Royal Academy of Engineering

Welsh Valleys Engineering Project

Evaluation Report

2018 – 2022

Table of Contents

Introduction

The Welsh Valley's Engineering Project (WVEP), run by the Royal Academy of Engineering with funding from The Panasonic Trust launched in March 2018. The WVEP applies a partnership approach between schools, colleges, government, and industry to promote engineering in education and the workplace. The WVEP delivered focused and targeted STEM (science, technology, engineering, and maths) resources, educational support, and career guidance to eight secondary schools and two colleges plus, from September 2018, five primary schools located in Merthyr Tydfil and Blaenau Gwent, South Wales.

The five-year programme provided funding and support for schools and colleges to engage with hands-on and experiential engineering-related STEM learning opportunities that enrich the curriculum, stimulate interest in STEM and enthuse learners irrespective of gender or social status. The Panasonic Trust Future Engineers Award provides additional support in the form of bursary funding to encourage and support year 11 students to study Engineering or engineering-related courses at college level (The Panasonic Trust Future Engineers Award – see separate report).

Year 4 of the project saw the launch of the Employer Engagement Strand (January 2021) which has connected local, national, and global engineering industries to the primary and secondary schools that were part of the WVEP. This was designed to deliver co-produced curriculum-embedded careers-based engineering challenges that could be used by every school within the WVEP. This has now received three-year follow-on funding from Welsh Government through the Tech Valleys Programme (from the school year 2021/2022 to 2023/2024).

The WVEP project aimed, through this multi-stemmed approach, to contextualise learning in the classroom, raise the profile of engineering and increase the uptake in STEM engineering-related subjects post-16. The aims of the WVEP were as follows,

Raise the overall profile of engineering in the local area/schools

Raise awareness and aspiration in young people towards STEM-engineering pathways and careers

Enrich the curriculum and extra-curricular activity by providing engineering-enriched STEM resources

Develop long-standing school networks and local industry collaboration that coordinates and delivers engineering-enriched STEM

This evaluation report documents the progress made toward achieving these aims during the project. The report also examines the process of the project and suggests recommendations

for future practice. Covid-19 affected the delivery of the project, and the teacher's workloads, during the 4th and 5th years of the WVEP.

The Project supported

Annual funding for STEM-Engineering resources for all WVEP primary and secondary schools

Annual Funding for Schools to support activities to promote British Science Week and Tomorrow's Engineers Week

Annual funding to support the progression or development of STEM-Engineering focused extra-curricular activities

CPD training for teachers for the RAEng teaching and learning resourse packs

Panasonic Trust Future Engineer Awards: 20 bursary grants per year for Year 11 students who are pursuing enginering-related courses to college level and beyond

Engineering workshops: provided by the Smallpiece Trust and by industry in year 2

As a result of learning from the project and in response to school need, the Employer Engagement Strand was launched in 2021: Linking Industry and Schools to provide engineering activities to enthuse young people about engineering wityh co-produced challenges

Key Outputs and Impacts

4 celebration events

2 promotional videos created

15 coordination meetings

650 + secondary pupils took part in the Employer Engagement Strand Engineering challenges

82 Panasonic Trust Future Engineers Bursarys awarded (from 2018-2021). 30% were awarded to female students

640 + primary pupils took part in the Employer Engagement Strand Engineering challenges

Over 20,000 pupils recieved engineering experiences over 4 years

9 engineering companies joinly developed engineering challenges with primary & secondary schools, delivering them termly.

3 Primary Schools developed STEM-Engineering Hubs or Learning Zones as a result of the WVEP reources

3 secondary schools trailed BTEC engineering in at least one year as a result of the upsurge in interest from pupils

One college introduced additional engineering courses due to increased demand

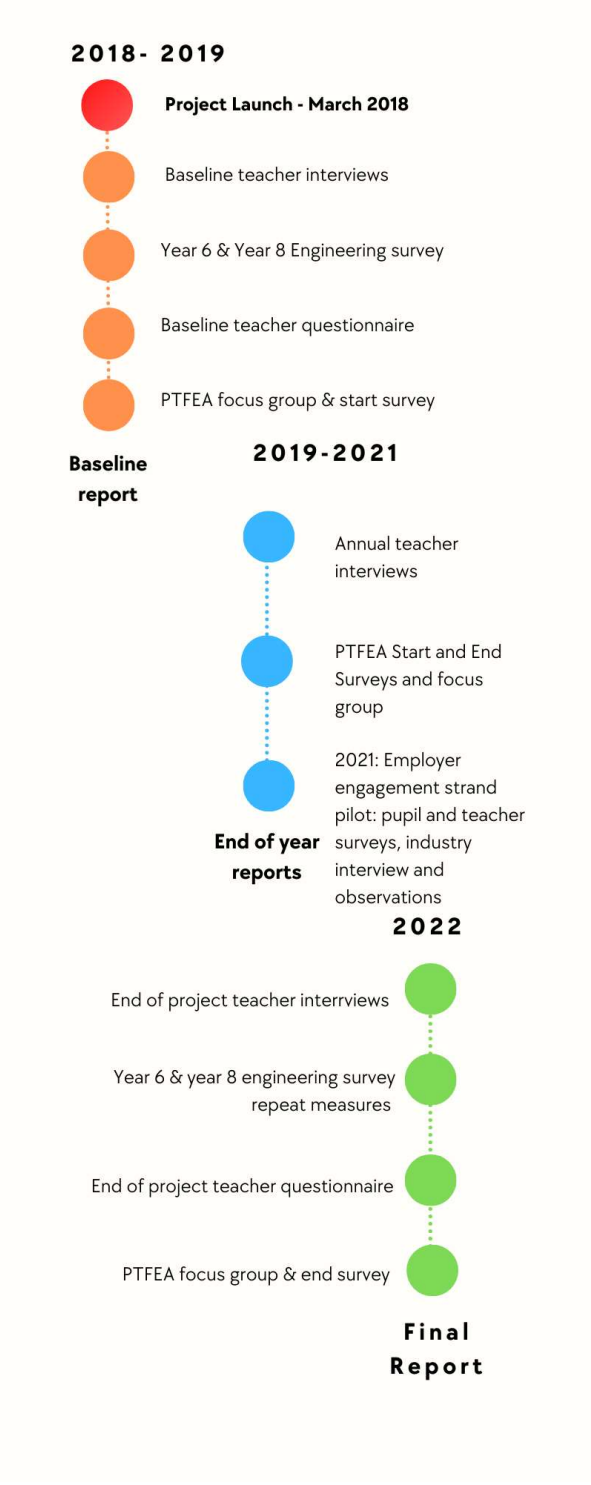
Both colleges had evidenced increased number of students selecting engineering (pre-Covid)

