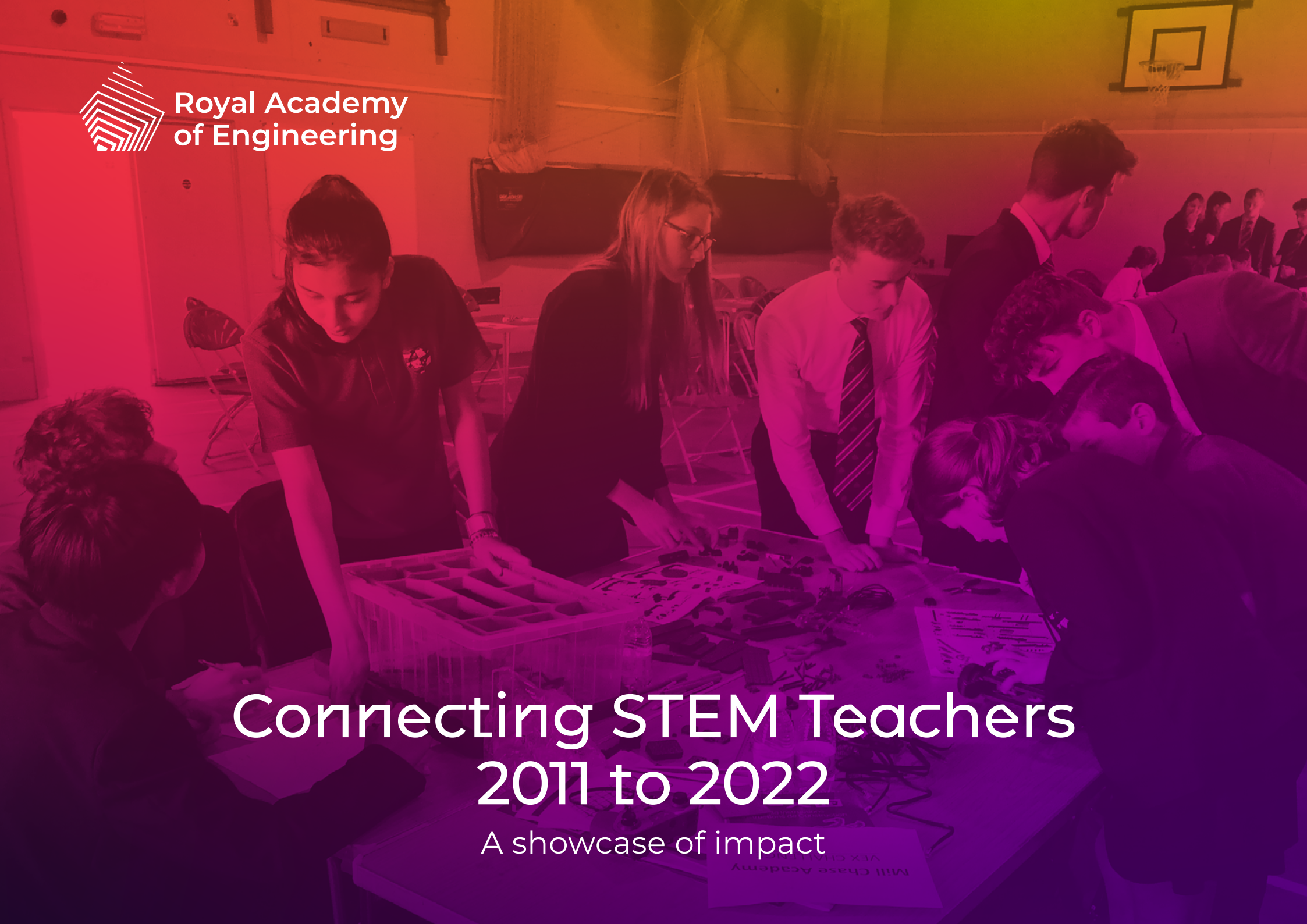


Royal Academy of Engineering

Connecting STEM Teachers 2011 to 2022

A showcase of impact

Foreword

September 2021 marked the 10th anniversary of the Academy's Connecting STEM Teachers programme, and I am delighted that we marked the occasion with many events and celebrations.

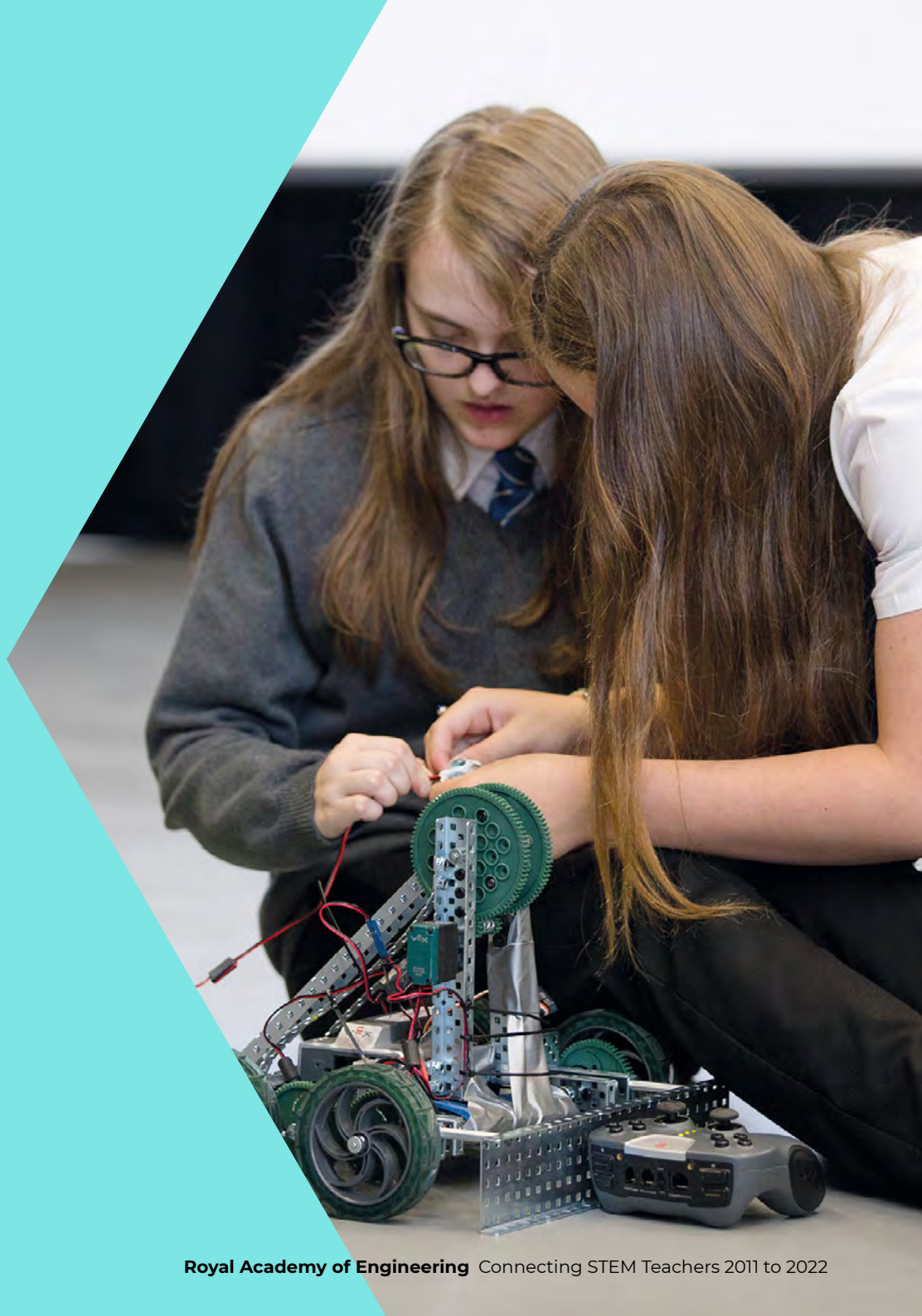
We have also produced this booklet, which provides just a glimpse of the excellent and inspiring activities that teachers across the UK have developed to engage and enthuse young people in engineering over the past 10 years.

The principle behind the Connecting STEM Teachers programme is simple. Teachers are professional educators – they know what works for their students in the classroom and how to engage them most effectively in their learning. But many of them have had limited opportunity to learn about the world of engineering; the application of science, mathematics, design and computing to revolutionary and groundbreaking technologies developed here in the UK, and the many exciting future career opportunities it opens up to their students. By providing practical, hands-on resources along with training opportunities to effectively use the materials, our teachers are able to develop valuable, real-world subject knowledge and creative problem solving skills in their students, giving them the confidence and interest to progress towards careers in engineering.

I am extremely grateful to the thousands of teachers that have engaged with us through this programme over the past 10 years, and to the many organisations that have generously supported the Academy's work to inspire the next generation of engineers. This new generation of talent will play a vital role in helping us to address some of the greatest challenges of our age.

Dr Hayaatun Sillem CBE
CEO, Royal Academy of Engineering

> **"I am extremely grateful to the thousands of teachers that have engaged with us through this programme over the past 10 years**



Introduction

This brochure provides an overview of the Academy's Connecting STEM Teachers (CST) programme; its aims and objectives, its delivery model, and its impact over more than 10 years of actively engaging with STEM teachers across the UK.

It includes a series of 25 inspirational case studies from programme beneficiaries, including STEM teachers and students, to showcase the programme's impact and celebrate its success.

We are incredibly grateful for the support of a whole host of colleagues and organisations who have helped make the programme the success it is today, with particular thanks to our partners at EngineeringUK and STEM Learning.

The programme would not be possible without the generous support of its funders. We are grateful to our strategic partner Shell for significant support of the programme, as well as Amazon, the Arthur Clements Fund, Boeing, the estate of the late Mr John Gozzard, the Helsington Foundation, and the Royal Air Force for their generous and continued support. CST was launched with funding from BG Group in 2011 and has historically received funding from BAE Systems and Petrofac Limited.

What is CST?

Over the last 10 years, CST has become a national programme that supports teachers of STEM subjects to engage a greater number and wider spectrum of school students with STEM education and engineering careers awareness. Through 48 regional school networks led by teacher coordinators (TCs), the programme has been building project-based pedagogy and teacher advocacy of engineering education to provide students with thought-provoking real-world engineering projects, helping them to make informed decisions about following a career into engineering.

The programme's five key aims are to:

- improve perceptions of engineering among young people
- apply engineering in the context of specific STEM subject areas in schools
- engage with schools in areas of low social mobility to increase the appeal of engineering careers among underserved and underrepresented groups of students
- create strong local networks of teachers, schools and local STEM support organisations to enhance the provision of STEM learning in schools
- improve student progression to STEM subjects post-16.

Supporting the Academy's strategy

In line with the Academy's strategy for 2020 to 2025 'harnessing the power of engineering to build a sustainable society and an inclusive economy that works for everyone', CST aims to embed social mobility as a key aspect of the programme. It does this by engaging with more schools in regions where the social and economic status is low and the percentage of students eligible for free school meals is high.

We have also been embedding sustainability in the development of our STEM teaching and learning resources. More information on successes in both these areas can be seen throughout this brochure.

Our strategy

Harnessing the power of engineering to build a sustainable society and an inclusive economy that works for everyone

Teacher coordinators

Building our school networks

Central to the continued success of the programme is the work of the Academy's 48 TCs, who are educational consultants or teachers of STEM subjects in schools.

Many hold the STEM Learning CPD Quality Mark – Associate Facilitator and they lead local networks of STEM teachers across England, Scotland, Wales, and Northern Ireland.

TCs establish large networks of schools, training teachers on a termly basis and providing them with continuous professional development and STEM-focused pedagogy to be used in their lessons and in STEM clubs.

They do this by:

- connecting teachers across STEM subjects and setting up peer-to-peer support networks for local schools and teachers
- promoting and facilitating cross-curricular working and collaboration
- delivering training on high-quality, curriculum-linked thematic classroom resources that link STEM in the classroom to engineering in a real-world context
- addressing gender imbalances and fighting stereotypes, for example by profiling female and underrepresented engineers and ambassadors at their meetings and events
- finding collaborative opportunities with STEM partners to deliver a unified experience for schools – STEM Learning regional schools' networks and EngineeringUK's careers resources and in-school challenges.

The following pages introduce our TCs and show their network locations.

What the programme means to our coordinators...

Stuart Higham

The John Warner School, Hertfordshire

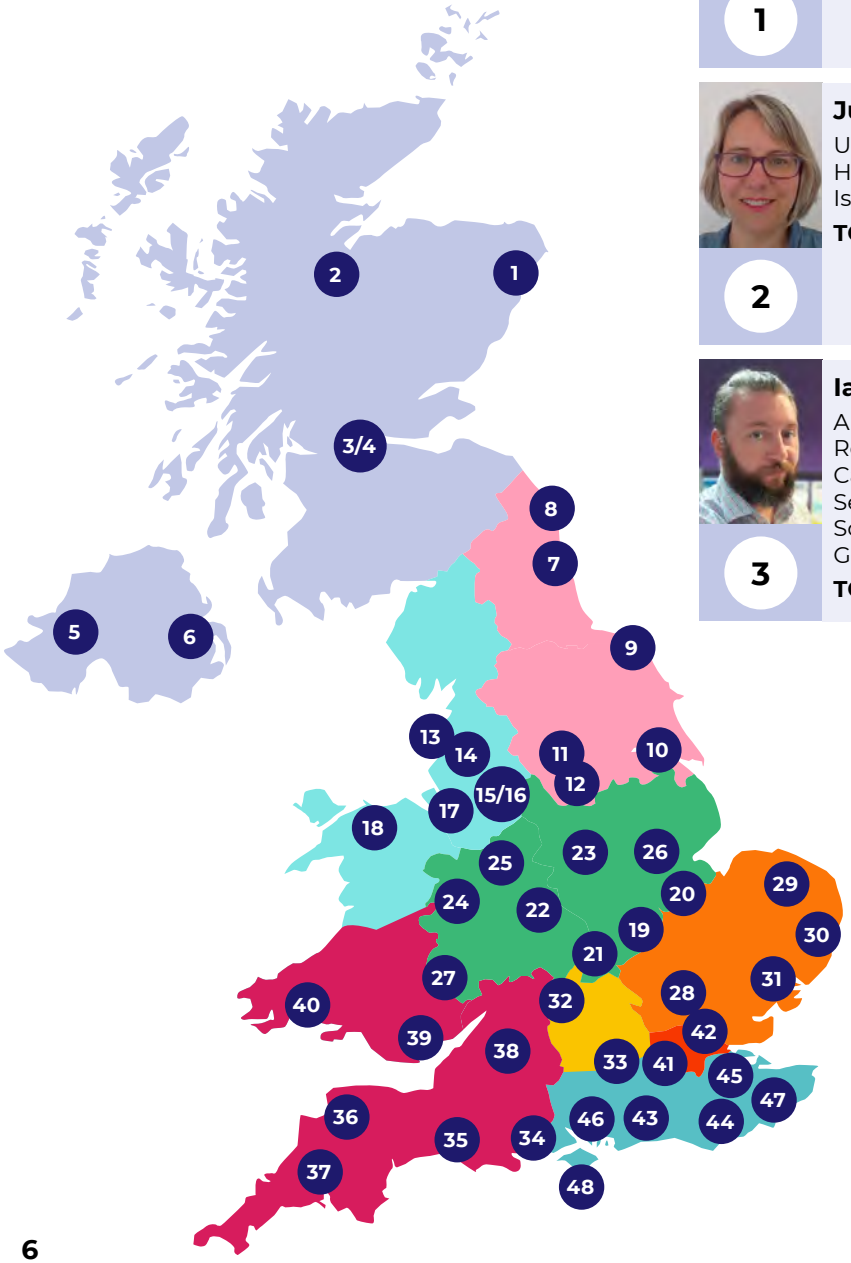
My greatest achievement since beginning the Royal Academy of Engineering CST programme has been **uniting a community of teachers** who, at times, can feel very isolated.

