THE JAMES DYSON FOUNDATION

ADDRESSING THE SKILLS SHORTAGE: A NEW APPROACH TO ENGINEERING EDUCATION IN SCHOOLS

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dyson

Design and Technology can open doors for young people. It offers the creativity of an arts subject and the analytical rigour of the sciences. The subject offers students the chance to shape tomorrow's world by developing new ideas and technologies.

James Dyson

Sir James Dyson
Inventor

Design and Technology (D&T) is in decline, with less students choosing to study the subject at GCSE and A Level. However, it is the subject that most directly equips students with the skills they need to become engineers – a profession with an ongoing shortfall.

To address the decline of D&T, the James Dyson Foundation worked with five schools in Bath from 2012 to 2018. The aim was to transform the way the subject is taught, and develop a curriculum based on iterative design and problem-led learning.

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ENGINEERING IN THE UK

Engineers have the skills and knowledge to solve problems and invent solutions. However, the UK has a crippling annual shortage of 59,000 engineering graduates and technicians.

The UK faces a crippling annual shortage of engineering graduates and technicians, which reached 59,000 in 2018.[6] At the same time, the UK is facing a greater breadth of challenges year on year, such as the need to develop clean transport solutions, manage the risk of cyber-attacks, and meet the needs of an ageing population.

Solving these challenges requires engineering minds. Engineers have the skills and knowledge to solve problems and invent solutions. So to address these challenges, the UK needs to support and nurture a generation of problem-solving, academically-minded young people who are ready to pursue engineering careers. Only then can the UK maintain its position as a powerful global economy and world leader in science and innovation.

Engineering UK has found that while the engineering sector is growing and diversifying, this growth isn't reflected in the education system – 40% of employers still report a shortage of science, technology, engineering and mathematics (STEM) graduates.[6] Investment needs to be directed more substantially into the education sector to support the next generation of engineers. It's our responsibility to equip students with the skills needed to tackle the challenges of the future. And if the UK is to succeed in attracting more young people into engineering, we need to enthral them at an early age.

This starts in school, where the excitement of science, engineering and inventiveness can be emphasised from the very start of academic careers.

NOTABLE REASONS FOR THE NATIONAL DECLINE IN D&T UPTAKE

Secondary schools are grappling with significant funding pressures – spending per pupil has fallen by 8% since 2010 and is predicted to fall even further by 2019.[1] D&T is an expensive subject to run, and it's tempting for curriculum planners to make cuts which reduce it to the boring, repetitive and traditional.

D&T has been excluded from the English Baccalaureate (EBacc), which assesses students in eight subjects. With fewer options available for the remaining subjects, less students are choosing to study D&T.

The link between D&T and engineering isn't clear enough for students, schools, universities and employers. The word 'engineering' isn't used to define and promote it, despite it being the subject most applicable to engineering careers.

D&T is often associated with fixing things or woodwork, and is seen as a subject for boys and the less academically able. It's not considered to be academically rigorous, and isn't held in the same regard as other engineering-related STEM subjects such as maths and physics.

The previous examination system focused on knowledge and traditional skills, rather than inventiveness and new design. The new GCSE and A level came into force in September 2017 and has made improvements, but these need to be built upon.

A Level D&T isn't compulsory for most university engineering courses, so students are less likely to study it at GCSE and A Level if they're considering an engineering-related degree. However, most universities welcome students who have studied D&T with maths and physics, as it shows proficiency in practical and technical engineering skills. This isn't clearly communicated.

Students' closest experience of engineering in primary and secondary education is through Design and Technology (D&T). It introduces students to the design process, allowing them to develop the skills they need to design and engineer new products. However, nationally the outlook for D&T in schools is not good.

D&T lessons are failing to inspire students, focusing learning on making fixed, irrelevant and uninspiring items such as key rings and pencil cases. And to our economic detriment, D&T was downgraded to a non-EBacc status subject (the core subjects students must study at GCSE) when Michael Gove was education secretary.

This means the proportion of students who are choosing to study D&T at GCSE and A Level is falling, and the rate of decline is accelerating: nationally, only 18% of students chose to study D&T at GCSE in 2018 – a decrease of over 50% since 2011.[7]

With fewer students studying D&T and less students choosing to become engineers, there is a very real risk that Britain will be a less inventive place, with an ill-equipped workforce.

If this decline continues, we can anticipate that the struggle to address the shortage of engineers will continue for many years to come. However, this does create opportunities for creative solutions from the private sector.

For example, Dyson took matters into its own hands by launching the Dyson Institute of Engineering and Technology and training engineers itself.

But the UK economy cannot solely rely on private initiatives to address the national shortage of engineers. Action needs to be taken in the existing education system.

THE JAMES DYSON FOUNDATION PROPOSES THE FOLLOWING

Make D&T a relevant, engaging and rigorous EBacc subject
to increase the number of students choosing to study it.

Improve the existing curriculum
in schools to teach students about engineering through problem-led, relevant and increasingly inter-disciplinary projects in maths, science and D&T.

Increase funding for schools
so they can develop their D&T labs to reflect industry standards, allowing students to use equipment and techniques relevant to engineering careers.

Increase support and Continuous Professional Development (CPD)
training for science, technology, engineering and maths (STEM) teachers, to enhance teaching careers and encourage more people to take up teaching.

Rebrand D&T
to make the link to engineering more explicit to students, teachers, universities and employers.

Expand current careers strategies
implemented in schools to raise the profile of engineering careers and make them accessible for students.

Children entering primary school today face a future in which 85% of the jobs they will go on to pursue don't yet exist.[2] Many of these jobs will be in the engineering and technology sector. So we need to equip these students with an innovative and creative way of thinking, and with strong academic foundations.

Modern D&T can achieve this by bringing together science, mathematics, design and coding – grounding rigorous academic engineering theory in real-world, practical applications. It should be exciting, challenging and relevant, so that it attracts the brightest minds. A subject like this offers teachers the opportunity to inspire a generation of problem-solving inventors who will build the technology of the future.

We have demonstrated the difference that these changes can make in the James Dyson Foundation schools project (detailed from page 14). We also conducted similar projects in Chicago and Tokyo (see Appendix on page 54).