Primary year 6 and secondary year 8 pupils showed an 19 percentage point increase in their understanding of engineering from year 2 to year 5 of the project

Aptitude for STEM related careers rose by 8 and 9 percentage points (for year 8 and year 6 pupils)

Evaluation Method

The evaluation utilized a collaborative mixed-methods approach, throughout the WVEP to gather data from the key stakeholders in the project (school coordinators, industry representatives, the local project coordinator, and the participating pupils). Appendix A shows a breakdown of the project years. The evaluation used the following methods,



Raising the overall profile of Engineering

Raising Awareness in Primary Schools: teacher perspective

The primary school coordinators reported that the WVEP has resulted in high levels of engineering activities throughout the schools that have raised the profile of engineering not just across the student body, but also for the teaching staff by increasing teacher confidence to deliver engineering curricular and extra-curricular content in schools.

The Welsh Valleys Engineering Project has enabled the schools to build up STEM-engineering resources and supported teachers to purchase additional resources to support hands-on activities that enthuse the pupils for Tomorrow's Engineers Week and British Science Week. Throughout the project, the school coordinators have been able to integrate engineering into Key Stage 2 projects and curricula activities as well as into the Foundation Phase.

The baseline evaluation report (July 2017-18) illustrated the scarcity of engineering awareness and resources across all WVEP primary schools, and more pertinently, the lack of understanding and confidence around teaching engineering across primary teaching staff.

The continuous funding and coordination/communication via WVEP meetings, training (through the Royal Academy of Engineers) and the increased connection to industry through the Employer Engagement Strand have aided in the development of teacher confidence and allowed the schools to put a central focus on engineering within the class and in extra-curricular activities. One coordinator teacher commented,

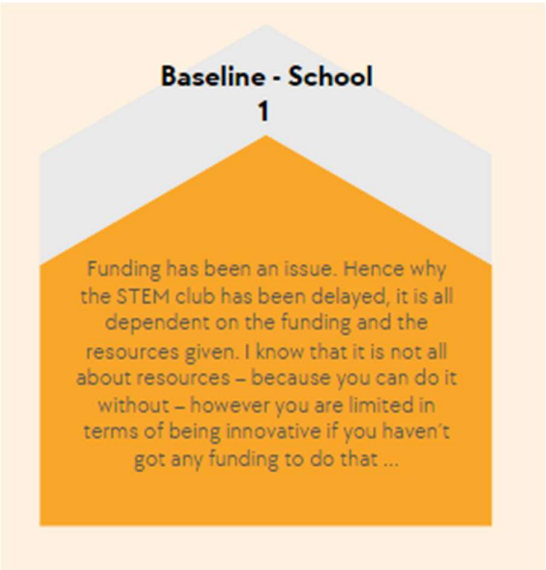
> ***"It has been fantastic. It has put a spotlight on the industries and jobs available to our pupils for the future. Our pupils love the 'challenge' element of the WVEP. Having the opportunity to become a lead school has also allowed us to develop community and cluster school links to further enhance our STEAM curriculum and area of learning***"
>
> (Coordinator Teacher, School 1)