I feel that I have been lucky to have experienced a wide range of STEM activities since becoming a teacher and **there is little more rewarding** than experiencing the sense of achievement students gain from these opportunities.

As a coordinator for the TC network, I have been able to share this experience with teachers who **share my passion for STEM** but maybe haven't had the same support or chances to exploit the vast number of activities that are available in the UK.

Opening up pathways for teachers to employ their passion with their own students shows that **STEM is not just about individuals**, single schools or even local communities but a much wider, global opportunity for all young people.

Teacher coordinators network locations



1

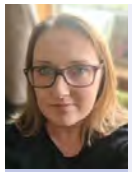
Beth Nicoll
Lochside Academy, Aberdeenshire
TC since: 2020

2

Judith Munro
University of Highlands and Islands
TC since: 2020

3

Iain Goodart
All Saints Roman Catholic Secondary School, Glasgow
TC since: 2019



4

Lynne Mylet
All Saints Roman Catholic Secondary School, Glasgow
TC since: 2019

5

Clare Doherty
St Mary's College, Derry / Londonderry
TC since: 2019

6

Thomas Lavery
Belfast Model School for Girls, Belfast
TC since: 2012

7

Michael Nelson
Education Consultant, Newcastle upon Tyne
TC since: 2015

8

David Thomas
Education Consultant, Northumberland
TC since: 2012

9

Edward Lyell
George Pindar School, Scarborough
TC since: 2019

10

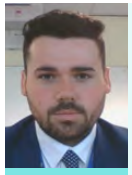
Trish Colley
Beverley High School, Hull
TC since: 2020

11

Daniel Toms
Harrogate Grammar School, Leeds and Harrogate
TC since: 2020

12

Jorden Birch
Wales High School, Sheffield
TC since: 2016



13

Matthew Thomas
Hodgson Academy, Blackpool
TC since: 2019

14

Chris Wallis
Ashton Community Science College, Preston
TC since: 2016

15

Simon Brown
Wellington School, Greater Manchester
TC since: 2018

16

Martin Simmons
University of Manchester, Greater Manchester
TC since: 2011

17

Glyn Jones
The Mosslands School, Liverpool and the Wirral
TC since: 2020

18

Neil Humphreys
Ysgol Bryn Elian, North Wales
TC since: 2020

19

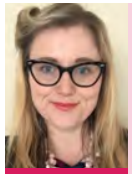
Arthur Harwood
Bishop Stopford School, Northampton-shire
TC since: 2015

24

Andrew Gilbert
The Thomas Adam School, Shropshire
TC since: 2017

29

Kate Finlay
Hethersett Academy, Norfolk
TC since: 2016

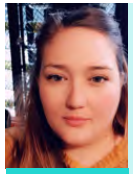


34

Laura Watford
King Richard School, Portsmouth
TC since: 2016

39

Peter Thomas
Education Consultant, Cardiff
TC since: 2012



44

Amanda Courtney
St Simon Stock Catholic School, Kent / East Sussex
TC since: 2017

20

Gareth Richards
Peterborough UTC, Cambridgeshire
TC since: 2011

25

Rich Walker
St John Fisher Catholic College, Stoke-on-Trent
TC since: 2021

30

Anthony Vaughan Evans
East Point Academy, Suffolk
TC since: 2015

35

Michael Cronk
Colyton Grammar School, South Devon
TC since: 2015

40

Susan Quirk
Education Consultant, Carmarthenshire
TC since: 2019

45

Krissi Pink
Invicta Grammar School, Medway
TC since: 2015

21

Gaynor Sharp
Education Consultant, Coventry
TC since: 2012

26

John James
Sir William Robertson School, East Lincolnshire
TC since: 2021

31

Beverly Maloney
The Royal Hospital School, Essex / Suffolk
TC since: 2017

36

Philip Goodland
Pilton Community College, North Devon
TC since: 2019

41

Gwen Andrews
The London Oratory School, South London
TC since: 2021

46

Holly Leat
St Anne's Catholic School, Southampton
TC since: 2016

22

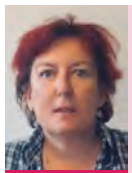
Tracey O'Connor
Bishop Challoner Catholic College, Birmingham
TC since: 2016

27

Sarah Peers
New Model Institute for Technology and Engineering, Herefordshire
TC since: 2022

32

Claudia Clarke
Cokethrope School, West Oxfordshire
TC since: 2011

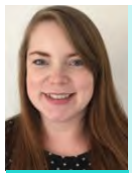


37

Lorraine Drybrough
Bodmin College, Cornwall
TC since: 2015

42

Jed Marshall
Alexandra Park School, North London
TC since: 2020



47

Emma Harvey
St Anselm's Catholic School, East Kent
TC since: 2019

23

Lauren Evans
The Joseph Whitaker School, North Nottingham and Mansfield
TC since: 2019

28

Stuart Higham
The John Warner School, Hertfordshire
TC since: 2016

33

Annie Beglin
St Crispin's School, Surrey / Berkshire
TC since: 2015

38

Sam Lawrence
Winterbourne Academy, Bristol
TC since: 2016

43

Scott Atkinson
Royal Academy of Engineering, Hampshire / West Sussex
TC since: 2015

48

Peter Swann
Ryde School with Upper Chime School, Isle of Wight
TC since: 2019

Collaborative projects

Distinctive learning experiences for students from different schools to participate in

Collaborative projects are 'enhanced learning experiences' developed with network teachers and delivered by TCs for schools in their networks.

Teachers from different STEM subjects come together and support each other to develop their students' knowledge and understanding of engineering and engineering careers. They also develop practical opportunities for students to start developing engineering habits of mind: systems thinking, adapting, problem finding, creative problem-solving, visualising, and improving. (See more information on *Engineering Habits of Mind*, on the next page.)

The collaborative projects also provide opportunities for students aged 9 to 14 from diverse backgrounds to work together with STEM ambassadors and local STEM-based industries through a variety of engineering-focused activities and challenges.

Students receive engineering careers information and experiences that help them to make informed decisions about the role engineers have in society and understand the pathways into engineering careers.

Collaborative projects also aim to:

- create long-term collaboration between schools in each regional network beyond the life of the programme
- provide network schools with opportunities to participate in shared STEM learning experiences on an annual basis
- offer students from different schools and different year groups the opportunity to work together on interdisciplinary creative problem-solving tasks.

STEM teaching and learning resources

Enhancing and enriching the curriculum

The Academy's STEM teaching and learning resources have been developed in partnership with teachers and engineers to engage students with STEM subjects and inspire them to consider careers in engineering. They are thematically linked to real-world challenges such as sustainability, climate change and, more recently, the COVID-19 pandemic and the role engineers played in the global response.

They 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. We have developed an online interactive EHoM quiz at https://stemresources.raeng.org.uk/stem-at-home/engineering-habits-quiz/ for young learners to identify which EHoMs they might be using for different challenges.

Since its launch in September 2011, CST has produced 18 resource boxes to enhance and enrich the STEM curriculum and 20 STEM club resources. Our resources are freely available for all schools and can be downloaded from the Academy's website.

We have recently started producing tutorial films for teachers and STEM leaders to support those outside of our networks, who do not benefit from training, to confidently deliver the activities in each resource. The resources are extremely popular on TES online and STEM Learning's e-library, where they have been downloaded more than 50,000 times in total and are currently being downloaded at an average rate of 500 each month.

Our response to COVID-19

During the pandemic, socially distanced lessons were taught to small groups of key worker children in school and the majority of students learned from home without access to digital devices. To address these challenging circumstances, we redesigned our resource boxes and created individual packs for students to continue with 'digital free' practical activity and scientific experiments unable to be delivered during school lockdowns.

In the absence of STEM clubs and after-school activities, 25,000 *This is Engineering: Entertainment* and *Engineering in a Pandemic* individual packs were posted to students to use while they learnt from home. Students uploaded evidence of the activities undertaken from each resource to an accreditation website specifically designed at the start of the pandemic, and received digital STEM badges in recognition of their achievement.

10 years of Connecting STEM Teachers

CST launches in September with **seven TCs, increasing to 20** by the end of the academic year.

2011

125 schools engaged

2012

The number of resource boxes used in schools and associated teacher training continues to rise as more schools join the programme.

CST hosts its first celebration event in recognition of the success of the programme to date.

5 STEM resource boxes developed

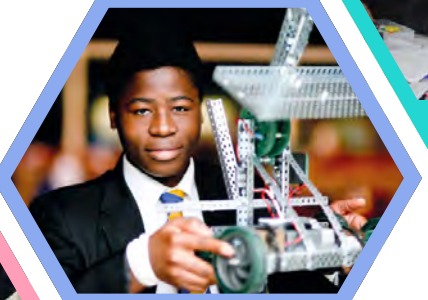
2013

2014

TCs deliver their first collaborative projects, bringing schools together for enhanced STEM learning experiences.

16 Collaborative projects

TCs actively identify and recruit schools in areas of low social mobility, encouraging schools to engage underrepresented groups of students. CST launches its first sustainability-themed resource.



2015

67,000 Student beneficiaries

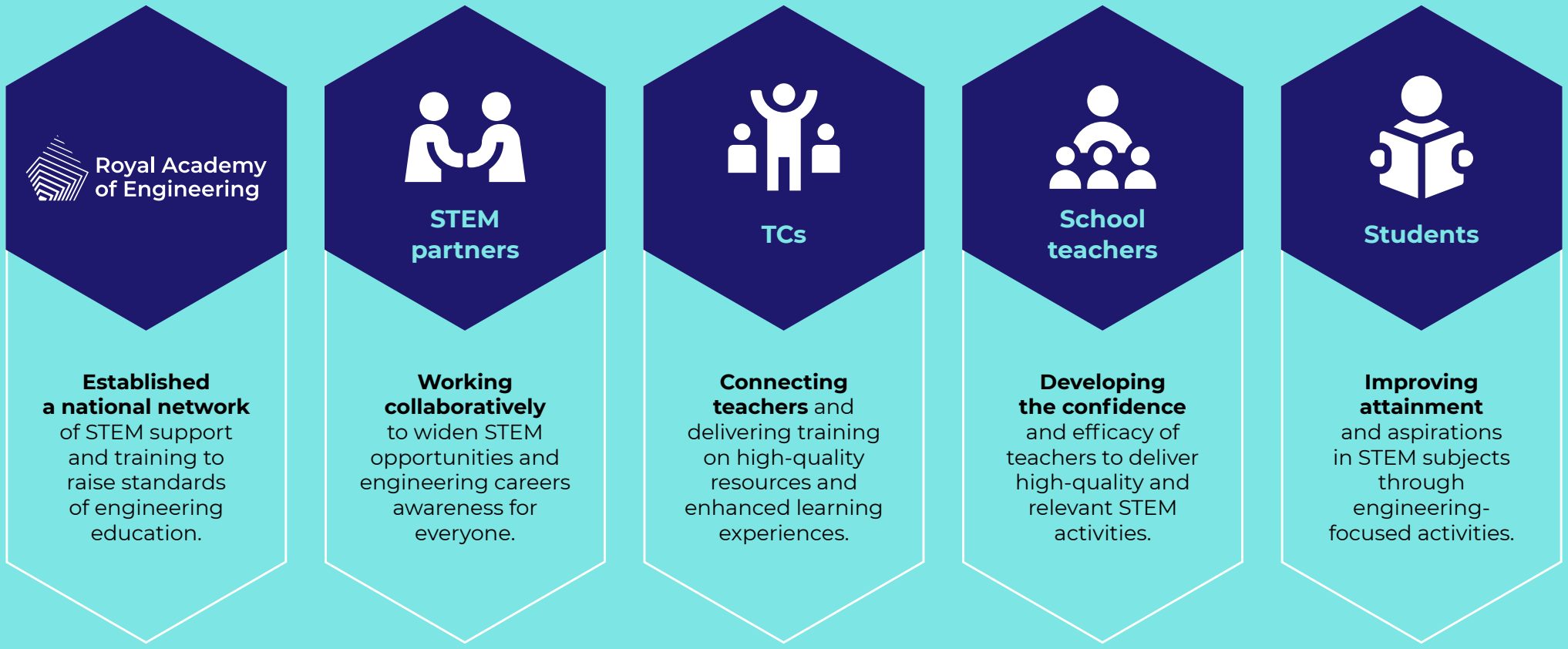
2017

42 Teacher coordinators

Academic year	Number of unique schools engaged in CST	Number of teachers trained during regional network meetings	Number of resource boxes used in schools (and home learning packs in 2020-2021)	Number of student STEM experiences resulting from schools participation in the programme
2011–2012	125	230	400	11,000
2012–2013	385	448	384	37,000
2013–2014	401	461	242	35,000
2014–2015	417	473	365	33,000
2015–2016	570	744	752	67,000
2016–2017	675	881	587	67,000
2017–2018	700	1,023	2,274	84,000
2018–2019	689	920	1,626	89,000
2019–2020	990	1,429	1,923	144,000
2020–2021	1,015	1,987	32,500*	197,000
TOTAL	**5,967**	**8,596**	**8,553**	**764,000**

*Individual STEM packs replaced resource boxes

CST community and partners



Achievements in AY20-21

Participation

As can be seen, the number of teachers participating in the programme has risen year-on-year with a record **1,987 teachers from 1,015 unique schools** engaging with the programme across the UK last academic year (AY).

These teachers go on to **deliver STEM resource activities to an estimated 197,000 students**. The map shows the geographical spread of the schools participating, followed by data on social mobility.

1,987
teachers

1,015
unique schools

197,000
students

Achievements in AY20–21

Social mobility

We measure social mobility for all CST schools in England, Scotland, Wales, and Northern Ireland, and identify student engagement and the number of STEM experiences in the most deprived regions compared to the rest of the UK.

We do this by cross-referencing regional and national data in the public domain – IMD (indices of multiple deprivation), students eligible for free school meals and ethnicity on the school's roll – to calculate the number of STEM engagements experienced by students from underrepresented groups.