As a society, we are failing to help young people by not connecting the science, design, technology and maths they learn in the classroom with the exciting and important engineering problems and solutions in the outside world.

Sir James Dyson

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THE JAMES DYSON FOUNDATION SCHOOLS PROJECT: A NEW APPROACH TO DESIGN AND TECHNOLOGY

The James Dyson Foundation believes that a Design and Technology (D&T) curriculum based on iterative design and problem-led, project-based learning is more relevant and engaging to students. As a result, students enjoy D&T more, their perception of engineering improves, and more of them opt to study D&T at GCSE and A Level. And, in time, more young people choose to become engineers.

To test this hypothesis, in 2012 the James Dyson Foundation set up a research project with five schools in Bath. The partner schools were Wellsway School, Ralph Allen School, Chew Valley School, Hayesfield Girls' School and Writhlington School.

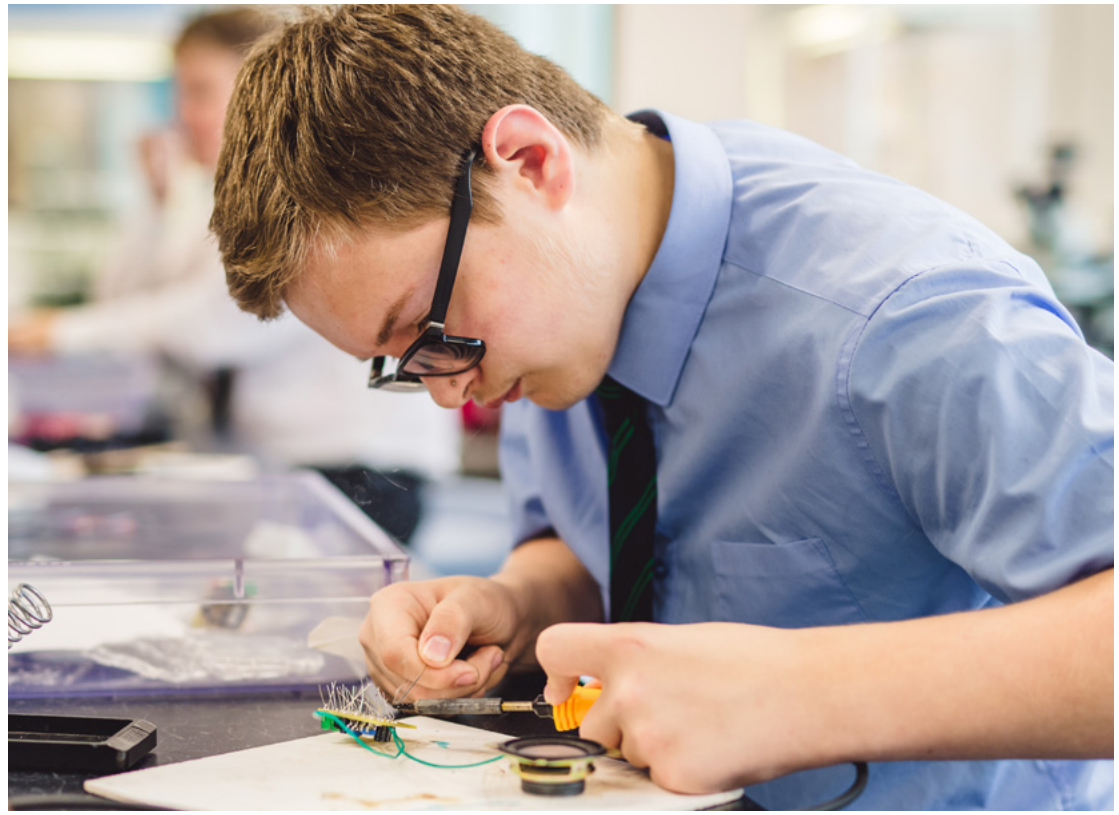
The project aimed to inspire young people to become designers and engineers by bringing real-life design engineering into the classroom, through problem-focused, open-ended projects supported by access to high-tech equipment. It ran for six years and concluded in August 2018.

The James Dyson Foundation donated £75,000 to each school. All schools matched this amount with £25,000 of funding to create state-of-the-art D&T labs, featuring equipment such as 3D printers, laser cutters and routers to develop industry-standard lab spaces. Alongside this, the James Dyson Foundation worked with the Bath schools' teachers to develop strategies to transform teaching and learning in the D&T classrooms.

This ensured that all D&T lessons integrated the following:

- The iterative design process practiced by Dyson engineers
- Real-world contexts and engineering challenges
- Practical and intellectual skills relevant to engineering careers
- Student autonomy in the design process
- Applications of science, technology, engineering and maths (STEM) knowledge
- Access to modern, industry-relevant equipment

Taking this new teaching method into consideration, the James Dyson Foundation worked with teachers and Andrew Barker, the project's educational consultant, to create nine D&T schemes of work. Through this, a core backbone for every James Dyson Foundation project was created (see page 20). These schemes of work are now available to download for free from the James Dyson Foundation website.



THE JAMES DYSON FOUNDATION BACKBONE

Conception
Students are introduced to the characteristics of engineers, the iterative design process and how design and engineering is connected to problem-solving. In specific projects, they are presented with a brief in which they identify problems, issues and user needs.

Development
Students work to research the identified problem, create mind maps and sketches, complete a design brief, project plan and outline evaluation criteria.

Realisation
Students begin prototyping at an early stage. As part of the iterative design process, they must reflect, evaluate and re-design as necessary. Improved models are then produced and evaluated. A final stage of reflection and overall assessment completes the project, and students produce multiple prototypes based on evaluations from testing. Teachers equip them with the skills they require to progress their project.

Presentation
Students present their design process and developed prototype to their peers, understanding that the aim is not a final product, but a clever engineering solution to the identified problem. They provide peer feedback to help them understand how the design could be further improved, and continue to the next stages of production.

Example project: Disaster

Brief

Design a 'disaster box' containing all the essential supplies that might be needed for people to survive a natural disaster.

Overview

The project explores the contextual theme of responding to the unexpected. It is based on the scenario of a large-scale disaster, where the means to carry out everyday life have suddenly and dramatically been removed. The challenge is to create a rescue design that supports people or communities who find themselves in this situation.