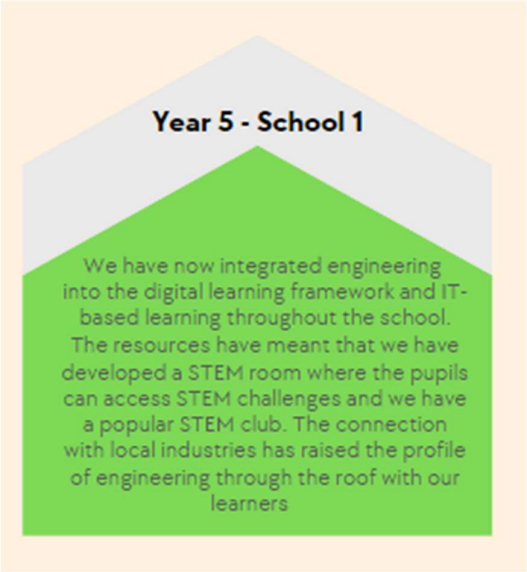
And another

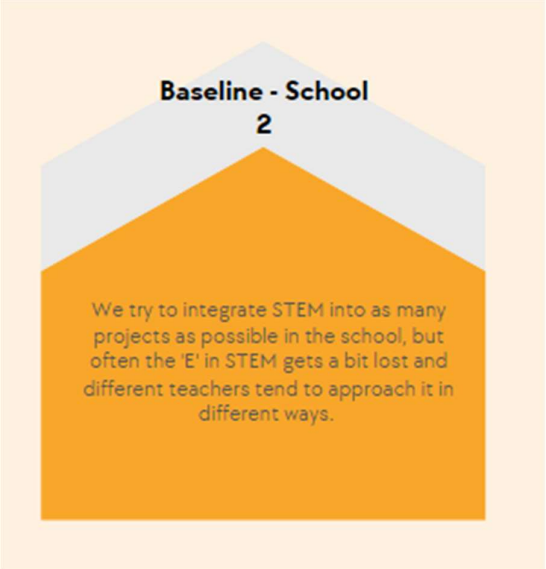
> ***"The WVEP has introduced me to the world of engineering. WVEP enabled me to purchase resources to support STEM teaching and learning. Created links with the local College and engineering students who then supported us and our learners. It has provided us with the most amazing links with industry and exciting challenges to work towards. Overall, it has enabled our pupils to showcase their engineering skills"***
>
> (Coordinator Teacher, School 5)

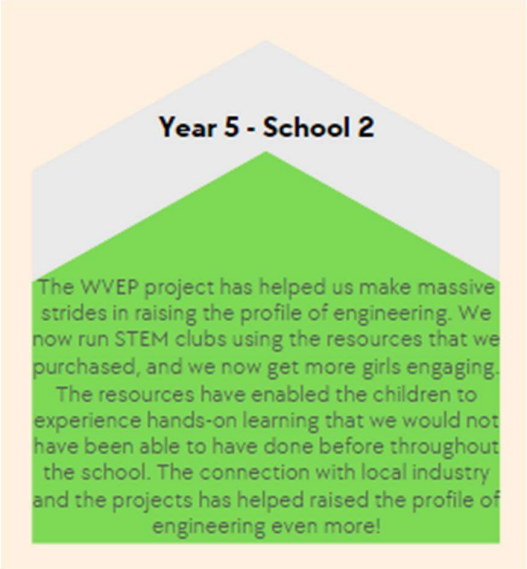
WVEP bringing about change

To illustrate the changes that the WVEP has brought about in the Primary schools the primary school WVEP coordinator's comments are compared below from the start of the project (baseline) to the end of the project (year 5),









Baseline - School 3

Engineering was poorly covered before, it is getting better – we are doing more building of things. But it is a mysterious entity to primary school teachers put it that way...

Year 5 - School 3

This project has definitely raised the overall profile of engineering in our school. I think that is evident in the children and how they talk about engineering now. The confidence and drive to embrace engineering has improved across the school. Working with the industry has really pushed us to incorporate areas that we wouldn't have had the expertise to deliver to the pupils before – especially the cyber security and coding projects

Baseline - School 4

Our STEM engineering activities have been focused principally on STEM week at school, we don't have many resources to support it. The school has not previously pursued visitors from STEM industry or STEM departments from universities coming in.

Year 5 - School 4

The WVEP has definitely raised the profile of engineering in the school, I think before it was an abstract concept for most of the pupils but meeting real people from local industry and taking part in some of the projects that we have been able to run in the school due to the resources we have purchased has been great to really highlight the varied roles of engineering

Baseline - School 5

Up until last year – D & T wasn't taught. It was always that subject where we always thought, 'Oh, we'll leave it until Christmas or the end of term' and it wasn't done. No one led it – and obviously, we are all so busy it is something that got left behind – or when it was done – it wasn't done effectively

Year 5 - School 5

The WVEP has been so successful in raising the awareness and aspirations around engineering in our school – and this element of STEM was practically non-existent in our school before the WVEP. It is now something that the pupils absolutely adore and they can't wait to take part in engineering activities now. We have now built this into the curriculum in our school and in our partner primary school too.

Raising Awareness in Secondary Schools: teacher perspective

The secondary school teachers were confident that the WVEP has helped to raise the profile of engineering in school. The secondary school model means that raising the profile across the whole school was more of a challenge, and different coordinators, depending on their department and specialism focused on varied sets of pupils and different engagement activities (through the resources purchased) to deliver the project. A further variable was that the coordinator teachers hailed from different departments including science, maths, design & technology/engineering and ICT which resulted in differing emphases and strategies for engaging and enriching the STEM-Engineering pupil experience. Covid-19 posed a particular challenge to secondary school teachers, and this especially impacted their ability to deliver hands-on projects to multiple classes.

The introduction of the Employer Engagement Strand was a welcome addition, and the teachers felt that this helped connect the pupils to real-world businesses and issues. Connecting with industries is an integral part of the new Welsh Curriculum, and this project has helped facilitate this transition and connected the schools with local, national, and global industries. However, the teachers all highlighted that the workload, structure, and delivery of this aspect of the project needed further development (discussed later).

The resources purchased enabled the teachers to extend the learning of the pupils and enrich their experience through hands-on equipment and new state-of-the-art technologies. The resources increased the number of engineering projects and integration into the curriculum across all WVEP schools. The schools were also more able to better equip their extracurricular clubs. Six of the schools developed specific clubs that have a greater focus on STEM engineering rather than just science. The schools were also able to focus attention and resources on Tomorrow's Engineers Week and British Science Week to engage a wider cohort.

The teachers specifically emphasized the Panasonic Trust Future Engineer Awards as an innovative way to promote the project and engage more of the year 11 students in thinking about engineering post-16.