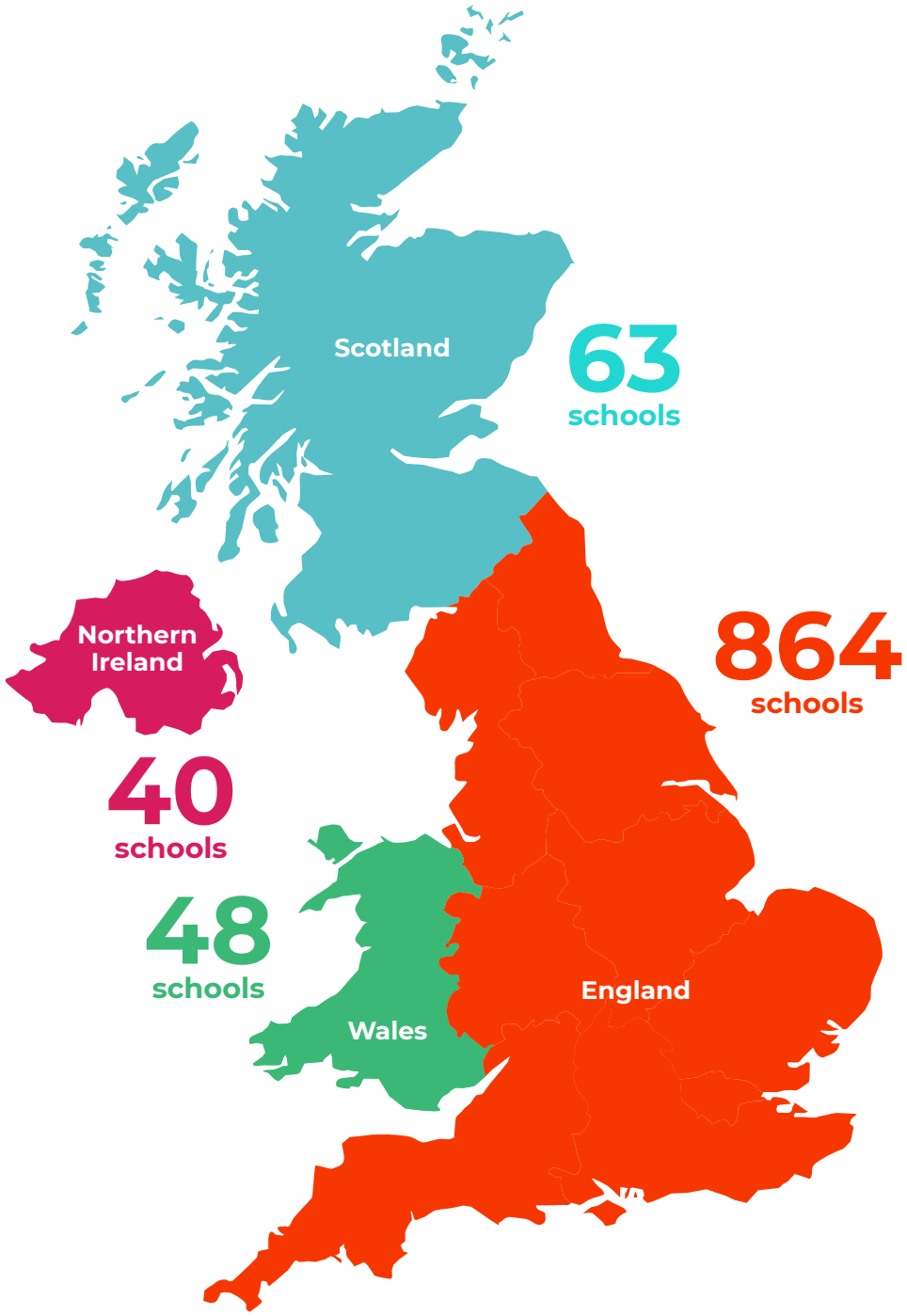
Using the 1,015 unique schools that participated in CST in AY20/21, we present the following data:

Scotland
14 Primary schools
49 Secondary schools
10,036 STEM experiences

Northern Ireland
8 Primary schools
32 Post-primary schools
8,435 STEM experiences

Wales
8 Primary schools
40 Secondary schools
8,890 STEM experiences

England
256 Primary schools
608 Secondary schools
169,938 STEM experiences

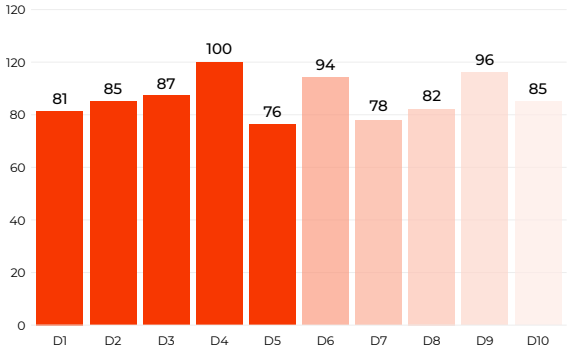


Achievements in AY20–21

Indices of multiple deprivation

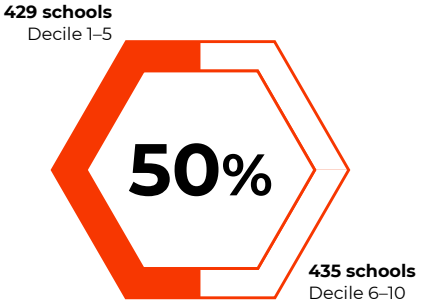
England

CST schools in most and least deprived local areas



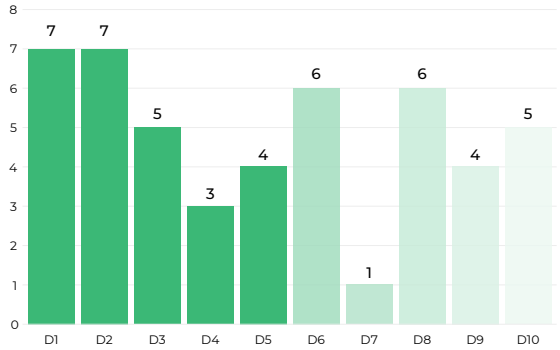
England

Number of CST schools in the 0–50% most deprived areas of England



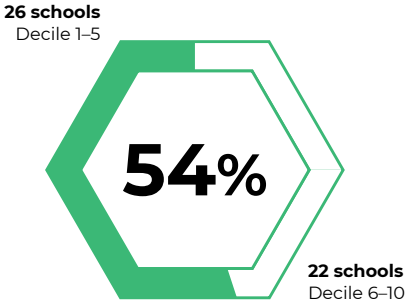
Wales

CST schools in most and least deprived local areas



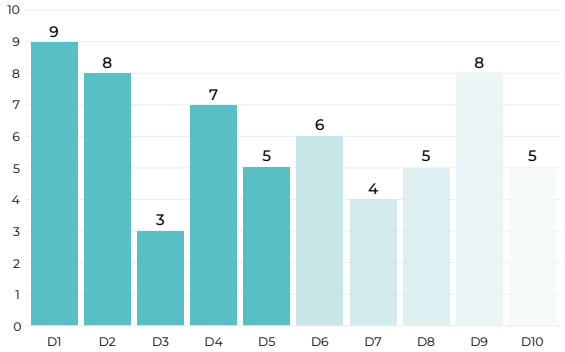
Wales

Number of CST schools in the 0–50% most deprived areas of Wales



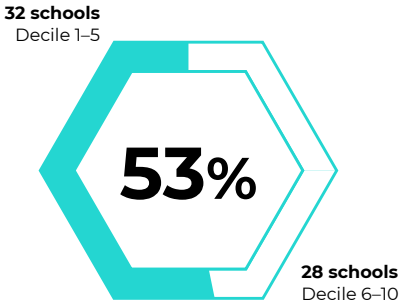
Scotland

CST schools in most and least deprived local areas



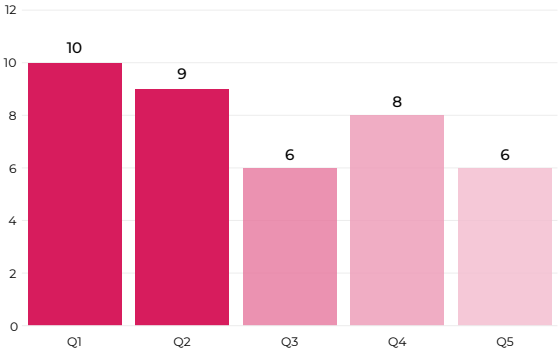
Scotland

Number of CST schools in the 0–50% most deprived areas of Scotland



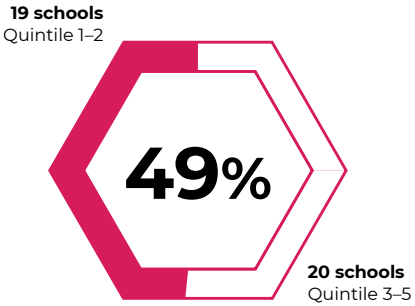
Northern Ireland

CST schools in most and least deprived local areas



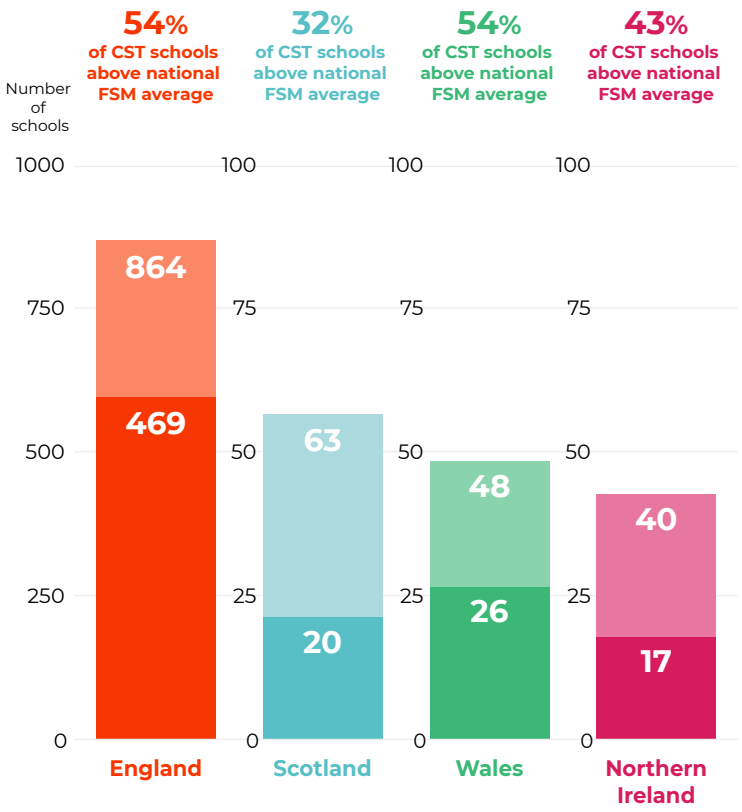
Northern Ireland

Number of CST schools in the 0–40% most deprived areas of Northern Ireland

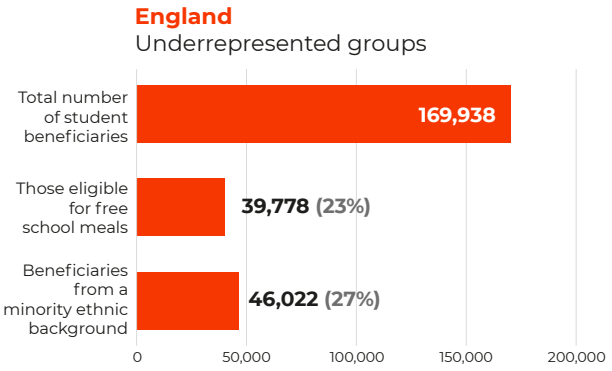


Achievements in AY20–21

Pupil premium and free school meals

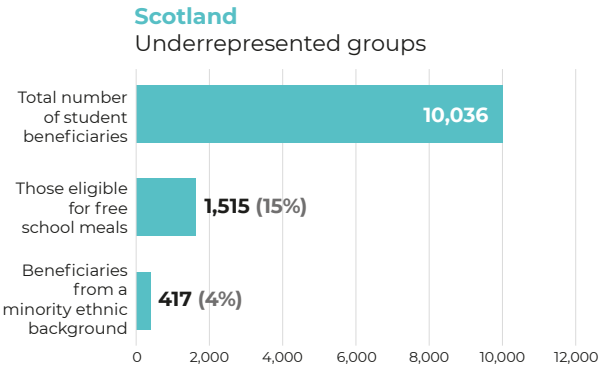


Participation by ethnicity



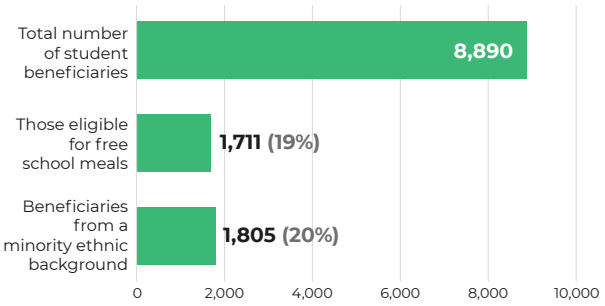
19.7% of students in England are eligible for free school meals in 2020

16.5% of secondary school students are recorded as being of minority ethnic background



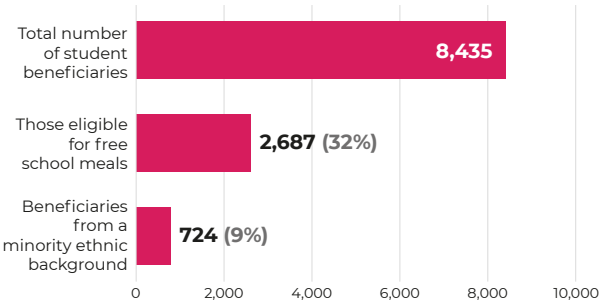
15.6% of students aged 5–25 in Scotland are eligible for free school meals in 2020

16.1% of secondary school students are recorded as being of minority ethnic background



19.9% of students in Wales are eligible for free school meals in 2020

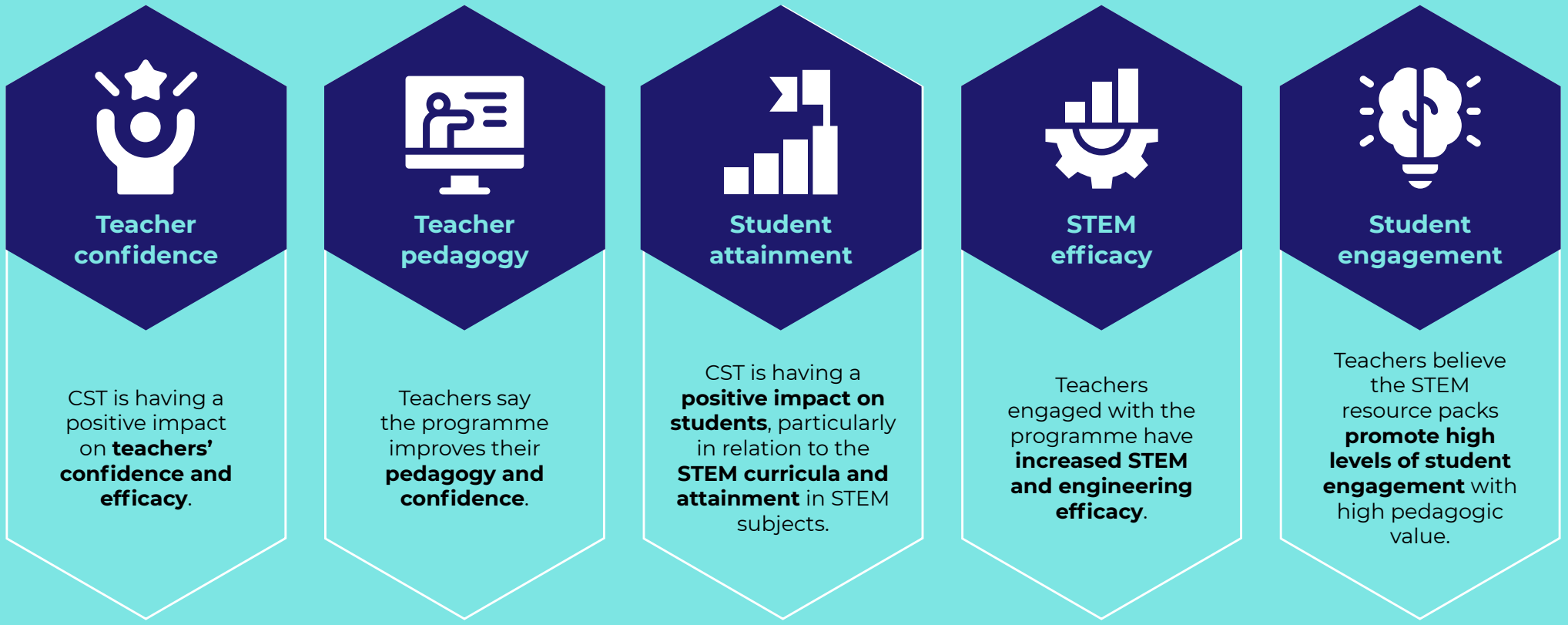
12.0% of secondary school students are recorded as being of minority ethnic background



29.9% of students across all school phases in Northern Ireland are eligible for free school meals in 2020

9.0% of secondary school students are recorded as being of minority ethnic background

Programme impact 2011 to 2021



Programme impacts

Teachers engaged with the programme over the longest period of time have higher levels of STEM knowledge, an increased range of pedagogic approaches, increased STEM and engineering efficacy, and understanding of STEM enhancement.