The project is intended primarily to inspire students to think of design and engineering solutions to real human problems. **This has two key functions:**

– To promote a positive attitude to technology and engineering, where students experience the positive effects they could bring to human existence.

– To help students realise some of the stark differences between highly-developed societies and those where life is an everyday struggle.

The project works best if the disaster scenario is real. Floods, hurricanes, earthquakes, volcanic activity and droughts are all possible stimulus events. The project was first used in the shadow of the Nepalese earthquake of 2015. The key is that the event should resonate with the students on a human scale; it is best if the event is reasonably current, and can be highlighted with good reportage and information. There will also be opportunities to explore cultural and other needs.

This project can be enhanced through the involvement of real relief agencies. In the UK, DEC (Disaster Emergency Committee) works with 14 key agencies who may be willing to participate. ShelterBox have also been successful partners. If practical to organise, the project climax is a presentation event, which provides an ideal opportunity for students to demonstrate and discuss their ideas with these relief professionals.

Curriculum mapping

The project is mapped to the KS3 Design and Technology National Curriculum/ Programme of Study (PoS) 2014.

Key Stage 3: 6 weeks (12 hours)

THE JAMES DYSON FOUNDATION SCHOOLS PROJECT
KEY FINDINGS

Over the course of the project, statistics were collected on Design and Technology uptake at GCSE and A Level. From 2012–2016, we also did annual anonymous surveys to monitor student perceptions of D&T and engineering across all year groups.

The key findings are outlined below:

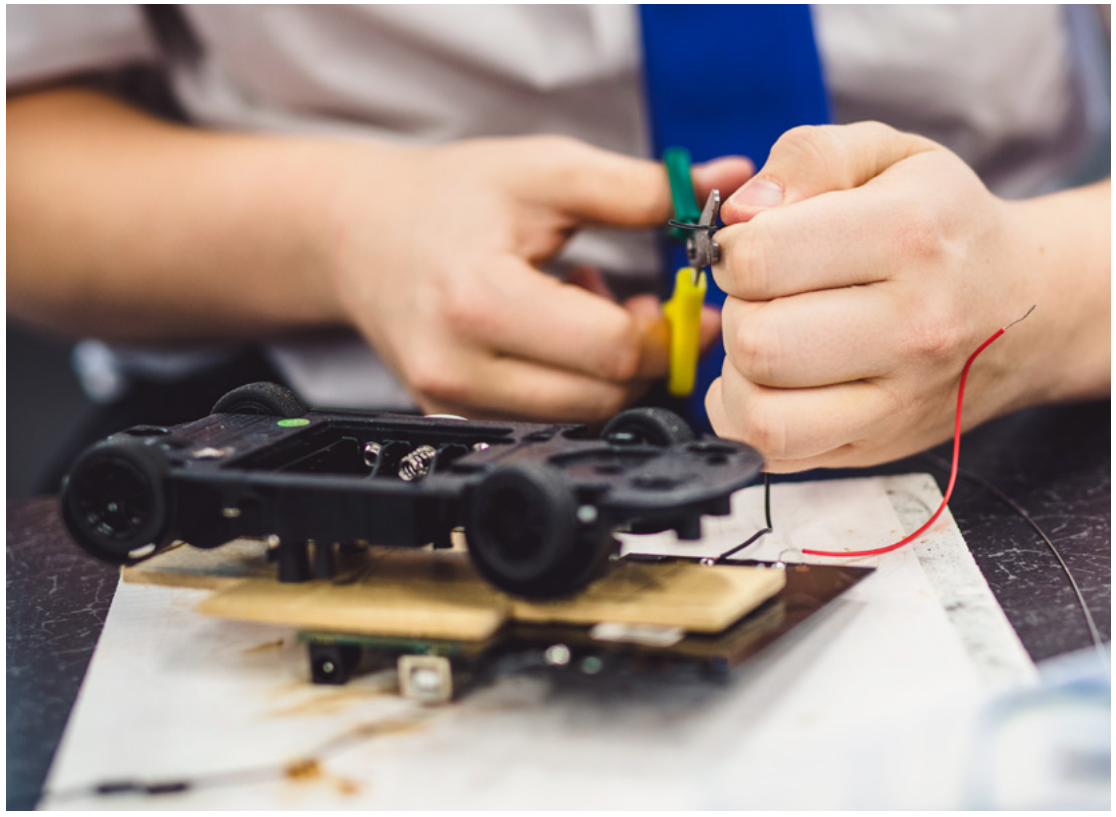
Increased uptake: more students chose to study D&T GCSE and A Level

Gender: more girls chose to study D&T, and there was improved perception of the relationship between gender and engineering.

Perception of D&T: improved student perceptions of D&T

Perception, and pursuit, of engineering: improved student perceptions of engineering

Teaching: improved teaching method and teacher enjoyment



GCSE

Uptake of D&T at GCSE in the schools increased by 37% over the course of the project, from 23% to 32%. Figure 1 (see page 28) shows how uptake across all of the schools changed since 2010. The uptake of D&T GCSE increased after the James Dyson Foundation projects were introduced in 2012. This trend continued until 2015, when the introduction of the EBacc caused a significant drop. Despite this, uptake increased again in 2017 and 2018, with two schools having to introduce extra D&T classes to cope with demand.

Increased uptake of GCSE D&T over the course of the project presents a quantifiable correlation between the James Dyson Foundation intervention and improved student perception – and enjoyment – of D&T. It also demonstrates that students felt D&T was a subject that they would like to gain a qualification in – indicating that they thought D&T was useful, relevant and could help them in the future.