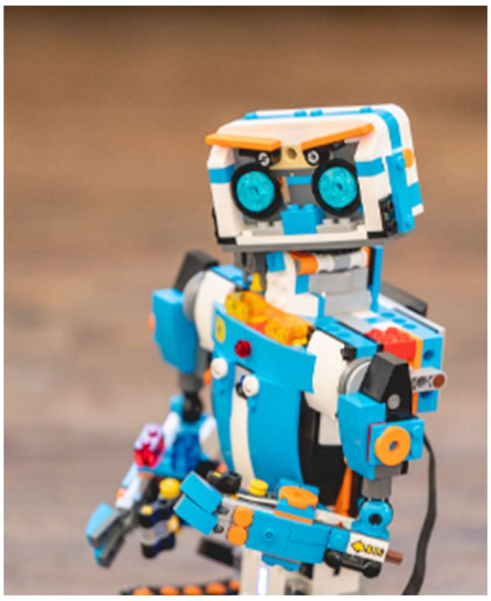
> ***"When we started five years ago there was very little opportunity for people regards to engineering. Exposure to it through the funding and the innovative resources being available and through the business partnerships and the Smallpeice Trust workshops has really helped to raise the profile of engineering in our school for pupils and teachers too because lots of the teachers have now been involved in delivering the project through the Employer Engagement Strand"*** **(Teacher, School H)**

> ***"The WVEP has definitely raised the profile of engineering in the school. The new technologies that we have been able to buy and***

the activities that they have been able to take part in. The students created their own Future Engineer lunchtime club, they got to make a video for the WVEP and attend the celebration event, so for those pupils especially – it has really helped to raise the profile of engineering, many of them are now going on to college to study engineering" **(Teacher. School E)**

"The project has hugely raised the profile of engineering across the whole school. The project has allowed us to run several activities over the years across the whole school. We now celebrate Tomorrow Engineers week along with British Science week and that really helps to raise awareness further. The project has given us a platform to talk to the parents about engineering too" (Teacher, School G)

The progression of engineering to be enhanced in the local area was hampered by COVID. Pre-Covid, many of the schools had been using the resources purchased for transition projects and open days to raise the profile of engineering to parents and prospective students.

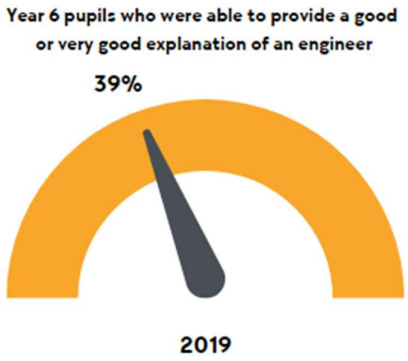


Robot - designed, built, and programmed by pupils at School B

Raising Awareness in Schools: Pupil Evidence

Pupil understanding and awareness of engineering increased in both year 6 and year 8 school pupils because of the WVEP project

The Year 6 pupils in the participating five primary schools were surveyed about their understanding, aptitude, and attitude towards engineering at the beginning of year 2 (*n*=149) and at the end of year 5 (*n*=138) of the project using a short survey[1]. The year 6 and year 8 pupils were asked the same open-ended question to establish their understanding of what an engineer does[2]. The results show an increase in understanding of engineering of 19 percentage points from the survey undertaken in 2019 to the survey undertaken in 2022, as illustrated below,



All year 8 pupils were surveyed about their understanding, aptitude, and attitude towards engineering in year 2 (*n*=501) and year 5 (*n*=497) of the project using a longer survey[3]. The

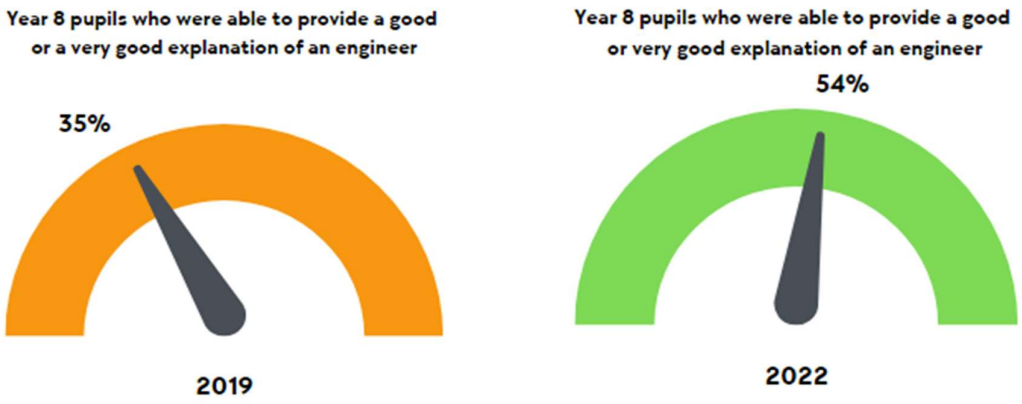
[1] The year 6 survey was administered by the independent evaluator in each primary school. Pupils were observed during completion so that they did not copy answers. The data was collected in May and June 2019 after the primary schools had received their first funding for engineering-related resources between September-December 2018. Some of the pupils from year six had attended the Celebration event for the WVEP in July 2019, and the schools had started delivering new STEM clubs to support extracurricular learning. Schools had also had additional input from external providers during British Science Week and Tomorrows Engineers Week. The 2022 survey was collected in May and June 2022, although not the same set of pupils, the sample size was comparable and all 5 schools took part (start survey included 149 pupils and the year 5 survey included 138 pupils, slightly more male pupils were in year 6 in 2022).