After two years of being part of the programme, **72% of teachers surveyed** reported a high level of confidence to deliver engineering content. Teachers are interacting with other teachers in their networks and developing work streams with STEM colleagues back in their schools.

94% of all teachers surveyed said they valued the support of other teachers in the network.

The STEM teaching and learning resource packs, developed by the Academy, are viewed by teachers to promote high levels of student engagement with high pedagogic value.

84% of teachers surveyed agreed that student attainment in STEM subjects will improve and **86% agreed** that students showed an increased interest in engineering careers as a result of participation in the programme's activities.

Case studies

Academy STEM teaching and learning resources

Introduction

The following series of case studies evidence where activities from the Academy's thematic teaching and learning resources have been used to build successful STEM clubs, inter-school collaborative projects and/or multi-year group enrichment events.

Examples of where these resources are being embedded into the STEM curriculum within timetabled lessons and changing young people's perception of what engineering is and what engineers do.

Bringing the world of STEM within the reach of students

Gerard Cocker

Subject Leader for Design Technology, Dover Grammar School for Girls

At a Dover grammar school, Academy resources are inspiring older pupils whose enthusiasm then percolates down to younger pupils.

We are in an area of lower social aspiration, so raising expectations and aspiration was crucial alongside demonstrating that the world of STEM is achievable. The combination of the Academy kits, the teaching resources and online information has been incredibly helpful. We have used several of the kits in both whole year group and mixed age challenges, during activity days and weeks.

My teacher coordinator, Emma Harvey, provided excellent hub sessions which allowed all of those attending to fully understand the resources and share possible challenges and outcomes. She was always available if help or advice was needed.

The results have been striking in terms of how students perceive the world of STEM, with some students reassessing their options choices and career routes. When using the Academy kits in mixed year groups, you see the leaders and critical thinkers emerging during each activity. The enrichment activities have included the *Future of Flight*, space travel and life on a remote planet boxes. Students had to think about the energy, materials, logistics, food, and clothing in creating possible solutions.

Mapping out a career path

Some of the resources we have used stimulate discussion and challenge understanding from Key Stages 3 to 5. We currently use the careers materials and online resources a lot in school, especially with older students who are still uncertain about next steps. A great example of the impact these resources have had is when we used them during our enrichment fortnight in the summer term.

We used the *Future of Flight* resources with Year 8 and supported them with several DT A-level students, which worked really well. The work carried out by the sixth form students not only helped the younger students but firmed up career paths in two students and refocused two more towards Engineering and Design.

This has resulted in students completing UCAS forms and university applications with a clearer picture of where STEM skills can be used.

The Academy kits are an excellent resource, both sustainable and understandable. They give students and teachers the chance to adapt to suit each challenge. We have used the resources in our school in a variety of ways, and they are having an impact above our expectations.

Of our 28 sixth form DT students, eight are applying for STEM based university courses, while three have applied for Level 6 apprenticeships and one succeeded in being accepted onto a Level 7 apprenticeship.

The experience of working with the challenges and the resources has been crucial in some pupils being reassured about their choices; for others, it's helped them to adjust their routes. One example was a student who wanted to study business and finance at university, but who is now applying for design engineering degree courses.

A word on the Academy

I would like to thank the Academy for their support, and especially our local hub leader who has been excellent in her organisation and clear explanations of provided and available resources.

Re-engaging students and developing a love of engineering

Debbie Glenn

Lead science teacher at Whitmore Park Annexe, Coventry

Academy resource kits are being used to break down barriers and open up conversations around science among students who've had to leave school for medical reasons.

Coventry's Hospital Education Service is a unique setting split across three key areas – University Hospital Coventry & Warwickshire, home tuition and a small school setting called Whitmore Park Annexe. We aim to provide continuity in education when pupils miss school for medical reasons. Whitmore Park Annexe caters for very vulnerable pupils aged 11 to 16; the majority have Education, Health and Care Plans (EHCPs), severe anxiety and mental health issues.

The Annexe provides an alternative setting for these disadvantaged pupils in which we try to give them hope and qualifications for the future, including reintegrating them back into their mainstream school.

We mainly work 1:1 with pupils who have become disengaged with education either through mental health or physical illness, and the Academy resources are a great link to build trust and relationships with these pupils.

[The impact on the students] The kits cover such a wide area of science that I'm able to pick a suitable one to match each pupil's special interests one-to-one. The 'This is Entertainment kit' was used with Year 10 pupils in the Physics curriculum to demonstrate physics in the real world. In the near future, four of the pupils are moving into STEM careers.

One Year 8 pupil had 1:1 lessons with his tutor and the pupil's special interest was IT. His teacher used the Code and Rescue kit, and the pupil excitedly explained how he had programmed lights. He is gaining good grades in all of his subjects but is particularly talented in his GCSE Computer Science and is applying to do computer science post-16. One anxious Year 10 pupil asked to do some electricity, so we used the Sustainable Futures kit and she was able to study electrical circuits. The pupil comes to science every week now, and I am confident she will be one of our future STEM scientists.

Practical benefits

Practical science is a fantastic way of encouraging our pupils to open up and communicate. It also benefits pupils in the areas of maths and IT. By using the kits as an introduction to science, it's possible to remove the barriers to a subject that is often perceived as difficult.

Pupils have really engaged in these activities, and the kits have been good in building relationships – it's all about discovery, not right or wrong. Pupils don't fear sharing ideas with a teacher, which builds that positive relationship you need to encourage learning.

A word on the Academy

Our Teacher Coordinator, Gaynor Sharp, has a clear understanding of all the activities in the kits. They're of extremely high quality and are very generous in terms of the resources included. We will be able to use them for many years, and they particularly suit our settings as they are mobile, so I can take them into homes to teach a pupil.

Using STEM teaching and learning resource boxes to develop a thriving STEM club

Sharon Rees-Williams

STEM club organiser, Ysgol Gymraeg, Abercynon

From boosting STEM engagement among girls to transforming the prospects of a selective mute pupil, Sharon explains how the Academy's STEM teaching and learning resource boxes have inspired and engaged pupils.

I've been teaching at Ysgol Gynradd Gymraeg Abercynon for over 30 years, and I've taught every year at some point. I am currently teaching Early Years, and I've been running the school STEM club for years 5 and 6.

The Academy's STEM boxes give us more confidence to try different activities, and also show us what resources are needed. As we move towards the new Curriculum for Wales, I think these STEM activities are going to be invaluable.

We had a thriving STEM afterschool club with some very enthusiastic pupils (usually around 15 to 20), and the Academy's STEM boxes were great to get us going.

We also won the Academy's regional CST Marble Run STEM Challenge in 2019, beating other teams from across South Central Wales. The pupils put a short PowerPoint presentation together, explaining their work on the marble challenge. We found an increasing number of girls joining us, being enlightened by the realisation that STEM isn't just for boys.

Enthusiasm for cross-curricular work has soared, and project-based learning approaches have been adopted. The STEM club participated in and won a network STEM challenge. A range of staff members have been involved, and report excitement across the school.

Finding the words

One day, a mother arrived to collect her daughter, who is a selective mute and a member of the school STEM club.

The mother was overjoyed to say that her daughter had been transformed through the club (inspired by and centred around Academy resources), and she looked forward to participating each week.

She described how her daughter had gone from never speaking in school to leading on problem-solving initiatives in the STEM club, and how the girl was planning on being an engineer when she grew up.

I remember the girl when she started her early years in school refusing to speak. As a school SENCo, I worked with her, trying to help her overcome her difficulties. It was a pleasure to see her in STEM club chatting away with others as they were trying to problem-solve, plan and discuss different projects we were undertaking.

She had started to speak in school, but to see her confidently discussing with her friends how to solve a problem was such a positive thing. It was also lovely to hear her mother praise the club for helping her daughter to find her voice.

A word on the Academy

Lack of resources is an obstacle with any STEM projects but the boxes provided by the Royal Academy of Engineering have been fantastic. They have also given us more confidence to try activities with the students.

Repurposing redundant PCs into student-driven arcade games machines

Sam Lawrence and Terry Watts

Sam: Technology teacher at Olympus Academy Trust in Bristol
Terry: Assistant Head Teacher and computer science teacher at Cotham School in Bristol

Two Bristol teachers have created a unique range of freestanding and tabletop arcade machines, using Academy funding and network resources to repurpose old PCs into student-designed games machines.

Terry: It all started while we both worked at Cotham. I was running a games programming club and the boys in the club wanted to build an arcade machine because they were making these games but had nowhere to showcase them. They said, 'can we make an arcade machine?' I said, 'yes, we could, but ask Mr Lawrence, our design technology teacher, what he thinks'. They pitched the idea to Sam, and the following week he came back with some drawings.

Sam: It was very organic, fuelled by kids and a need, and it just spiralled from there. We ended up with this amazing eight-foot tall 1980s-style arcade cabinet that the kids designed graphics for and named, and that ran all their games.

It was so popular in the school community and when we started doing the Academy's networking meetings together, we decided to see if we could get other schools doing this. Terry was running the software side of things and the interface was done over in the computer science faculty. Then in the technology department, we were bringing it all together with wiring and laser cutting parts.

The machine loads into game selector software written in GameMaker, and the kids' games were programmed in either Unity or GameMaker. We used an iPad to interface the Windows machine with the joystick buttons, so each joystick is essentially a keyboard press. We also programmed our games to a consistent button mapping so they all work together.

Sam: The project was really well supported by the head teacher at the time, who gave it a high profile within the school, championing it as extracurricular and using the collaborative project funding from the Academy. That meant that we could try and roll it out.

When we came to do workshops, we split the day, so they did coding with Terry and building with me. We took the machine to a big event with trade shows and career stands, and our students were showing the machine off. We had contractors working with Sony there, because I remember one pupil went off and did a WEX placement with them, working on a Sony project! We had universities, colleges and employers all saying they liked what we were doing and engaging with the students, which was really good.

Funding, support and assistance

Sam: The Academy paid for this project, and the CST network meetings gave us teachers to call on. We knew we had something people would be interested in but making the jump to actually getting teachers on board with groups of students was quite another thing.

Projects like this demonstrate the link between being an engineer or a computer scientist and something that kids probably sit down in front of every day and play.

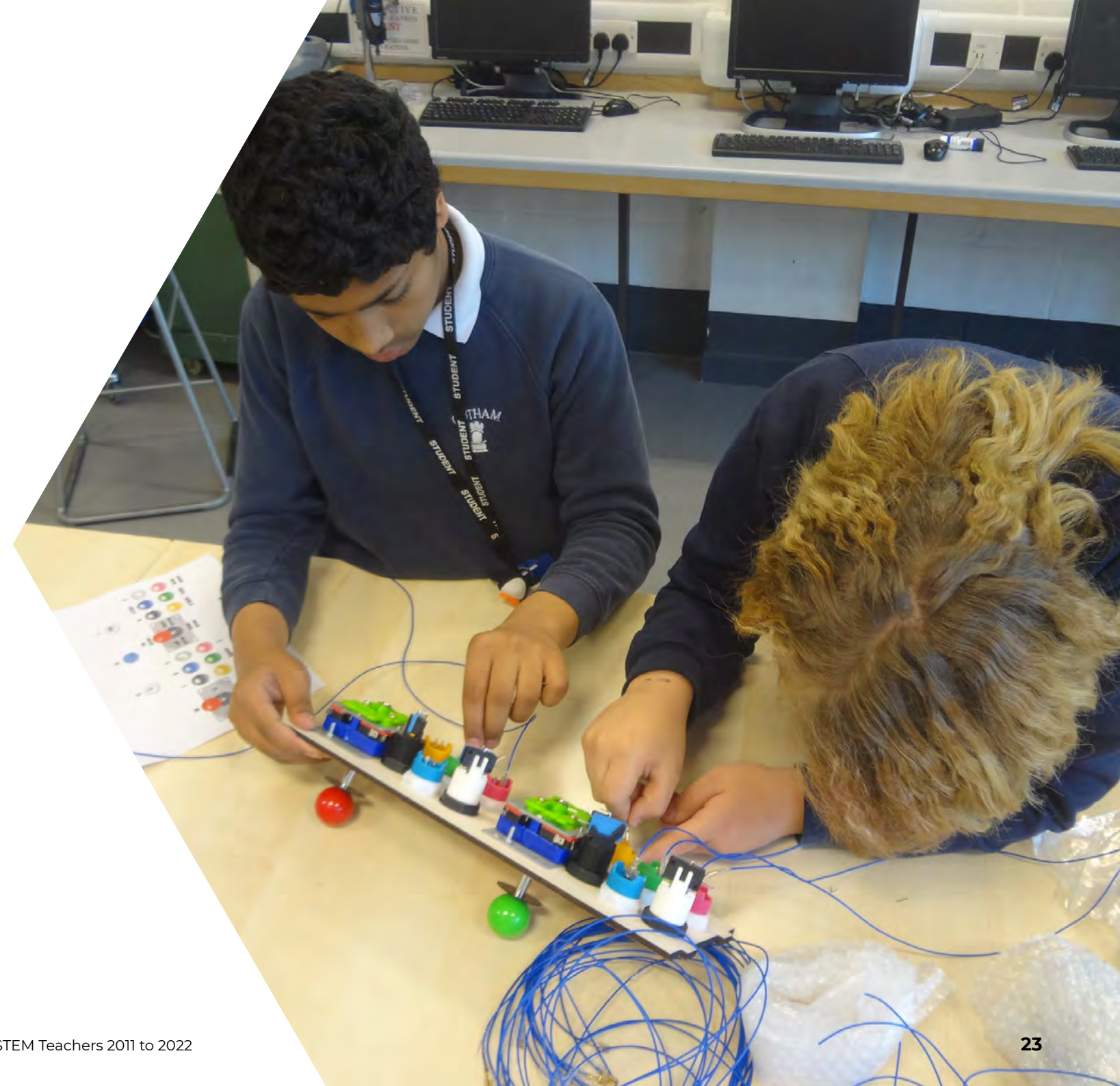
We had about a dozen teams, a few parents and 30 or 40 students. Over and above the Academy's funding, having them on board really gave us kudos with the parents, and Scott Atkinson was very good at getting the word out to national media and computing magazines.