Figure 2 demonstrates that, whilst uptake of GCSE D&T increased in the schools, the number of students choosing to study D&T GCSE on a national scale decreased by 54% in the same timeframe.[7]

Figure 1
% uptake of D&T at GCSE in the James Dyson Foundation schools since 2011

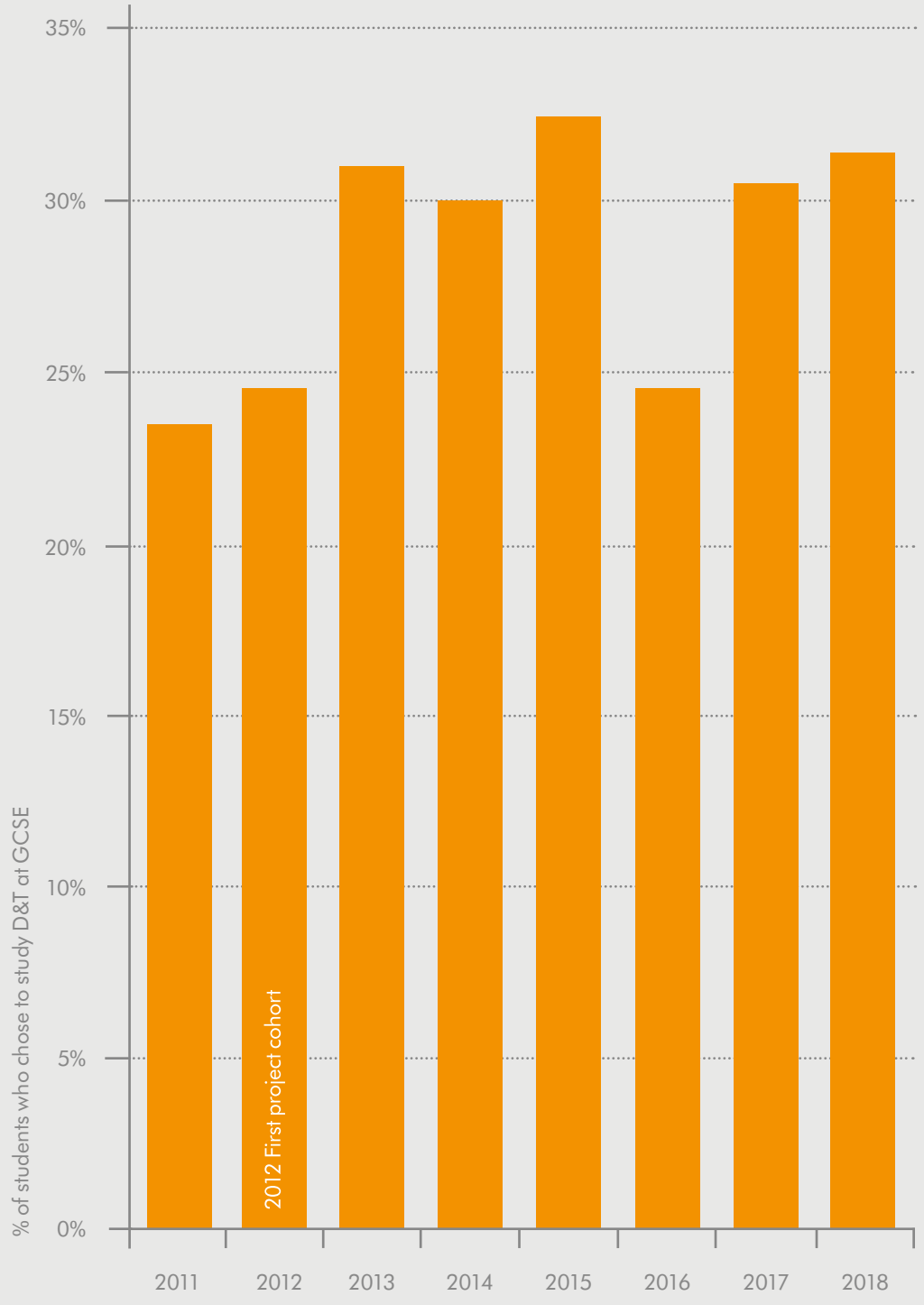
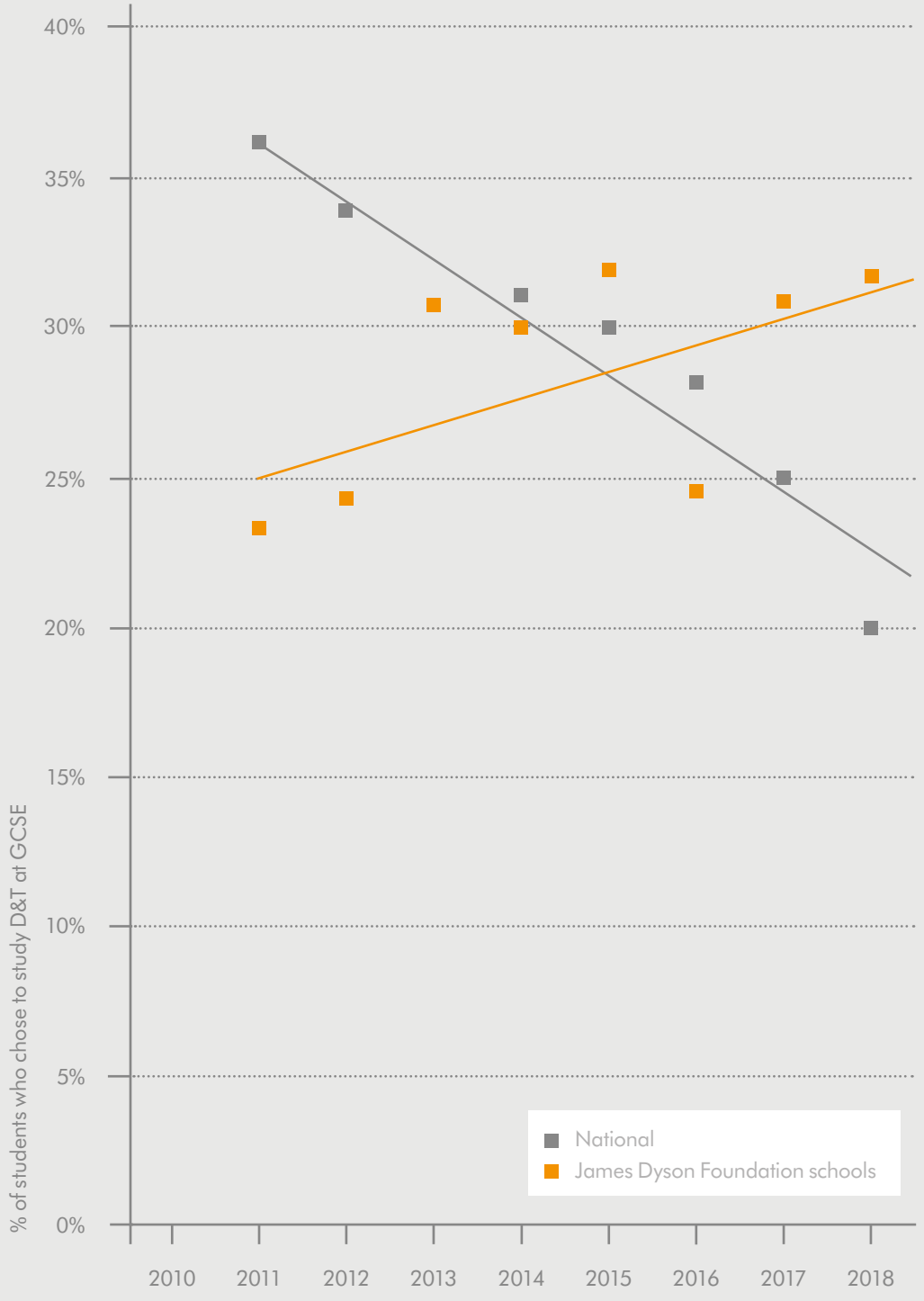