[2] Pupils were asked an open-ended question to 'say what an engineer does', In the light of the ambiguity around defining an engineer's role the responses to the open-ended question were coded into the following,

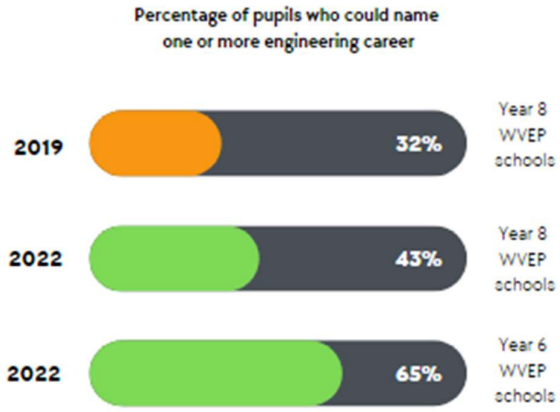
Very Good Explanation: Mentions fixing, making, or designing a range of things and can demonstrate a wider knowledge of at least one or two types of engineering or mentions STEM.
Good Explanation: Mentions fixing, making, and designing things.
Average Explanation: Mentions fixing, but not designing things
Poor: Links engineering to fixing cars or engines (i.e. mechanic)
Very Poor: Provides an explanation connected to trades or other non-related professions

[3] The year 8 pupil survey was administered by online link or paper forms. Teachers were given instructions that pupils were to complete the survey under exam conditions. An incentive to enter a competition to win £25 vouchers helped to garner a good response rate. The first set of data was collected in May and June 2019 after the secondary schools had received their first funding for engineering-related resources between September-December 2018. One school could not take part in this survey. The 2022 survey was collected in May and June 2022 with the current year 8 pupils., Although not the same set of pupils, the sample size was comparable (using demographic and engineering profiling data). Only the schools who took part in the first

results show that in year 5, the year 8 pupils were 19 percentage points more able to give a good or very good explanation of an engineer than the year 8 pupils in year 2. The results are illustrated below,



The pupils in year 8 increased their ability to name one or more engineering careers because of the project. In 2019, 32% could name one or more engineering career and in 2022 this rose to 43% (the remaining pupils still could not name a type of engineer, or specify a mechanic, plumber, builder, or electrician). 65% of the year 6 primary school pupils were able to name one of more engineering careers by year 5 of the project (note; this question was not asked in the pre-survey taken in 2022 as it was deemed too advanced for the year 6 pupils). This change is illustrated below,



survey were included and the results from a school who temporarily withdrew from the project were removed. This resulted in 501 completed the survey in 2019 and 497 in 2022.

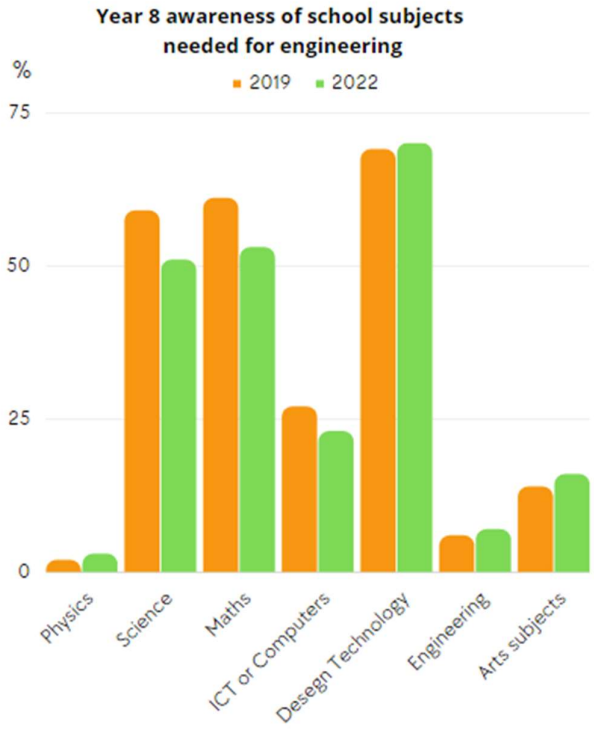
The year 8 pupils in year 5 of the project were 11 percentage points more able to name one or more engineering careers than the year 8 pupils in year 2 of the WVEP. The types of engineers mentioned included,

	Year 8		Year 6*
Engineering Career	**2019**	**2022**	**2022**
Software or computer engineering	4%	13%	17%
Electrical Engineer	9%	12%	4%
Mechanical Engineer	10%	9%	2%
Automotive Engineer	11%	8%	10%
Civil Engineer	9%	8%	2%
Aerospace or aeronautical	5%	8%	4%
Gas/Water/Railway/welder	0%	5%	3%
Chemical	4%	6%	
Biomedical	1%	4%	7%
Structural & Technical	0%	3%	
Design & Architect	0%	2%	8%
Environmental	2%	2%	1%
Industrial	1%	1%	
Nuclear	1%	1%	
Petroleum Engineer	1%	1%	
Materials Engineer	0%	1%	