Terry: The kids came up with their own Genetically Modified Games branding. We went to the art class and asked if anybody was interested in drawing a logo for us, and this Year 8 girl came back with three or four different designs for our logo, which were amazing. That was a really nice moment, because again, it was student content we were using.

A word on the Academy

Having the Academy support meant we had a key relationship with a group of local teachers – being able to plan a local event and get them to give up their Saturdays was a big help.

“Because not everybody had the space for full-size cabinets, we explored with the students pulling apart old Windows Vista PCs and seeing if we could fit them inside little desktop arcade machines.”



Introducing STEMunity – a national charity inspired by the CST programme

Jorden Birch

Enrichment and STEM Coordinator, Wales High School, Sheffield

An online platform developed by the Academy during lockdown inspired two network members to establish a charity, aimed at funding STEM academies across the country.

If COVID-19 has taught us anything, it's that blended learning is not only an important approach, but it opens the doors to even better possibilities for learning. During the first national lockdown, Dr Margaret Ritchie, the CST lead for Glasgow, developed the STEM Academy Scotland model. This online platform allowed young people and families to access careers workshops developed in partnership with academics and teachers. Through the CST programme, Laura Watford and myself ran this project, and over nine thousand students accessed the online workshops.

Following the success of the programme, we began to develop a STEM Academy North (north England), and STEM Academy South (south England), working in partnership with university academics, teachers and industry partners. To access more funding to enable the projects to become truly national, we formed STEMunity, which gained charitable status in August 2021.

Making a real difference

STEMunity has worked on many local and national projects. The charity has produced bespoke educational workshops, and STEM Academy South has developed three workshop activities which have been professionally filmed with organisations like ViridiCO2, Conrad Manning Racing and the Hampshire & Isle of Wight Wildlife Trust. During these online workshops, students will develop their understanding of career opportunities in STEM, and also complete curriculum-linked activities either in their classroom lessons or through home learning.

STEM Academy North developed a series of digital escape rooms that were in line with the latest Royal Academy of Engineering resource boxes for each term. These were live sessions designed for students aged 9–14, consisting of timed workshops that students needed to complete in order to be entered into a national prize draw.

The first workshop was based on an Apollo 11 mission, aimed at primary students aged 9–11. Over three thousand students participated in the live event across the UK and the workshop received a five-star rating in teacher feedback. In line with the *This is Engineering: Sustainable Futures* resource, STEMunity developed a Sustainable Futures digital escape room where over five thousand people nationwide took part. The recent *Future of Flight* escape room was the biggest to date, with over seven thousand young people participating in December 2021's live event.

A big focus for the coming years is to increase the capacity of the existing project and focus on SEN provision in STEM, digital resources and digital badges linked to the Gatsby benchmarks.

STEM Academy South ran a vertical farm challenge in line with the Academy's *Engineering a Better World* resource box. Students worked in their own time to develop their ideas about sustainable farming by designing a vertical farm for St Margaret's Community Church.

"During 2021, over 23,000 young people across the UK from ages 4 to 18 engaged with STEMunity activities."

Case studies

Engagement with STEM subjects

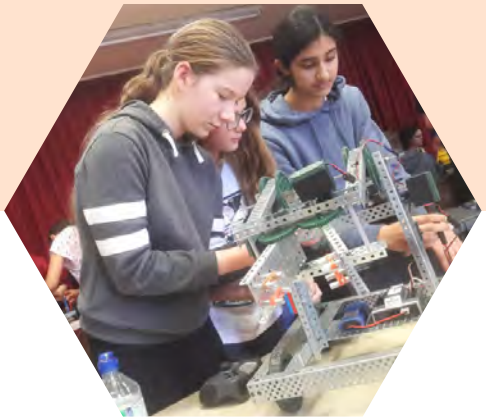
Introduction

The following series of case studies tell the stories of how schools have engaged with STEM subjects, including the introduction of new engineering qualifications as well as increasing the number and diversity of pupils selecting STEM subjects.

From Coventry to China via Crumble kits

Pete Maguire

Head of STEM at Finham Park School in Coventry



Academy resources have given a Coventry school an international profile, while the head of STEM has been using resource kits to train teachers as far afield as Shanghai.

I used to work in engineering, but one of the reasons I left was because I was surrounded by people who were waiting to retire. I couldn't understand why there weren't any younger engineers, but reflecting on my own educational experience, there wasn't anyone inspiring young people to take up engineering or D&T. I thought I'd look into it further and ended up enrolling on a teacher training year at Nottingham Trent Uni, specifically focusing on engineering. I particularly moved to Finham Park in 2015 because they taught engineering.

As an active member of the Design & Technology Association (DATA) I am asked to run teacher training courses, and one of the things my school does every other year is a school sightseeing trip to Shanghai. When I joined, the head teacher asked if I'd be willing to head up a student leadership STEM project in China, with our students leading the Chinese students. Over three days the student's collaborated using LEGO Renewable Energy kits to demonstrate innovative ways to generate sustainable energy. DATA also put me in touch with the Shanghai Engineering Technology Education Research Center (ETERC), so I did a bit of consultancy work for them while I was out there. They were really interested in how we taught D&T and engineering, and they would periodically pay for me to go out to teach the Shanghai teachers engineering and STEM-type projects.

In 2019, Finham arranged for me to have a sabbatical year to work for the ETERC in Shanghai with my family. We all went out and I did some amazing engineering and DT-related teacher training.

Search and rescue in Shanghai

It's been a pleasure to be aided by the kits the Academy has been distributing over the years. One of the resources we took out to China was the Crumble microprocessor, and around that time the Academy launched the *Code and Rescue* pack, which is a fantastic resource kit. We used that in China to train some of the teachers out there who were pleased we'd taken an innovative approach to using the microprocessor, rather than just using it in buggies or night lights.

Initially at Finham, we didn't have any girls taking the engineering course we were running, so we targeted our efforts on getting girls interested in robotics. They saw this as a relevant pathway into engineering. We had three successful teams at different age groups competing in the VEX IQ challenge, several of whom went on to study engineering as a subject, one achieved an Arkwright scholarship, and her journey started with the kits the Academy sponsored us with right at the beginning.

A word on the Academy

Over the years, the support the Academy has given us in terms of sponsorship with VEX kits has allowed us to compete at national level, and STEM involvement has snowballed from there.

An all-female team is teaching engineering skills through robotics and programming

Jo Brown

Senior YSC Officer, UCLan and Ri Young Scientist Centre (YSC), University of Central Lancashire, Preston

Academy resource boxes have inspired a new workshop at the University of Central Lancashire and Ri Young Scientist Centre, giving students a taste of engineering careers through hands-on activities

The UCLan and Ri Young Scientist Centre opened in 2015 as a place where school groups could come and experience hands-on STEM activities in a purpose-built lab. We were the first branch of the Young Scientist Centre outside London, where the original lab is situated in the Royal Institution.

We wanted to add an engineering skills workshop to our programme, and after attending a CST network meeting run by Chris Wallis in March 2020 for the Code and Rescue resource box, ideas started to form. It was my first introduction to the programmable Crumble board, and I knew that I would be able to build on the activities in the box to develop some new activities for the YSC.

The new Rescue Robots session was run as a two-hour session with Year 8 pupils from the University's network of widening participation schools in January 2022, and there are more sessions planned before the end of the summer term this year. The session is currently being expanded into a four-hour workshop, to bring in some of the real-world uses of robots that researchers at the university are involved in.

"Our teacher coordinator Chris is a great help in opening up opportunities for engineering activities. I've learned lots of new skills from the sessions he has run, and I feel much more confident in designing and running the activities."

In terms of coding, I was an absolute novice, so going to the network meetings and talking to Chris gave me the confidence to think this is something I could definitely use within our workshops, and pass this onto students. Teachers come in from other schools and ask loads of questions about things. I hope I'm not only inspiring the kids and getting them to think about engineering and what engineers do, but also seeping out further into other schools as well, planting that seed for teachers.

When we first ran this session, the buzz in the room was amazing. I was really pleased – you want to make it as engaging as possible, but until you actually put it in front of a group of students, you don't know how it's going to go. The kids were really engaged in it, but we also had quite a few student ambassadors who are undergraduates from the University who work with us.

When we have school groups, they come and support them, and they loved it as well. And they were really getting involved, which rubs off on the students too. Because it's really hands on, they can pick up the basics really quickly. That's what I really love about the Crumbles; it's so simple and you can do very simple things with it, but you can very quickly build on that.

What I've learned myself

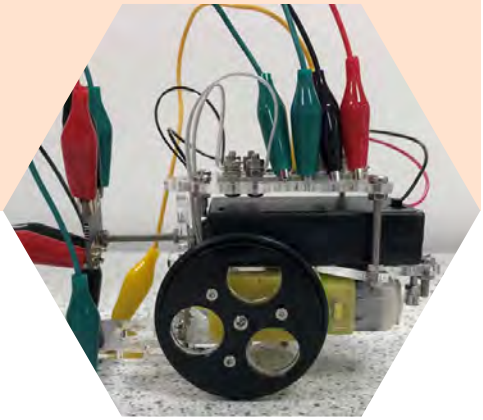
I think if a teacher had talked to me about engineering, telling me the sort of things I could go into, I totally would have gone down that road. But it was never really on my radar; I thought you had to be really good at maths, and it didn't seem appealing. If having this equipment available in schools or having positive experiences makes a student realise 'this is something I could really do', that's got to be good for the industry.

Plans for the future

The activities will also be used in a new full day workshop for KS2/3 pupils to introduce them to robotics and the skills needed to be an engineer. All the full-time staff are women, acting as role models to promote the involvement of women in engineering.

A word on the Academy

The Academy kits are a springboard for other ideas, giving me a tried and tested foundation to work from. Having access to try out the equipment takes out the guesswork that's often part of workshop development when you want to try something new but don't quite know where to start!



“You get some students who just do the basics and try to get to grips with it, but you’ll have others that absolutely fly and love being able to experiment with things. If they pick it up really quickly, they can have a go at putting code in, or writing their own code.”

Developing the next generation of resources and training materials

Holly Leat

Assistant Head Teacher at St Anne's Catholic School, Southampton

A team of Academy teacher coordinators have created their own STEM Academy project to enhance opportunities for some of the most disadvantaged young people in their communities.

Portsmouth teacher coordinator Laura Watford and I were appointed at the same time. We had similar roles within our schools, and our lives have mirrored one another a little bit as well, so we formed a friendship around that which led to us collaborating on a number of projects. A few years ago, we were approached by the Hampshire and Isle of Wight Air Ambulance. They wanted to discuss resources that they'd produced and get some teachers' opinions on it. They were talking about doing workshops for students when we were separately organising collaborative events, and we saw an opportunity to offer workshops as part of our event.

We're collaborating with another TC Jordan Birch this year on the 5PARKS project, which has been designed across two regions (South Hampshire and South Yorkshire) and three STEM networks. It involves a workshop and a five-piece student pack aimed at WP students from our network schools.

In the South, the event will take place at Winchester Science Centre with an action-packed day to engage young people into the STEM disciplines, exploring and developing their *Engineering Habits of Mind*. A sister event is being carried out using the same model in Sheffield, supported by funding from the Academy's Connecting STEM Teachers Collaborative Project Fund.

We aspire to remove barriers, inspire, and encourage the young people to consider careers in STEM, and to nurture their creativity and innovation.

The importance of events

We ran our first collaborative event at Winchester Science Centre, with workshops and a flyover from the air ambulance. The first year we had ten to 15 students from around ten schools, and the next time we did it in 2019, there were around 200 people there. Of the pupils who came the first year, the vast majority came back subsequently. The kids really enjoyed the workshops, especially with the air ambulance staff. We also have a 'STEM ambassador speed dating' activity where they got to go around and meet lots of different STEM ambassadors, which was a good opportunity for them.

Whenever we've done collaborative projects, we always try and give the students who have been there on their own a pen or a badge or something they can take home. That will hopefully spark a conversation when they get home about what they've been doing.

Connecting the generations

We organised a trip to Lifelab, which is based in the University of Southampton, as part of a health education programme. We structured it so the kids came along for the morning, did the activities and learned about everything, and then in the afternoon the parents came along, and the kids taught the parents what they'd been doing. I think the parents really enjoyed having that time to spend with their teenagers. Often, the older kids get, the less they want to tell you about what they've been doing at school, so that was a really nice opportunity for them. It was great to see the students being in the position of knowledge and sharing what they'd learned with the parents, rather than it being the other way around.

Sometimes parents are worried that something will be too difficult for their children. I also work in a girls' school and there's often a perception that engineering sectors are too male-dominated, and therefore it's going to be a difficult work environment for students. Parents can unwittingly have this unconscious bias about STEM-type careers as well, so it's good to show them some positive sides of it and reassure them as well as their kids.

A word on the Academy

Engineering Habits of Mind gives a nice structure and links between the different boxes and resources activities. I think that works well, especially if people can see it as a sequence through the different activities, even though the themes of the boxes might be quite different. It definitely helps the kids to tie things together from the different boxes and activities.

Boosting design and engineering uptake through field trips and resources

Simon Brown

Design and Technology teacher at Wellington School, Manchester

Having identified low uptake in design and technology subjects, a Manchester school planned and implemented a new engineering course which has now become a unique selling point locally.

When I joined Wellington School in 2019, there wasn't any engineering teaching taking place at that time. I did some groundwork and research on what qualifications are out there, and there are various options such as a BTEC and GCSE. However, a V Cert run by NCFE seemed to be the best fit for our learners, having got to know them for a year before our engineering course started. It allows high ability students right down to low ability students to access the curriculum, and hopefully move one step closer to a STEM-related career choice.

I did some groundwork before I set up the course, and I was really surprised to discover that there were only a couple of schools in the South Manchester area offering engineering. The course has been well received by parents and students, and the uptake is really good. We have just over 30 students per year, which is two classes worth – pretty good for an options class.

The engineering course is well resourced, with equipment including a sheet metal guillotine, a metal lathe with DRO and a plethora of hand tools.