Figure 2
% uptake of D&T at GCSE nationally, and in the James Dyson Foundation schools since 2010

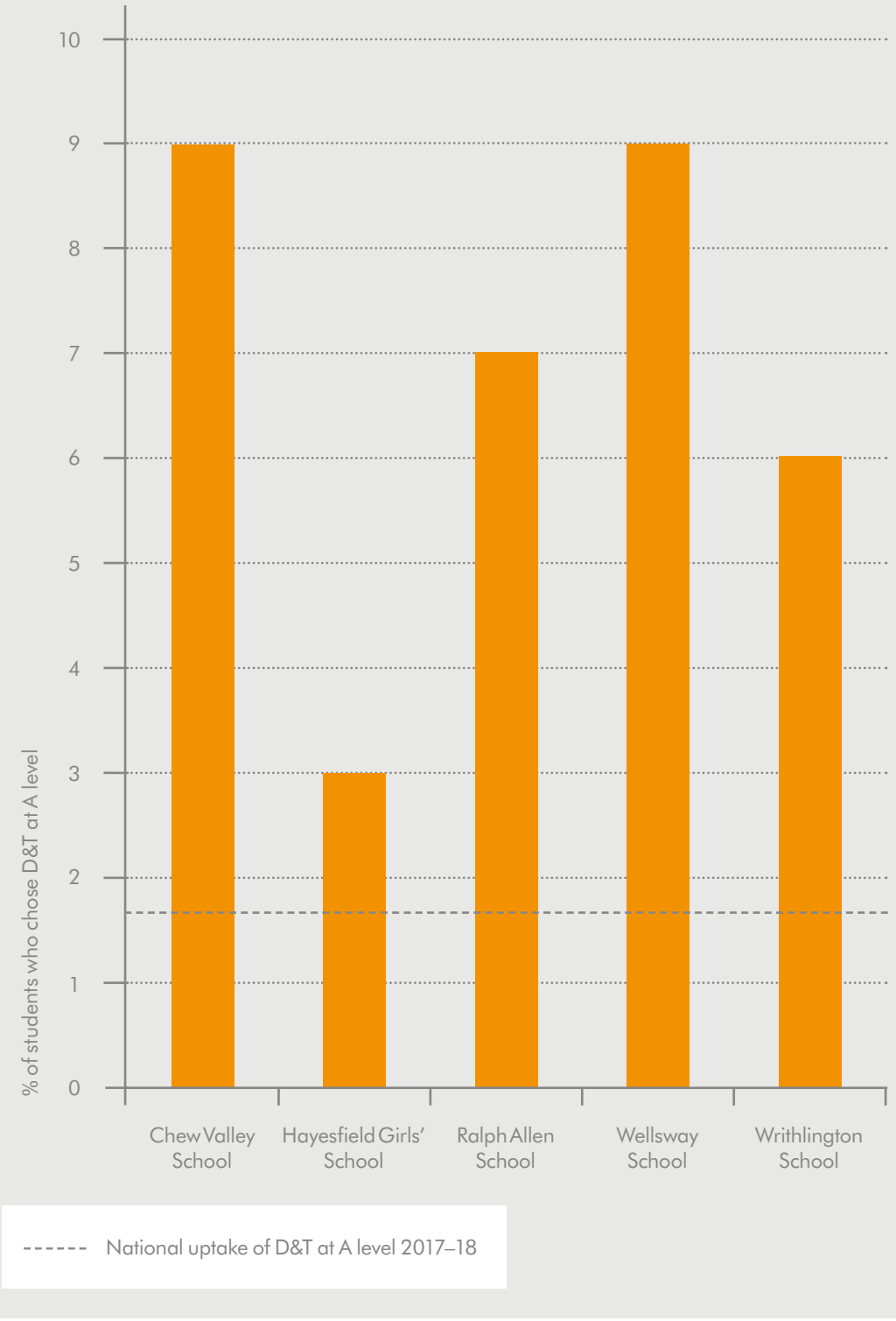


A-LEVEL

Similar to GCSE uptake, the number of students choosing to study D&T at A Level increased over the course of the project. In 2017, an average of 7% of students, across all the schools, chose to study D&T at A Level, against a national figure of 1.7% (demonstrated in the graph opposite).[8]

Overall, GCSE and A Level uptake figures show that the project had an impact on D&T in the Bath schools, by making it a more appealing subject for students to study and gain a qualification in. It also suggests the new teaching methods made D&T more engaging and enjoyable for students.

Figure 3
% of students studying D&T A Level in the James Dyson Foundation schools in 2017–18



GENDER

Alongside a general increase in the uptake of D&T at GCSE and A Level there was also a shift in the proportion of males and females choosing to study the subject. In 2018, 38% of D&T students in the schools were female, compared to 16% in 2010. In addition, over the course of the project there was an increase in enjoyment of D&T amongst female students. This coincided with improved perceptions of engineering careers and a view that engineering careers were accessible to female students.

This resulted in three times the number of females interested in being an engineer, across all year groups, by the end of the project. This suggests the new approach to D&T in the James Dyson Foundation schools developed it into a subject that is not only more relevant and challenging, but also accessible to all students.