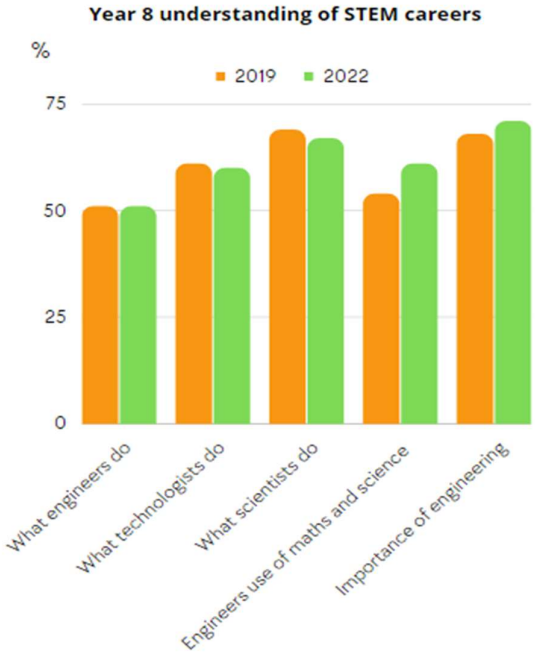
*This question was not asked in the year 1 survey for year 6 pupils.

The results show a growing awareness of the year 8 pupils of what engineering entails and the range of engineering opportunities available. The growth in awareness of IT and Software engineers is thought to reflect the emphasis on coding and technology resources purchased and the cyber security and hardware and software Engineering Challenges developed and delivered as part of the Employer Engagement Strand.

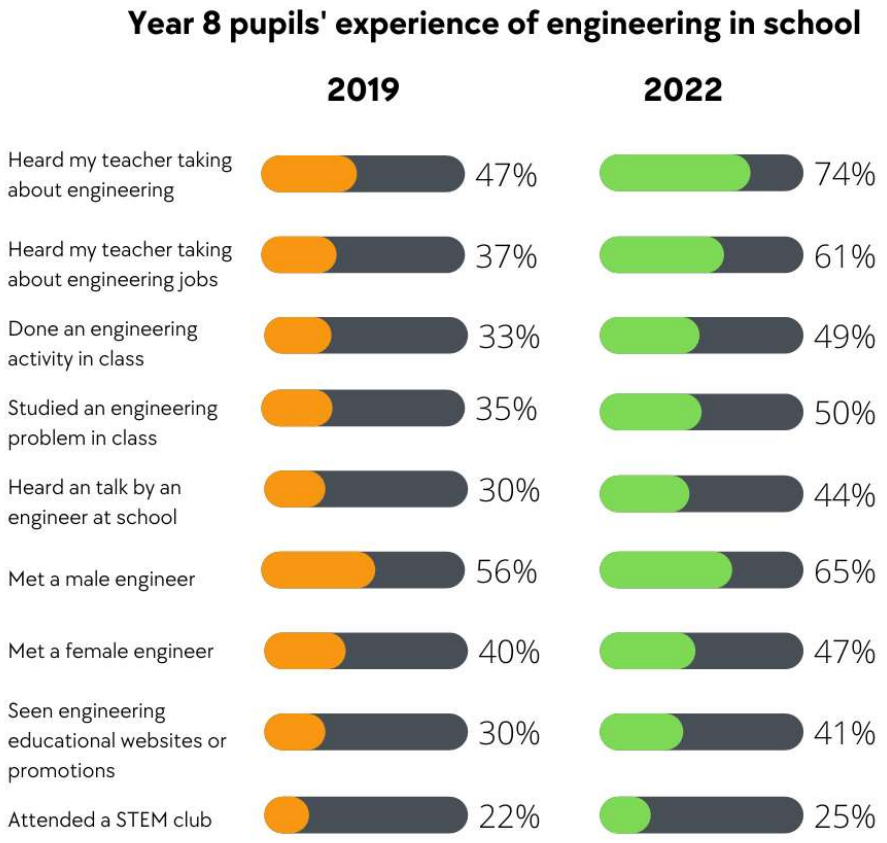
The year 8 longer survey included several questions related to the awareness of the pathways to engineering and understanding of engineering. In 2022, year 8 pupils evidenced slight, but not significant, decreased awareness of science and maths being subjects needed for engineering than the year 8 pupils in 2019. For both years, the students were most likely to select Design and Technology as a central pathway into engineering perhaps reflecting the more practical hands-on projects that the schools have embraced as part of the project. These results are shown in the chart below,



In 2022, the year 8 pupils were slightly more able to indicate that they understood how engineers use maths and science in their jobs, there was little change evidenced for the other indicators. This data is presented in below chart,



The Year 8 survey showed an increase in engineering activity across the schools as a direct result of the project. The results show increased exposure to engineering across all activities since 2019. The greatest increases were in teacher dissemination and incorporation of engineering in the classroom and new activities, as shown below,



Note: there was only a marginal increase in attendance of STEM or Engineering clubs because all after-school or lunchtime clubs were suspended during the pandemic and the schools had been slowly re-introducing them since September 2021.

Raise aspiration in young people towards STEM-engineering pathways and careers

Raising Aspiration & Aptitude for Engineering in Primary School: Teacher perspective

The Primary school coordinators felt that the WVEP activities and especially the Employer Engagement Strand had helped to broaden the pupil's knowledge of the different engineering careers and possibilities. All schools had integrated engineering activities into their curricula from the Foundation Phase to year 6 so it was felt that the pupils had been exposed to opportunities rather than necessarily settling on career opportunities. The connection with the industries was felt to strengthen this link as it connected the pupils directly with tangible and local engineering companies. The teachers agreed that the pupils could only benefit from exposure to a wide variety of different careers and opportunities that could broaden their horizons and direct their focus on different careers that might not be visible to them in their local communities.