We're quite lucky that engineering is primarily run out of the science and technology department. We have a good STEM club at the school, which a lot of other teachers get involved with. I run that club as well, so we have some input from maths teachers and science teachers who co-run it with me. Predominantly, we run Academy provided activities; we've been doing the Future of Flight activities recently, and we're coming into the VEX Robotics project which is going to be the collaborative project for our region. Our club will be getting involved in running a team to get involved in that competition.

Exploring the world

We've had a technical tour of Concorde at Manchester Airport on the engineering course, and we're hoping to do more external trips now that COVID has eased. I came to the school at a strange time; I got my foot in the door but then COVID hit, and I've not been able to do as much as I'd hoped, so more external companies and professionals being involved in the course is something which is going to happen in the near future. We've got a parent in the aviation sector working for Airbus, who's interested in having us to their place of work to look round.

A word on the Academy

The Academy STEM teaching and learning resources are high quality. They're thoroughly engaging and through the nature of running the club, we tend to get students who are enthusiastic about these subjects, so it's been great to run.

Collaborative triumph in the middle of lockdown adversity

David Melvin

Product Design and Engineering teacher at Cardiff West Community High School

One teacher's inspired idea to encourage online teamwork using Academy resource boxes saw dozens of pupils engaging with STEM activities at the height of lockdown.

The day I joined was the first day of the 2020 lockdown, so there were not any STEM activities being run. My teacher coordinator, Sue Quirk, was doing some consulting work with the school and I was recommended to join her Royal Academy network meetings where she introduces STEM resource packs and makes them available. I thought that would be a brilliant way of introducing STEM into school without having to wait until we came back.

Opening the packs live was like opening Christmas presents! Their faces on-screen and their excited noises assured me this was going to be a great event, and so it turned out.

I came up with the idea that the pupils could have a pack where they didn't know what was in it. I wanted to recreate that Christmas-present surprise element where they didn't have any idea of what we're going to do. I got in touch with the parents and posted all the packs out and asked them not to open them in advance. One of the 20 pupils couldn't resist opening them, but the rest managed to resist the temptation! I told them they would need pop bottles but not why, and then they were all on the screen...

The pupils hadn't come across any of this before. They were fascinated by the fact that it worked, and the laughter and excitement of doing it live with me and with their mates was brilliant.

I was listening to their explorations and excitement as they were talking to each other about what was in the packs. I could see them talking as though they were just next to each other, as though they were in each other's houses, having their own conversations. Some were having trouble, some were doing it easily, some mums came and helped, brothers were helping, and they all made wind tunnels using a two-litre pop bottle, a motor, a battery and a fan. Some were going wrong, and we were talking about how to get the circuits the right way around, but the engagement was absolutely fantastic and very successful. We also had the Bumble Beep and the RGBug in the kit.

Lighting the way

The good thing about the Academy resource packs is that if there are ten experiments in the pack, I can select two which are the most achievable remotely, and each pack covers lots of fun different things. They are excellent – really good quality. The RGBug with LED lighting which they can adjust to get any colour they like is brilliant, and the pupils absolutely love them. They don't come across these components in a mainstream school; electronics hasn't happened in our school, so this is all new to them. There's nothing quite like touching and holding this kit and seeing what it does and asking questions and taking it from there.

Opportunity from disadvantage

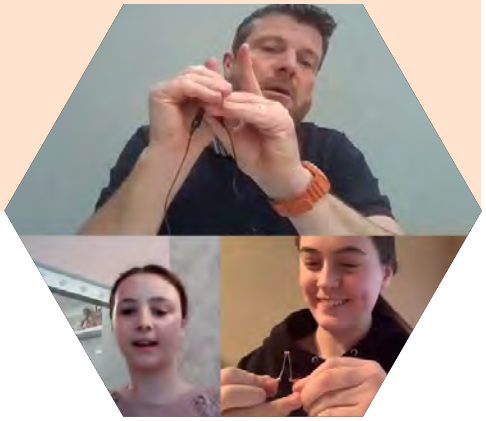
Our school has got the highest percentage in Wales of free school meal pupils and disadvantaged students due to its catchment area. These pupils didn't really engage – people who would normally not have had anything to do but getting involved was great for them. There's a beauty in seeing people who were probably just going to be on their Xbox and be left alone day in and day out actually engaging with the resources. It's a pleasure to see pupils benefit from those things when there's opportunities, having fun and not worrying about making mistakes. That's one of the things we love, just letting pupils have a go and make mistakes.

What the pupils said:

"I think this project is fun as we get to try out loads of different experiments and it's a great thing to do after school" – *Thanisha P*

"This is like magic" – *Ffion C while playing the Bumble Beep piano*

"This is really cool. I never thought I could actually do this!"
– *Summer W, working out how to create colours using the RGBug.*



“Pupils who didn’t attend live have since watched the video of the lesson and engaged. The pupils can’t wait for the next pack where I know we will have even higher numbers attending. This has been an excellent way of engaging pupils online.”

Royal Academy of Engineering

THIS IS ENGINEERING ENTERTAINMENT

Case studies

Pupil achievement and progression

Introduction

The following series of case studies tell stories of individual or group successes resulting from CST experiences which led pupils to demonstrate their exceptional skill and aptitude to achieve significant accomplishments at school, leading to studying engineering at further/higher education and/or progression to a successful career in the profession.

How one teacher has brought science, technology, engineering, and maths together

Neil Pacheco

A year 5 teacher, and part of the Senior Leadership Team at Kiveton Park Meadows Junior School

The story of how a pond and a welding course inspired girls at a Sheffield junior school to see themselves as future engineers.

When I joined Kiveton Park Meadows, they weren't doing STEM at all. The head teacher was very keen on science, but STEM was fairly new and nobody had much experience of STEM involvement or teaching it. With support from the head teacher, I went on various courses and began introducing STEM activities into school.

My work with the Academy started when I told my teacher coordinator, Jorden Birch, that I wanted to do robotics after a robotics session with the pupils at the National Space Museum. Jorden gave me an Academy robotics kit, and having demonstrated it to the head teacher, I applied for funding from the Institute of Physics for two more kits to use in school. Jorden has supplied me with various other Academy kits, including the Entertainment and RAF 100 packs.

I find pupils that display challenging behaviours get bored easily and need something interesting. STEM resources like Robotics and Crumble boards challenge them to think about computational skills and debugging code.

Being science lead in my school, I encourage other teachers to take a more practical approach rather than using iPads or laptops to do research. Children don't internalise what they learn when they're just copying, whereas if they do it in a practical way, they get a better understanding. STEM subjects lend themselves to that very well.

In our catchment area, girls have very little to aspire to. To see themselves as potential engineers, involved in activities like virtual welding, a lot of the girls outperformed the boys, which made them think this is something girls can do as well. It opened up another avenue for the girls in my class, and I'd love to continue it.

Joined-up thinking

The other thing Jorden did was to get us involved with Lincoln Electronics, where students got to engage in welding. We have a pond in the school, and to keep it clean, we've invested in a pump. We decided to make a waterfall feature with it, so we got the students involved in building the housing for the pump. We discussed how they'd connect housings, then we tied that in with welding and how different materials could be joined together. It had a great impact on the girls because they never saw themselves as engineers.

The impact on the students

I've used the Crumble kits as part of the IT curriculum. Using IT programming, I've supplemented it by putting it in *Code and Rescue*, so students work as a team to solve problems.

A word on the Academy

The most recent pack from the Academy – *Future of Flight* – had a wind tunnel and came with a sensor. We used that to show how air resistance was affected by shape, using maths and introducing pupils to negative numbers.

How a student achieved the first Arkwright Engineering Scholarship in his region of Northern Ireland

Karola McShane

Teacher of Technology & Design and Engineering, Foyle College, Derry/Londonderry

Foyle College teacher Karola McShane was instrumental in helping Year 14 student Callum Buchanan achieve an Arkwright Engineering Scholarship, which led to him pursuing a career in architectural engineering.

I graduated with a B.Ed (Hons) Technology and Design in 2004, and have been teaching ever since. I have enjoyed teaching KS3, 4 and 5 Technology & Design in Foyle College alongside my Head of Year 8 responsibilities. It's a subject that is continuously expanding and developing, so the connection with the Royal Academy of Engineering has been extremely beneficial.

An Arkwright information evening was arranged for all local CST schools where teachers, pupils and parents met with Arkwright representatives. This was the first stage in the process for Callum, and my first time entering a student. Callum's Arkwright Engineering Scholarship has motivated him to apply for the MEGA Degree Apprenticeship at Ulster University and to pursue a career in Engineering, while he's participated in video calls with engineering companies including BAE, Olympus medical engineering and Balfour Beatty.

Our department is filled with enthusiastic male and female students, many hoping to pursue a career in this field. It's our aim to provide them with the best possible experience and demonstrate the many aspects of STEM.

I don't believe there are any other scholarships or schemes open to A Level students – certainly none that I know of that give such a high level of mentoring along with financial rewards. I will continue to attend termly CST teacher meetings, participating in CST competitions and events. Foyle College has also been selected as one of six local schools for the Goldman Sachs ENTHUSE Partnership programme with STEM Learning. Callum's achievements have also influenced other students within the department.

In his own words – Callum Buchanan

The Arkwright application process

The application process was lengthy and detailed, ensuring all candidates had solid engineering interests. It began in December 2019 with a school or teacher nomination, a lengthy application form followed with many probing questions such as 'why do you want to be an engineer', 'what inspired you to consider engineering, and why'? There were also sections asking specifically about engineering-based hobbies and interests.

The Arkwright form would have been very difficult to fill out without having experienced engineering in action through my many projects, the technology and engineering teachers demonstrations, various CAD/CAM and CNC machines in the workshops, and using these machines for our GCSE and A-Level projects.

The second stage of the process was the aptitude test, based on a real-life design question. We were tasked with designing innovative and realistic solutions to a set criteria. The focus of our challenge was to utilise conductive fabrics and textiles (wearable technology), to design three separate solutions in an attempt to improve the safety of cyclists on the roads. After this, the standard process would have been an interview, but I didn't get to do my interview due to the COVID-19 restrictions at the time. In lieu of the interview, I had to fill out another questionnaire and personal profile document. These were similar to the initial application form but more detailed, focusing on the engineering projects that I had undertaken. This was the final stage in my application process, and I was announced as one of the successful candidates in October 2020.

After being awarded the Arkwright Engineering Scholarship, I was matched up with a mentor, Stephen Raggett-Batchen. He coached me by answering any engineering-based questions I had, keeping in touch on a regular basis, and he was always interested in the progression of my engineering projects. He also helped by proofreading my personal statement and CV, providing constructive and helpful feedback.

Plans for the future

The discussions within school and with everyone I talked to helped me decide between mechanical or civil engineering. In the end, I decided to go for a balance between the two, choosing architectural engineering (building services). This incorporates many of my interests and provides me with an opportunity to shape the sustainable buildings of the future.

From the National Grid to national robotics competitions

Michael Cronk

Head of computer science at Colyton Grammar School in Devon

A word on the Academy

Clare Doherty, the teacher coordinator, has been amazing at keeping teachers informed and motivated to participate in the programme. Her enthusiasm is contagious!

A broken shoe led one student into a career in engineering, while others were inspired to enter a life-changing robotics competition.

A few years ago, National Grid made 40 grants available to schools to start VEX Robotics competitions.

The grants were to start all-girl teams, called Girls into STEM, and the Academy distributed the information. I put out a message inviting girls from years 11 and 12 to meet in one of the D&T workshops.

When I went along, the only girls there were working on D&T coursework – they weren't there for the meeting, but we started talking and I convinced them to join. Another girl walked in, but only to glue gun her shoe, because it had broken!

She was studying physics and maths but she certainly wasn't doing D&T or computer science, and was a bit lost about what she wanted to do.

To obtain a grant, students had to produce a video about what engineering meant to them. I produced a video with the girls which we submitted to National Grid, and ours was one of the winning entries. They gave us about £1,000 worth of robotics equipment to get started, plus some training. We went to a regional competition and won, which surprised all of us, and that's when it took off. After that, the girls were in every lunchtime, and taking the robot home in school holidays.

One girl immersed herself in the online communities associated with the VEX competition, and lived and breathed VEX after that moment.

The impact on the students

The girl who only came in to glue her shoe back together is now studying a degree in computer science, one of the other team members studied computer science and has got a job at Google, and another girl is studying for a degree in robotics.

A VEX-ing issue

The format of the VEX Robotics competitions involves designing a robot to compete in a fast-paced two-minute game with four robots.

You form an alliance with another team and you're battling against another alliance; it's nice that you're working as part of a team.

The format of going to the competitions is really exciting. We've just come back from this year's nationals, and you've got 60 teams there, with judges who are STEM ambassadors from big international engineering companies walking around. There's a sense of occasion about it, and students are able to be with lots of other people under one roof who are completely enthused about robotics, which builds the energy levels.

A word on the Academy

I'm going to be using my Academy funding this term to start VEX IQ teams in six local schools. Robotics programmes are expensive, but the CST funding enables schools to get involved, taking down those barriers to entry.

Unlocking the teaching power of robotics

David Kennedy

Head of Technology and Design at Mitchell House in Belfast

A Belfast teacher engaged in fundraising to buy a robotics kit for his school, before leading a team of special needs pupils to two competitions and a trophy win.

At Mitchell House School, we primarily cater to pupils with a physical disability. We offer the full curriculum, and in my role as Head of Technology and Design, the aim has been to make the subject accessible, safe and fun. It's been my passion to adapt a practical process or task to the learner, teaching them the theory and skill but making it suit their physical ability.

The project was to attain a VEX robotics kit, construct a machine and take it to our regional competition hosted by the Royal Academy of Engineering. We used our extended schools funding to set up a robotics club, and after some fundraising we were able to purchase a robotics kit. The primary benefit of VEX was the tabletop accessibility; our pupils were able to sort, view, organise and construct their robot following the plans. The next stage was testing and preparing for the competition, which was a fantastic opportunity for the pupils to tackle practical design challenges – changing gearing for speed versus torque, and so on.

Once we had the design, the pupils added flair, style and attitude!

At the Academy competition, we were pleased to see so many other schools taking part. We love the opportunity to compete and represent our school, and this competition stood out as there were no categories or divisions by age or ability.

A level playing field

We encourage our pupils to compete and reach their full potential, but we're often faced with limited opportunities of ability-matched peers or events that allow us to be genuinely in competition – not just in participation. We have repeatedly entered the VEX robotics challenge; as a school and as a robotics team, we have found this to be one of the few events that provide the unique balance of pupil independence via their robot and uninhibited pupil pride in their creation, abilities and performance. We also won the 'Spirit of the Competition' trophy in 2018.

The VEX kits provide us with an openly creative STEM design challenge, whereby the pupils can physically manufacture their ideas to test them. With many of our pupils seeing a career in traditional industry as unaccommodating to their physical needs, this competition ignites their design and development engineer qualities to identify problems and invent solutions. It proves that through good design, they can compete and win – both in VEX and in industry.

In a student's words: "I'm biomechanical, so this is second nature to me" – manual wheelchair-using pupil, assessing our robot's turning circle.