300%

increase in the number of female students, across all year groups, who would like to be an engineer

82%

more students think engineering is a good job for a woman, compared to at the start of the project

29%

more female students said they enjoyed D&T lessons, compared to at the start of the project

GENDER CONTINUED

Figure 4
% of females studying D&T at GCSE in the James Dyson Foundation schools in 2010

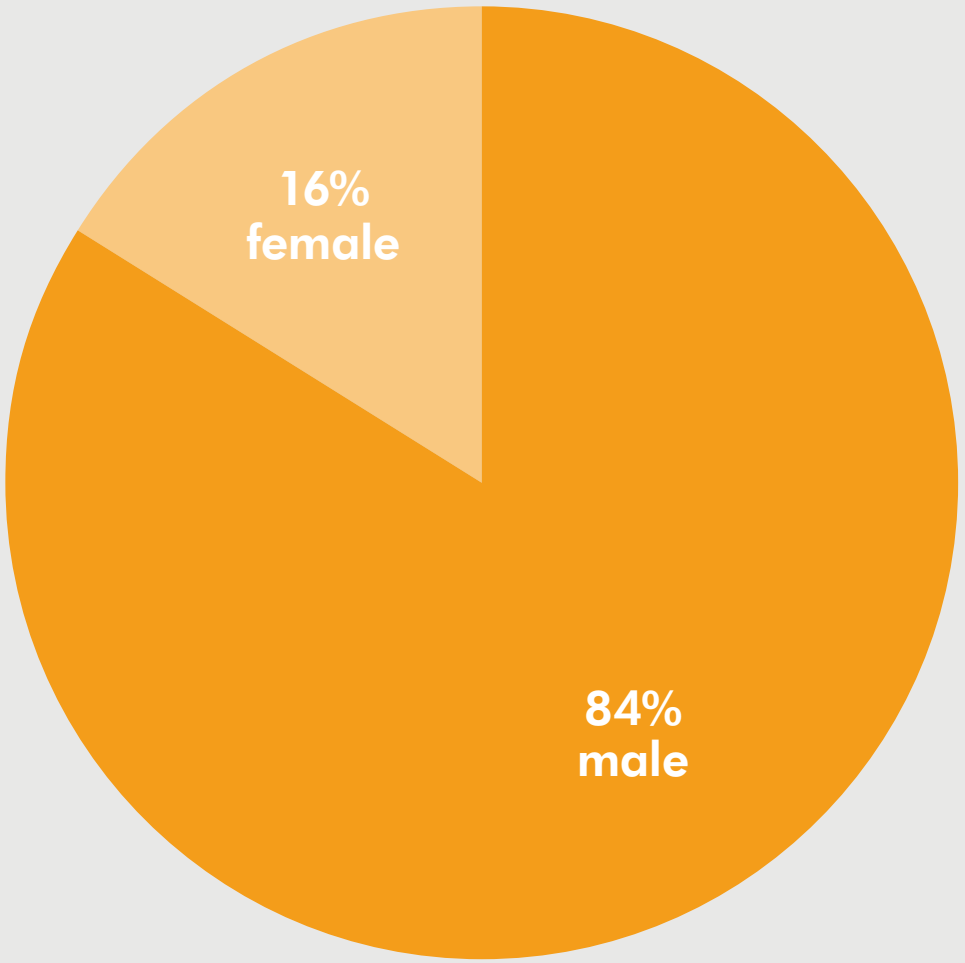
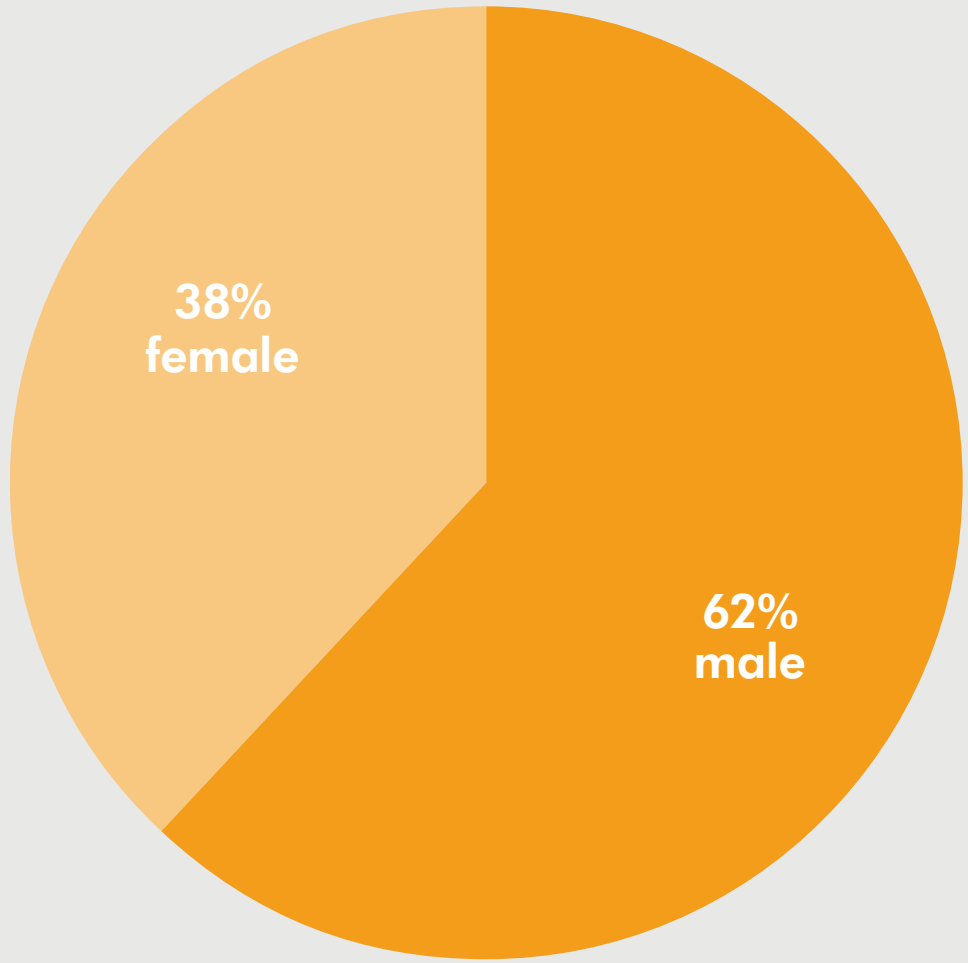


Figure 5
% of females studying D&T at GCSE in the James Dyson Foundation schools in 2018



PERCEPTION OF DESIGN AND TECHNOLOGY

To complement the quantitative data collected on GCSE and A Level uptake, the James Dyson Foundation distributed annual surveys that monitored students' perceptions of D&T and engineering. This qualitative data ensured that increased uptake of D&T correlated directly with a transformation in the way students view and experience D&T, adding further credibility to the teaching methods introduced in the schools. The results from these surveys revealed that student perception and enjoyment of D&T increased over the course of the project.