The secondary teachers felt that the Panasonic Trust Future Engineer Award (PTFEA) was a key driver in raising aspirations and aptitude for engineering post-16. As one teacher commented,

> ***"I think the PTFEA awards have really helped this for the year 11 pupils who are going on to college I know that some of them have gone onto university to study engineering now. it has been a real incentive for some of our students to get involved in engineering"***
> (Teacher, School H)

The Employer Engagement Strand, the projects and resources in school were able to enthuse the pupils and provide increased awareness for some pupils, which has led to them considering engineering careers. Some of the teachers felt that the hands-on projects were able to enthuse the normally harder-to-engage students. Pupils were also made more aware of the different ways to access engineering, through apprenticeships or university, through the project. The coordinator teacher from school C warned that some activities and workshops could act oppositely if the pupils don't enjoy them.

Engineering opportunities have also grown in some of the schools. At the start of the project, three of the secondary schools offered engineering GCSE or BTEC options for their pupils. By the end of year 5 of the WVEP, three schools have trailed engineering BTEC for at least one year[4] and one other school is in discussion with SMT to develop an engineering pathway through the school. The schools that already offered an engineering BTEC or GCSE had

[4] School H and School G have trailed one year of BTEC engineering and School D (who suspended activity with the WVEP due to staffing issues) also trailed engineering BTEC at the school. School B is in discussion to start delivering engineering.

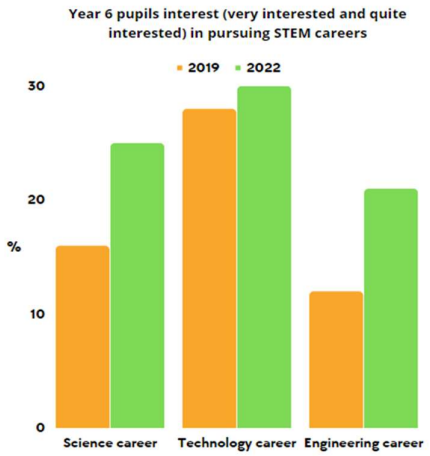
noticed increased uptake from the more academic pupils and for some of the years, an increased uptake from female pupils (although these numbers are still significantly lower than the male pupils).

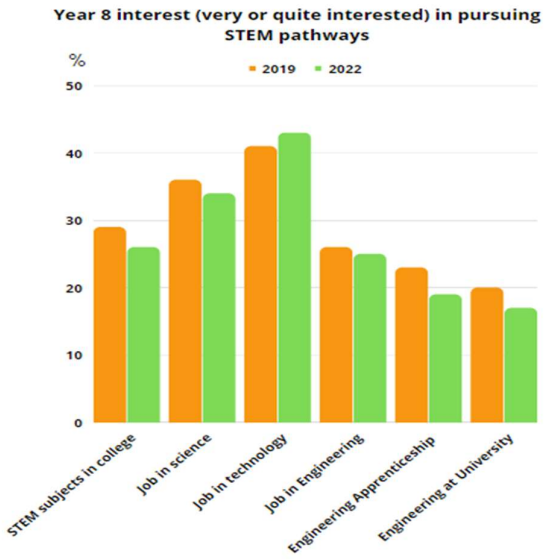
Four schools provided 6-years of uptake and attainment data for the STEM subjects (Appendix C). The data shows some increased uptake for engineering-related subjects in the schools and some increased attainment (as compared to the 6-year average) in many of the STEM-engineering-related subjects. Continued increased attainment since 2019 was seen across the four schools in Double award science, Design & Technology or Product Design, Maths and Engineering (where offered).

Raising Aspiration & Aptitude for Engineering: Pupil Evidence

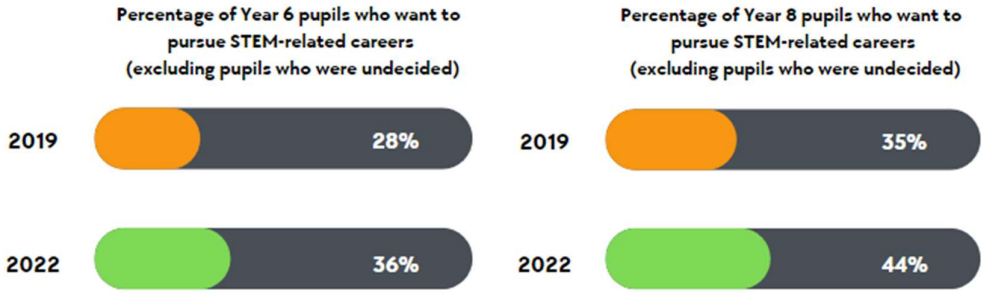
The Year 6 and the Year 8 pupils evidenced slight increases in an aptitude for pursuing engineering careers and larger increases in selecting STEM careers, especially those connected with technology.