A word on the Academy

The diverse and engaging STEM teaching and learning resource kits have been well thought out and designed to work as either a complete unit or as a standalone project. The topics chosen have facilitated pupil-led exploration and investigation into the topics.

How an Academy-funded visit inspired one pupil to embrace STEM subjects

Anthony Vaughan-Evans

Maths teacher and STEM consultant, East Point Academy, Lowestoft

The transformative effects of a field trip to the Sizewell B power station in Suffolk are described by a maths teacher, one of his students and their parent

'STEM in Action at Sizewell 2015' was a collaborative project funded by the Royal Academy of Engineering through the CST programme. The focus was to highlight local STEM careers, encourage teachers to focus on STEM in the classroom and collaborate out of the classroom in an industrial environment, while engaging pupils in STEM activities to raise their aspirations.

The students enjoyed and learned a lot from the experience. Hopefully they got some idea of the range of career opportunities involved and the quality of the employer – that certainly seemed to come across in conversations with them.

Eight schools and 120 year 8 pupils took part in a collaboration with EDF on a project that followed the 'STEM in action' model, where a syllabus-related STEM problem is introduced to the pupils during an industrial visit in context. The pupils then develop a solution by working with engineers from EDF back in the classroom.

In his own words – Iwan Jones, University of East Anglia, Norwich

I went on a school trip to Sizewell B in 2015. I'd never heard of the phrase 'STEM' beforehand, and I had little knowledge of what engineering was, or how many different career opportunities were available when studying STEM subjects. However, going on the trip had a massive impact on my life. I found I really wanted to work hard and get good at maths and computing.

Although it was many years ago, I still remember the vast size of the power station, and how overwhelmed I was as to how many different buildings and structures there are. I remember telling my mum about being shocked that only three people worked in one of the massive buildings at Sizewell. To have that few people work at one massive site inspired me to work hard and be determined to get the grades I would need to possibly one day work at a top level.

I decided to take computer science because after going on the trip, I realised I wanted to take maths to a higher level. After high school, I studied mathematics at college; I found it challenging, but knowing there was a logical way to figure out a problem made it more rewarding. Then I had to find something that worked well with maths, and although I've always had an interest in coding, I decided that computer science would be the choice for me. Whilst being here, I've had the chance to try all different types of coding languages, and being a data scientist really has me excited about the future and what paths could lead to different roles.

This project had a massive impact on me, I never really found any lessons intriguing, and if I could, I'd have been playing football as much as possible. Now I have an idea of a career and many subjects that I found enjoyable at school, college, and university. It's so important that young people have the opportunity to learn about everything that STEM is, and the umbrella of subjects that fall under it.

A parent's feedback

My son Iwan was lucky enough to visit Sizewell B with Mr Vaughan-Evans. He thoroughly enjoyed the trip and was amazed by what he saw and learnt. (Tea went on forever because he had so much to tell us!) He had never experienced such a thing. For me, the most impressive thing he gained from the trip was something that I had not seen in him for a very long time, and that is hope. He could see why it's important to work harder at school, because he could see that there is a possibility of gaining an apprenticeship if he gains decent results.

"I am currently studying at UEA, learning computer science, so STEM subjects have had a massive impact on me even at university. I believe this was mainly down to the project that took place at Sizewell."

Case studies

Upskilling of teachers

Introduction

The following series of case studies tell stories of the cumulative impact of training and professional development within network teachers practices as a result of participation in the CST programme.

Improving knowledge, understanding and awareness on the implementation of STEM practices and pedagogy in schools, including higher levels of confidence and efficacy in delivery.

Using Academy resources to transform STEM engagement and uptake

Lydia Knowles

Head of Science and SENCo, Brenchley and Matfield Primary School, Kent

Academy kits and a committed teacher coordinator have had a significant impact on teaching and student support at a primary school in Kent.

I have been working at my current school since 2014, where I was first introduced to my teacher coordinator, Krissi Pink. Involvement with the RAEng STEM network began partly because of my interests in science, which played a key role in my early teacher development.

Krissi's training provides us with a safe and supportive space to ask questions, experiment, and essentially be the students ourselves, before we go back to our schools.

Working in a small school, everyone does a bit of everything, and we're a very close-knit team. Our Headteacher is committed to offering a rich and varied curriculum, preparing the pupils to be fully engaged citizens as adults. This outlook and approach has always been rooted in Krissi's training and development, and her enthusiasm for the projects is boundless. Her ambitions for our projects have always focused on purposeful, meaningful and wholly-inclusive opportunities for pupils, irrespective of their background or perceived ability. I feel privileged to be able to work with Krissi, and I'm certainly a better teacher for having been supported by her.

Investing in the future

Due to economies of scale, resourcing for specific technical equipment can prove challenging. Budgetary constraints mean we have a duty to demonstrate how any investment we make in resourcing learning will be impactful, sustain long-lasting improvements and also build capacity. Time is a commodity that all teachers periodically feel they are lacking, but our involvement with the programme has mitigated these potential barriers enormously. There is definitely an increase in staff confidence engaging with the STEM projects, particularly engineering aspects.

The impact on the school

We have been able to run extra-curricular STEM clubs and Children's University STEM courses and supplement our existing curriculum with real-world case studies and the application of technology.

We've had the opportunity to network with industry professionals and STEM ambassadors, who have subsequently come into school to work directly with the pupils, providing unique, personalised and memorable learning opportunities.

The Academy kits highlight real-world scenarios which help the pupils to explore scientific issues and dilemmas, and examine deeper things like the use of drones, flooding or disaster relief. The collaborative project days, and experiments and investigations facilitated by the kits, provide those magical 'awe and wonder' moments, that we all crave as teachers, where concepts are brought to life and can be physically manipulated and changed. This type of hands-on learning, which is at the heart of the RAEng offering, also undoubtedly increases students' confidence to tinker with things, nurturing broader computational thinking skills.

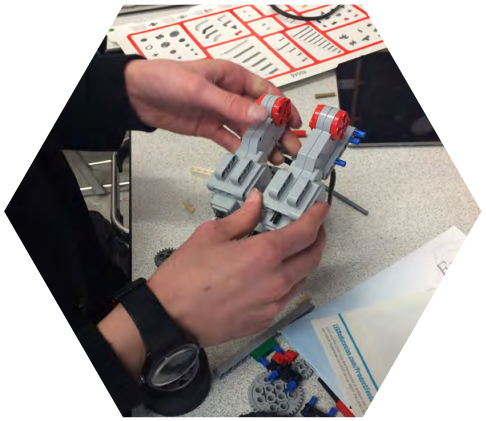
A word on the Academy

The kits given out are incredibly generous with regards to their content. The accompanying plans are very user friendly, full of accessible background information and opportunities to deepen learning.

Building a diverse array of clubs and classes

Jane Doran

A teacher at Coundon Court School in Coventry since 2016



With the support of her Academy teacher coordinator, one Coventry teacher has transformed her school into a hotbed of STEM clubs and classes.

I started as STEM coordinator about six years ago, when there was a single STEM club. The teacher running it left, and it fizzled out. I restarted it with four kids building robots, but I had no idea what it really involved. I asked Gaynor, my teacher coordinator, for help and she was brilliant. She came and sat with me for a whole afternoon and got me started with the Academy's STEM resource boxes, which were a great starting point. Her enthusiasm spread to other science staff, and she supports them to set up additional clubs.

I started a STEM club where the kids chose their own projects. I extended it with a robotics club, STEM club and chess club, then we had lots of enquiries from kids who didn't have the investigative skills but wanted to do STEM stuff. I got a colleague to start mini-STEM, which is a bit more guided where kids try experiments out. She started doing that and is now doing it with no support. We now have three STEM clubs, three robotics clubs, a chess club, an eco club and a pet care club, plus I'm hassling IT to help me set up a coding club which will hopefully launch this September!

We've got STEM, mini-STEM, a year 12 STEM class, three robotics clubs, an eco-club and a carousel, so year 7 pupils get to experience different extra-curricular events. We've even set up an animal care club, with a teacher who's got a really wild selection of pets and brings them in to teach a six-week pet care club.

Student-led projects

We've seen where the kids are particularly inspired and then created clubs to fill those niches. We wouldn't have gone into robotics otherwise, because it went from having a STEM club to doing investigations to "can we have a robot" to "let's buy you one LEGO robot and see where we go from there" – until eventually we got into the national finals of the EEP Robotics Challenge twice. Then we switched over to the FIRST LEGO League and made it to the national finals for the last three years. We've gone from nothing to being quite good at robotics, which we wouldn't have evolved into if we hadn't had the STEM boxes.

Year 12 and 13 pupils come back as mentors and support the running of these clubs. This gives them an opportunity to enrich their CVs, as well as a chance to develop their skills.

A word on the Academy

The STEM resource boxes were a really good stepping stone. If you're starting off a STEM club, you need those boxes to give you ideas on how to get going, and after that you can build on it and come up with other experiments.

How a teacher developed his own rocket for STEM teaching

Arthur Harwood

A teacher at Bishop Stopford School for 34 years

Academy network meetings inspired one DT teacher to create his own rocket, which is now being built by competing teams at a regional STEM day at the University of Northampton.

Jon Sidgwick is employed by my school as a DT specialist. He was inspired partly by the Academy network meetings where we came up with the idea of having a regional STEM day, where teams of students from different schools across Northamptonshire come together and have a series of STEM activities – a competition with a winner at the end.

Jon Sidgwick did it all himself, and that is why I nominated him for the STEM category of the Northamptonshire Education Award, which he won.

As part of this collaborative project, we considered what activities we could get the students to do. We wanted something a little bit different, and Jon came up with this idea of a ULAUNCH rocket. It was so good, we looked at it within the network and decided to run with it as one of the activities for the students to do at the STEM day. It is programmable – it goes up and then deploys its own parachute to land at a certain altitude, but the students must program that for it to happen.

Individual inspiration, collective contributions

Jon has gone above and beyond, and the Academy network has benefitted as a result. He sourced all the parts from China and adapted it and worked on it. The rocket is made from cardboard tubes, so it is not expensive, but you have got some quite elaborate circuitry inside it. We kept looking at it at our network meetings where all the teachers would chip in with ideas. Jon was working on it for six months before it progressed beyond a prototype.

The air-powered rocket has an automatic parachute system, which involved designing and 3D printing sections as well as getting purpose-built circuitry made in China. It is quite a tricky bit of kit to set up, but it is very impressive when it works.

We produced a schematic for the students to use and a lot of the students who come from different schools have got STEM clubs, so we thought it would be a nice activity to work on in a STEM environment. Each school in the network will build, program, develop and test their rocket themselves with the parts we have given to them, and then come to the regional STEM day in June at the University of Northampton's Waterside Campus. That is the finale where we all set each other's rockets off and vote on who did it best. Each team must get it back down to earth within a certain area, taking factors like wind speed into consideration.

Final thoughts

The feedback we got was very positive, and it really does look like a pukka rocket when you see it. It doesn't half go up when you launch it, but we want the students to deploy it and bring it back. It'll travel a long way, but we want them to send it just 30 or 40 feet off the ground; if it goes much higher than that, it will drift off when it comes down and go out of range. That is part of the programming conundrum – if they do not do it right, it will go really high and when it deploys its parachute it will drift off into another county! Once they press the big red button, their programming has to work properly to make the parachute deploy at the right altitude, which is part of the challenge the students are provided with.

The impact on the students

We are running the STEM day at the University of Northampton, which is a key part of the day for inspiring the students to think about university and STEM subjects. Many students across the county will have the opportunity to learn about rocket design, engineering and computer programming as well as developing questioning, problem-solving and divergent and creative thinking skills.

A word on the Academy

Thanks to the Academy for their support, because if they had not funded this collaborative project, we would not have been able to do it!

Case studies

STEM ethos and identity

Introduction

The following series of case studies demonstrate how schools have embraced inter-disciplinary teaching and learning of STEM subjects, embedding this within their curriculums or adopting a whole-school approach. Incorporating project and problem-based learning through cross-curricular programmes of study.

Using a STEM day to inspire and engage tomorrow's pupils

Una Doherty

Head of Technology and Engineering/Head of STEM Development, Christian Brothers Grammar School, Omagh. Co. Tyrone

An all-boys grammar school in County Tyrone has seen huge engagement with a STEM day, where different departments deliver a carousel of activities and challenges to students who will be enrolling the following year.

STEM subjects are very popular within our school and appeal to our single sex (male) student body. Our biggest challenge is normally having to select pupils for the events! Our uptake in Maths, Physics and Technology post-16 is very strong, with a large number of students progressing to third-level education in a STEM related area. Our department now offers Technology and Design at KS3, GCSE and A-level alongside BTEC Engineering, GCSE Construction and BTEC Construction.

Our school has had a dedicated head of STEM development since 2012, and all departments are encouraged to contribute to the STEM message.

The STEM day that we organise every year allows some of the local primary schools to sample our enthusiasm for STEM within the school, while showcasing our facilities. We have found that this insight 'lights a fire' in some of our prospective students, and this can be nurtured through the delivery of the entire curriculum when they join our school the following year.

On the STEM day, approximately 120 Primary 6 male students are brought into the school, and I deliver a presentation on what STEM is – aspects of which have used resources collated through the Academy's Connecting STEM Teachers forum.

After this short introduction, pupils are then split into groups where they carousel between three different activities:

- Activity A: Rocket building and launching – provided by the Technology department
- Activity B: Science insight – provided by the Biology, Chemistry and Physics departments
- Activity C: Food technology – provided by the Home Economics department.

We have recently reinstated a lunchtime STEM club, run by our Year 14 Technology and Engineering students, which attracted 88 students out of a possible 135.

This club uses resources which had been shared by our CST teacher coordinator, Clare Doherty. Her energy and enthusiasm in promoting STEM and collaboration between schools is inspiring, and I've certainly benefitted from being part of the training and support offered over the years. Long may it continue!

We are currently trying to facilitate the inclusion of the Maths, ICT and Geography departments in a treasure hunt collaboration involving numerical data analysis and coding. All three departments are keen to contribute but it will require additional time – this is our focus for 2023!

A word on the Academy

Within Omagh Christian Brothers Grammar School, we are indebted to the Academy for the wide range of support and resources made available to us through the CST scheme. This has encouraged us to make links with other subject departments to deliver STEM in a holistic manner across the curriculum.

Unlocking every student's engineering potential

Sue Quirk and Steve Allen

Sue: Retired teacher and CST teacher coordinator for south west Wales
Steve: A design and technology teacher, Ysgol Glan-Y-Môr School in Burry Port, Carmarthenshire

A D&T teacher and his teacher coordinator discuss how the new Curriculum for Wales will help to bring engineering to the fore.

Sue: I'm retired now but I was faculty lead at Ysgol Glan-y-Mor School. From 2017 through to 2020 I was part of the team that developed the science and technology Area of Learning and Experience for the new Curriculum for Wales. When developing this new curriculum area, I introduced the curriculum team to the *Engineering Habits of Mind* (EHoM). These then significantly informed our thinking as the curriculum developed. I brought the Academy's EHoM to the table, and we used that heavily in developing our new curriculum.

Engineering is the link between science and technology because it sits across both, and it's a great vehicle for bringing together science, technology, IT and computer science departments that currently find it difficult to connect their individual subjects.