Surveys distributed before the project revealed that many students felt that D&T was irrelevant and they felt restricted by written tasks. At the end of the project, survey data revealed that students felt that D&T was more creative, practical and allowed them to get straight into the design process.

By the end of the project, many students identified designing and making as the most enjoyable parts of D&T. This corresponds with a 169% increase in students across all year groups answering positively to the statement 'I enjoy D&T lessons' by the end of the project.

More students also agreed that the D&T projects they were working on were more relevant, highlighting the success of giving D&T projects real-life contexts. Alongside this, students also agreed that D&T helped their learning in maths and physics – indicating that D&T can be just as rigorous as other STEM subjects with EBacc status. Overall, these findings suggest that the James Dyson Foundation's approach to D&T has improved student perceptions of the subject.

Over three-quarters of students agreed that design and technology helps their learning in other subjects, like maths and physics.

169%

more students said that they enjoyed D&T lessons, compared to the start of the project

77%

of students thought that engineering is a good job in 2018, compared to 54% in 2013

WHAT DO YOU ENJOY THE MOST ABOUT D&T LESSONS?

2018 RESPONSES

Making
Designing
Practical
Creative
Freedom
Inventing
3D printing
Fun
Exploring ideas
Using equipment
Hands-on
Limitless design
Group projects
End result

PERCEPTION AND PERSUIT OF ENGINEERING

Alongside improved perceptions of D&T, student perceptions of engineering improved over the course of the project. It could be argued that this correlation indicates that the relationship between D&T and engineering was made more apparent to students as the project progressed. Indeed, at the start of the project, the majority of students thought that engineering was about fixing things. By the end of the project, making and designing were the two main attributes that students associated with engineering.

More students also considered engineering to be a good job, and to be important to our lives. And whilst they consistently thought engineering is a good job for a man, more students thought it is also a good job for a woman.

This also coincided with more students wanting to pursue a career in engineering.

This suggests that, as D&T became more enjoyable for students and relevant to engineering careers, more students viewed engineering as a good career option. In fact, there was a 156% increase in the number of students who said they would like to pursue a career in engineering. This suggests that improving D&T provision can help to inspire the next generation of engineers.

156%

increase in the number of students who would like to pursue a career in engineering

WHAT DO YOU THINK THE WORD ENGINEERING MEANS?
2018 RESPONSES

Making
Designing
Problem solving
Creating
Invention
Building
Helping people
Technology
Products
Technical
Imagination
Research
Manufacturing
Improving

TEACHING

Whilst student enjoyment and engagement with D&T improved over the course of the project, there was also a transformation in the experiences of the teachers in the James Dyson Foundation schools. This is against the backdrop of a national shortage of D&T teachers. Indeed, the subject saw the lowest recruitment of teachers in the UK in 2017, reaching just 42% of the overall national target.[4] Additionally, it has been found that 30% of teachers are leaving the profession within five years.[5]

In contrast, teachers in the schools felt that the project rejuvenated their teaching practice. They felt that they could be less rigid in their teaching methods, take more risks and work in a more creative way. They also felt more confident in delivering open-ended project work without getting too restricted by assessment requirements.

100%

of teachers agreed that collaborating with the James Dyson Foundation was a positive experience

One teacher said: “The work we have done together with the James Dyson Foundation over the years has been incredibly enjoyable and has transformed my teaching practice. In particular, the real-world contexts have brought an extra dimension that has helped with both teaching and learning. The contact with, and contribution from, the Foundation has made me much more confident with experimentation and in letting our students really be designers.”

85%

of teachers felt that D&T is valued in their school

75%

of teachers agreed that students were more engaged in D&T as a result of the project

3

SUMMARY

The James Dyson Foundation schools project has been successful in its aim to rethink the way D&T is taught in schools, and in transforming student experience of the subject. This is proven by increased student engagement and enjoyment, improved perceptions of D&T and engineering, improved teacher motivation. The James Dyson Foundation hopes the evidence from the five schools will support change on a national scale.

National challenges remain, such as financial cuts to D&T departments across the country, which make it a challenge for D&T teachers to introduce new methods of teaching. This is coupled with the fact that D&T is not an EBacc subject, which discourages students from choosing to study it at GCSE, and puts further strain on D&T teachers as schools are incentivised to direct funding to EBacc-status subjects.

However, the UK still faces the problem of a national shortfall of engineers. It would be short-sighted to allow a practical, creative and academic subject, which directly feeds into the engineering career pipeline, to vanish from school curriculums.

What the James Dyson Foundation project has shown is that the UK education system, and D&T departments in particular, should not resign themselves to the idea of D&T's demise. Rather, the project substantiates the argument that with the right support and approach, D&T has the potential to directly address one of the country's most pressing questions: how can we fare in an increasingly technology-led world, faced with pressing global engineering challenges, if here is a continued shortage of engineering talent?

The government needs to recognise the urgent need to re-brand D&T, by making it an EBacc-status subject and ensuring it has the funding and support needed to inspire the next generation of engineers.

Beyond this wider call to action, the James Dyson Foundation has made the successes and learnings of the project accessible to D&T departments across the country through nine schemes of work, which are free to download from jamesdysonfoundation.co.uk.

These schemes of work have been trialled and tested by the teachers at the schools and mapped to OCR Key Stage 3 and 4 specifications, but can also be applied to other examination specifications. They introduce teachers to the James Dyson Foundation's approach to D&T, allowing them to equip and empower students to take on real-world engineering challenges.

As more schools adopt this new approach to D&T, and if the government moves to support the subject in schools, D&T education could be revolutionised on a national scale. It is the hope of the James Dyson Foundation that this will encourage more students in the UK to study Design and Technology, so they can develop the vital technical skills and creative thinking needed to become the engineers of the future.

APPENDIX

JAMES DYSON FOUNDATION US

After the successful launch of the project in Bath, the James Dyson Foundation expanded its project with the aim of testing the new D&T teaching methods in a different environment. Three schools in both Chicago and Tokyo were chosen.

The United States doesn't have a formal, nation-wide Design and Technology course. As a result, the James Dyson Foundation had to break new ground to introduce engineering education into the three partner schools in Chicago.

To do this, the schools were firstly given funding to develop their academic classrooms into designing and making spaces equipped with industry-standard machinery. Secondly, whilst the teachers involved in the project had specialisms in STEM subjects, they required extensive and consistent training to equip them with the skills needed to deliver engineering-related lessons. After more than 100 hours of equipment and pedagogical training, the James Dyson Foundation established new student courses that integrated the teaching methods developed in the UK project.

The new courses were well received by students – enrolment in design and engineering classes rose from 0% to 14% in the targeted year groups in all three schools. In addition, student interest in engineering increased. For example, in the second year of the partnership, students in one of the schools independently established a girls-only engineering extracurricular club.

Similar to the UK, surveys were done during the 2017–2018 school year, to measure the impact the project had on students' attitudes and perceptions of STEM subjects and engineering careers. Overall, there was a positive improvement, with 59% of students who took part in the project interested in pursuing a career in engineering.

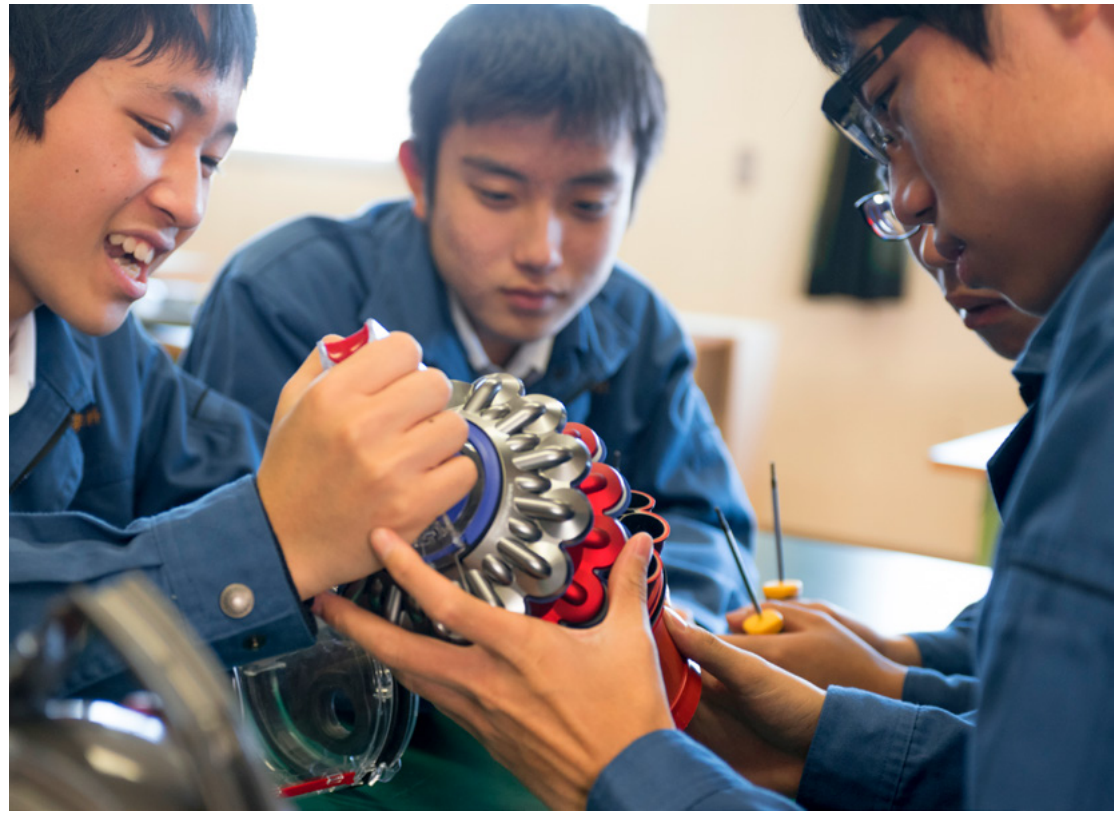
APPENDIX

JAMES DYSON FOUNDATION JAPAN

Similar to the US, in Japan D&T is not present in school curriculums. Instead, the closest students come to experiencing engineering-related lessons is through three years of technology education at junior high schools (age 13–15). To understand how the provision of engineering-related learning can be improved, the James Dyson Foundation implemented more rigorous and extensive technology-related lessons, using the teaching methods developed in Bath, in three junior high schools in Tokyo. Lesson plans were created that challenged students to use their technical knowledge to engineer solutions to everyday problems.

Survey data collected from the schools in 2017 and 2018 revealed that the project improved students' ability to identify problems and develop engineering-related solutions. This data also found that over the course of the project there was an 11% increase in students who considered engineering to be important to our lives, and an 18% increase in students interested in engineering as a career. The project was recognised by the Japanese government, and Japan's Ministry of Education has since embedded 'problem-led learning' into the national technology education program of study.

Overall, the Chicago and Tokyo projects allowed the James Dyson Foundation to test the teaching methods and curriculum developed in the UK in different contexts. Despite the differences between the countries and their approaches to engineering education, the results of the projects were positive. They also mirrored that of the UK project – particularly in regards to increased student enjoyment of engineering-related lessons, interest in engineering careers and improved perceptions of engineering. This demonstrates that the James Dyson Foundation approach to D&T and engineering education could be replicated in other classrooms around the world, and have a positive role to play in inspiring the next generation of engineers.



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You can find out more about the James Dyson Foundation educational resources online at **www.jamesdysonfoundation.co.uk**