Part of the philosophy of Curriculum for Wales is to encourage independent learners to focus on the progression of learning rather than outcomes, which you can see fits really well with the concepts developed in the *Thinking like an Engineer* report and the EHoM. Steve is supporting his pupils through the use of the EHoM to become those independent and active learners. The other part of the education and curriculum reforms going on in Wales currently is the development of new qualifications, and a new GCSE Engineering is a significant element of this.

Young people can find it difficult to connect the skills and attributes they have with engineering. Using the *Engineering Habits of Mind* supports them in making those connections and helps them to see themselves as engineers.

The Curriculum for Wales is a continuum of education from ages 3 to 16, and one of the other focuses is to link primary and secondary education, so it's a complete learning process. Engineering will go into primary schools for the very first time with Curriculum for Wales, with the statement of What Matters which outlines the roles of design thinking and engineering as the technical and creative ways in which we help solve society's needs and wants.

Steve: I think all students are born engineers. Right from the start, they play with Lego or build dens and tree houses out the back. I think the biggest thing we should be doing is going into primary schools and doing a bit more engineering. We do maths, we do English, we do a little bit of science, but the technology brings this all together in a fun and engaging way and often gives context to their learning.

I think some students worry about making wrong decisions, but at Key Stage 3 and 4 we do a lot with the James Dyson Foundation, and one of his key statements is "it's good to make mistakes". If James Dyson made 1,257 iterations before he actually made his product, the pupils realise he made 1,200 mistakes, and without those mistakes he wouldn't have succeeded. We want pupils to make mistakes and learn from them. We teach them that they should make one change at a time as they go through a project, so that they know exactly what has happened.

Future of Flight is one of three boxes we've used. There were loads of exciting things in the boxes that the pupils had never seen, other than in top-end GCSE or even A-level studies. A lot of people did really well within the exercises and a lot of them did really well with the systems thinking and visualising aspects. These are all key things which we want engineers in the future to be thinking about. The pupils said they really enjoyed working together in teams, especially the practical aspects, and they weren't too worried about making mistakes, which is what we want. They developed a greater understanding of who they were and where they were going.

A word on the Academy

The STEM resources that the Royal Academy of Engineering put out are perfect for actually helping to deliver on learning. They're really good, comprehensive kits.

Raising aspirations through People Like Me alumni speakers

Phil Lynch

Head of Physics at Colyton Grammar School, Devon

"The STEM resource boxes the Academy put together are amazing – things we would never be able to get organised, or pull all the different resources together."

With a rich portfolio of alumni employed in STEM roles, this Devon school hosts an annual presentation where female engineers inspire the current crop of students.

My head teacher went up to a CST celebration event held at the Academy about six years ago and was inspired to create the post of STEM Coordinator. I got the post, and since then I've put together activities for Science Week and ensured there's coordination across the STEM subjects in the school. Because of the pressures of the curriculum, it can be a challenge to try and fit it in around lessons, but we're lucky that we can run clubs at lunchtime which are very well attended, alongside activities like Science Week.

We've got several lunch clubs, including a science club in Year 7 run by one of our biology teachers. In Year 8, there's a STEM club where we start the year by entering competitions, and in the second half of the year we move into utilising the fantastic Academy STEM teaching and learning resources. They're really well set up so you can just pick them up and run with them, and they're ideal for running a STEM club because it's all self-explanatory. The explanations for the teacher and students are incredibly clear, and they're not having to worry about finding a catalogue number or individual LEDs from Amazon!

One thing we've done every year is the People Like Me activity, which was something I saw when I went to the Academy celebration event, where it was introduced to us as a way of encouraging girls into STEM careers.

Learning from past experience

We run People Like Me with the whole of Year 9 as an off-timetable day. In the morning, I do an engineering challenge with them to make a marble run. They're given templates and piece of card and a specific amount of equipment. They can buy other equipment, but it'll cost them a time penalty, and the aim is to keep their marble running as long as possible while taking into account both the running time and the penalties. This gives them the idea of being out in the real world where you can't just have infinite resources – you've got to make things work.

It's a nice mix of activities to get them thinking about STEM and where they might go with it.

Because we've had so many people go onto successful STEM-related careers from our school, there are lots of people we can contact to come back in and present People Like Me. The alumni are always women who've gone on to STEM-related careers. It's a really nice resource because it lets students make the connection between how they enjoy their work and where they see themselves going in future.

A word on the Academy

There are no other CPD and resources like the Academy's. Having everything in one place so they can set to work straight away and do something is fantastic – really exceptional.

Building STEM from the ground up

Maz Perry and Dene Ellis

Dene: Extended Leadership STEM at Bourne Community College, Southbourne
Maz: Senior Science Technician and STEM Activity Coordinator at Bourne Community College, Southbourne

A community college in West Sussex has transformed its STEM offerings through the construction of a dedicated new building, while adopting and adapting *Engineering Habits of Mind* as a whole school ethos.

Dene: We had to build engineering up from a low base at Bourne. It really didn't exist until two or three years ago. The turning point was what became our new STEM building, which was constructed because we needed more space and more teachers.

Maz: The new STEM building was a great assest for Bourne Community College. It became a STEM building because we were making STEM our unique selling point at that time, and it was opened by our local MP in October 2020. It's got five new teaching spaces, two maths classrooms and a state-of-the-art STEM classroom.

Dene: Each room in the new STEM building has facilities for 3D printers and CNC machining, and there's a design room with 25 computers and CAD software. Students do sketches and 2D design using laser cutters, and then they go on to 3D virtual modelling. SolidWorks has been key for us; we use it from Key Stage 3 onwards as part of the computing curriculum, and by the time they get to KS4 they're reasonably good at it.

Developing STEM involves a combination of a good sales pitch, assemblies, raising its profile through competitions and trips out. Every time a child goes out on an activity, it embeds it in their mind and they get to understand what it's about, so that's the way to keep promoting it.

Practical applications

Dene: Just today, we've done some mechanical models where students turn handles and cams and make things function. Maz did a lesson earlier with Year 5 doing 2D design through the ENTHUSE project, which is another aspect of what we're doing at the moment thanks to *Engineering Habits of Mind*. We adopted Habits of Mind for a combination of reasons. They get students to take responsibility for their own learning. What's expected is the soft skills, and then Habits of Mind is self-directed learning skills.

Maz: We're getting a lot more girls into STEM, which we've never had before. The girls' uptake has been massive, and they're wanting to do activities and asking when the next event is, whereas two or three years ago that didn't happen.

We had an OFSTED report recently and STEM came out brilliantly, which shows how important it's become to us.

Support from the Academy

The Academy's STEM network is really good at providing lots of different angles and links and connections to people that I never would have met or wouldn't have had the time to meet. By having those meetings it's a networking opportunity, and you can gain lots of ideas from them. The ENTHUSE project came out of an Academy network meeting, and Maz and I are going to London in July with a project the Royal Society provided us with £2,500 of funding for, which also came out of one of the Academy network meetings.

We had the ENTHUSE opening a couple of weeks ago, and that was one of the best events we've ever done. If you put 150 students in a room with a load of equipment and some clever staff, you can have an excellent time. Some of these festivals have a really good outcome; the kids absolutely love it, and they get a lot of direction out of them.

Dene: The staff understand that STEM is important. What they're doing with other subjects is important as well, but they understand technology and engineering are vital skill sets and careers for the students. They support it as a general idea, but we do have to remind them to be cross-curricular, rather than STEM being seen as a standalone subject.

A word on the Academy

We've adapted *Engineering Habits of Mind* to every single department within the school – they all chose one that represents what they're teaching themselves. Other departments have been really supportive.

Building links with other institutions and maximising available resources

Maddie Hathaway

Administrator at Midhurst Rother College in West Sussex

A rural college in Sussex has competed in a wide range of regional and national competitions, beating university teams and winning the STEM School Team of the Year award at The Big Bang Fair.

My job originated as a community partnership coordinator which covered STEM, but the school had no connection with universities or schools. My brief was to build those links, and within the local community as well. We expanded our STEM offering in 2014, so more pupils interested in STEM activities could participate.

We would host 30 primary school pupils from our 15 feeder schools for a STEM day, where using resources from the Bloodhound project, they'd build their own rocket powered cars, and then we'd race them across the tennis court.

The two science festivals we ran were funded by the Academy, and Scott Atkinson and I worked together on a number of projects while he was head of ADT at Midhurst Rother College and our local Academy teacher coordinator. One was the Greenpower car which raced at the Goodwood racing circuit, where we qualified for the international final. We also entered the University of Oxford National Annual Robot Games with a Year 10 team, who beat the University of Oxford's undergraduate team. Our students came back full of the fact they'd won it, which was hilarious!

Visiting a university is about trying to find things that inspire students, making the connection between what you're doing in school and where that leads you. Being in a small rural town, you have very little you can see around you in terms of why you're learning engineering or any of the STEM subjects. We want to get pupils out there so they can piece together the puzzle in terms of 'this is what I can do in future if I enjoy this'.

We had a huge career fair here a few weeks ago, when you realise how much is missing when pupils are only in school. They need to be out seeing other things.

Celebrating school-wide STEM

We entered the Young Engineer of the Year competition at the national Big Bang event in May 2016, where a team of four students had a stand about how STEM was an integral part of their education. We were invited to the Royal Academy of Engineering to present to a group of people there about what STEM was at Midhurst Rother College. The students were all amazingly driven and they worked so hard for it. They all knew what they wanted to do when they left because they were so passionate about it. One studied engineering at Brunel University, another studied at Swansea University, one joined McLaren as an apprentice and the other is now flying jet fighters after completing his officer training with the RAF.

A word on the Academy

Scott and I worked alongside a technician who was extremely proactive. The team brought the right people into the right place, and achieved a great deal.

From triple science to STEM awards and national presentations

Louisa Miller

Principal Leader of Learning, Caludon Castle Teaching School, Coventry

Caludon Castle School has an established STEM Club which has been running for over ten years, with students involved in a range of domestic and international projects and competitions.

We had a very clear idea of what we wanted to do originally. Our aims were to raise the profile of STEM across the school, and particularly to increase girls' participation in STEM. Our school allows students to opt into triple science; we don't select any of our students, but we were very keen to improve the uptake of triple science and to dispel the myth that it was elitist. If students enjoy STEM subjects, they should have access to that. At the same time, we also wanted to improve collaboration between the maths department, science department and the technology department.

The Academy has really helped with STEM activities, and we've been doing a lot of work with the drone box, which encompasses IT, computer science and design. It's a resource of three activities – you can use them as a standalone or for an afterschool club, or even for an activity day. We made them into a series of six lessons that fed into our new Key Stage 3 curriculum. The first one is '*What is a drone?*', dispelling some of the myths that they're all military-based and describing how they can be used from an agricultural point of view or for supply. We look at GPS and how that works – remote data, missing drones and how they can be used for search and rescue as well. We used the drone box as part of Science Week, and fed it into our clubs for quite a few years.

Caludon Castle has participated in the First LEGO League, field trips to Iceland and the Big Bang Fair Competition, where students won the Innovation Award, Young Scientist of the Year and were Overall Winners in 2019.

Student-driven learning

We're very much led by the students. At the end of each term, we get feedback from them, and the projects they enjoy the most are the ones where they get a longer term project like the FIRST LEGO League competition. They have to programme a robot around a course, but there's also a theme every year where they have to do a presentation to judges about a problem they've overcome. It's a really nice start to the year because it integrates new members into the club, it gets them working with our existing members on LEGO League robot planning, and it also improves their presentation skills.

We do quite a lot of standalone things as well, including icebreakers at the start of the term to get the students on board. We have the Big Bang Fair, where we had some real success in 2019. Three of our sixth form students who joined us in Year 8 were inspired by a medicine that was being used for one particular type of treatment. They wanted to see how it could be used for other types of treatments.

It was something that interested them when they joined the club originally, and they kept that enthusiasm going. They went up to the NEC and delivered a presentation, and won one of the Big Bang Fair prizes.

The impact on the students

Caludon STEM Club prides itself in raising the profile of science and engineering, encouraging future scientists and improving the uptake of STEM subjects. Students join STEM in years 8 and 9, with 86 per cent going on to study at least one STEM subject post-16, and 62 per cent studying 2 or more STEM subjects.

A word on the Academy

We have successfully integrated the Academy *Drones* resource box into our KS3 curriculum. This fantastic resource has enabled STEM to have a wider impact across the school and to encourage more students to consider science as an option at KS4 and beyond. We currently have over 40 per cent of our Year 10 students opting for separate sciences at GCSE.

"We've got students from all sorts of backgrounds and right across the ability spectrum as well, which we're proud of, instead of it being just for a certain type of student."

Building a STEM ethos from scratch

Claudia Clarke

Head of STEM at Cokethorpe School, West Oxfordshire

One ambitious head of STEM has harnessed Academy resources, parental experience and enthusiastic older pupils to create a thriving STEM community which is now being adopted by other schools locally.

When I joined Cokethorpe, they had very little STEM of any description. In my previous school, I built up a whole programme, so I set out to do that again here. The main aims were that it was whole school, very inclusive and didn't cost anything. The first time I did a whole school STEM week, in tandem with the junior school that's on the same site, it went really well. I've now got good departmental collaboration and everyone's engaged and involved. We use the Academy's STEM teaching and learning resource boxes for some activities – they're really, really good.

I enjoy reaching every pupil in the school through form-time tasks, inter-form competitions, STEM fayres, external speakers and running year group challenge days. The older pupils love to help run the events they took part in during previous years. It's really helped to build a buzz and develop interest among the pupils and staff. It's seen as being very successful by senior management and therefore they are very supportive as it also interests parents. The model for our STEM week is now being used by other schools in my network.

I think the STEM ethos I have built up has massively influenced the students in terms of taking the sciences more seriously, especially physics and maths.

Because I've done this for a few years now, the older pupils come back – the ones that are doing GCSEs and A-levels that I can't get off timetable that easily, but they still want to be involved. I've run a STEM fair at lunchtime, with lots of different stands where parents come in and discuss where they work. I've had people come in with VR headsets, biomedical engineers, F1 people, all with different stands and presentations. And we bring the whole school there in a rota, where they have lots of hands-on activities across maths, science, PE, DT and outdoor education as well.

The parents really enjoy it and want to be involved, but we have to be sure we are selecting the people who are really good in front of the pupils. We've done evening talks where I've had scientists come in, and that's something that we invite parents and pupils to do together.

We're trying to get a spread across the whole academic remit in terms of looking at the apprenticeship route, trying not to disengage anybody who thinks STEM has got too technical. A lot of students find it difficult to see that there's also another layer below that, so we've been working on trying to engage them.

A word on the Academy

I love the Academy resource boxes. Sometimes I wouldn't necessarily use a whole box – I'll pull things out for activities, but they are really good. I've used them in my teaching, in STEM clubs and in half-day or whole-day sessions.

Thank you

Connecting STEM Teachers is a support network for teachers across all STEM subjects ensuring they have the knowledge and confidence to engage a greater number and wider spectrum of school students with STEM. The programme operates across all regions of England, and in Scotland, Wales and Northern Ireland.

The programme, founded by the Royal Academy of Engineering, would not be possible without the generous support of its funders:

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