The year 6 pupil survey showed an increased interest in pursuing STEM careers from 2019 to 2022. For the year 6 pupils, the greatest increase was evidenced for engineering careers (+9 percentage point increase from 2019 to 2022). The year 8 pupils only evidenced a slightly increased interest in careers in technology when comparing data from 2019 to 2022, interest in engineering did not significantly change and figures in 2022 were all over 20%, with around 25% still saying that they would 'like to' or would 'quite like to' pursue an engineering career, which is a significant proportion of the student body. These changes are shown in the two charts below,

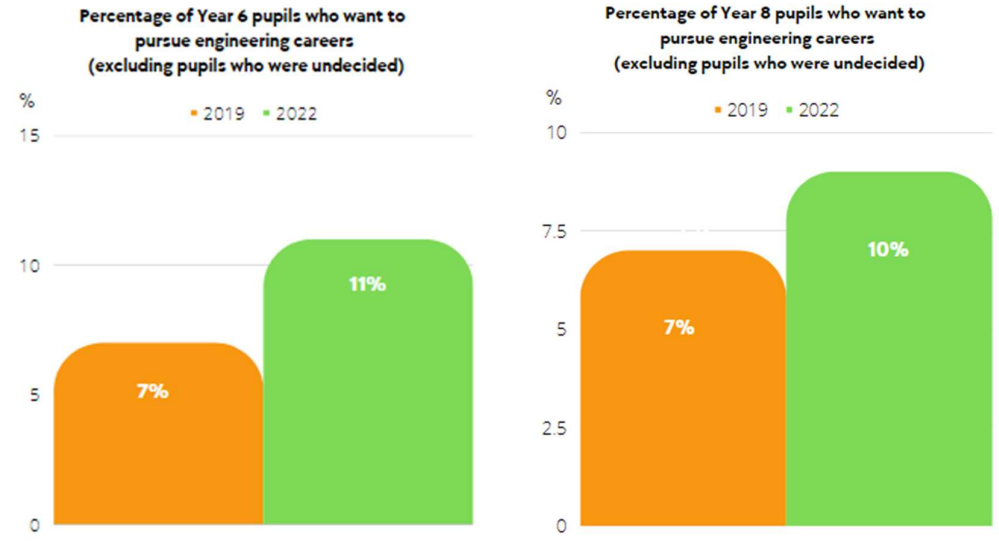




The pupils were asked a free-text question about their career aspirations, answers were coded into 33 different career themes. An increased interest in STEM careers[5] of 9 percentage points was evidenced from 2019 to 2022 from the year 6 pupils and an increase of 8 percentage points for the year 8 pupils. As shown below,



Interest in traditional engineering careers for the year 6 pupils rose by 4 percentage points. The year 8 pupils demonstrated similar results with a 3-percentage point rise for traditional engineering careers, as shown below,

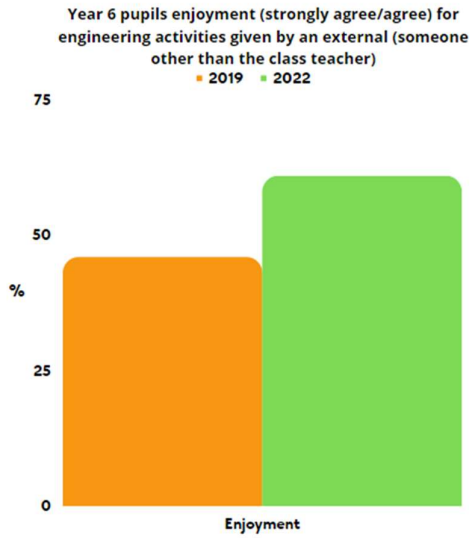


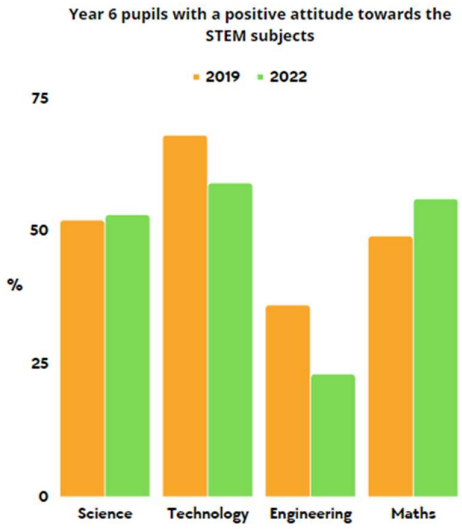
77% of the year 6 pupils said that they had experienced an engineering workshop given by someone external to their school. Rates of enjoyment for these types of experiences rose from 46% (in 2019) to 61% (in 2022) an increase of 15 percentage points.

However, the enthusiasm didn't continue for the pupil's attitude towards the STEM subjects with a slight increase in attitudes towards science and maths and decreased attitudes towards engineering and technology. Slightly more boys than girls demonstrated negative attitudes towards engineering. It is unclear why this might be the case, without further

[5] STEM careers included, Medical and Veterinary, Research science or science specialist, Programming or IT specialist, Engineering Careers, Mathematics and Accountancy, STEM (non-university) mechanic, builders and trades, STEM nursing, midwifery or health.

investigation, but it may reflect the pupils' partition of curricular requirements and extracurricular or external activities.





Pupils demonstrating drones

Enrich the curriculum and extra-curricular activity by providing engineering-enriched STEM resources

Primary Schools

The primary schools were able to access £1500 of funding per year for four years to support engineering-enriched activities in their schools (see Appendix B for a full list of resources). There was individual funding of up to £500 to support activities for British Science Week and Tomorrow's Engineers Week as well as funding of £200 for resources for extra-curricular activities. All teachers felt that the resources would not have been purchased if it were not for the WVEP as one teacher commented,

> ***"Our resources in the school before were old and antiquated. The WVEP has gone a long way to changing that – now in the school, we have 3D printers, codable drones, codable LEGO, VR headsets and Stix machines and loads of tools that we can use each year"*** (teacher school 1)

And another,

> "***We didn't have many resources to support STEM learning and specifically IT before this project. The resources we purchased through the project have been fantastic and we have integrated them into teaching the curriculum"*** (teacher school 4)

The teachers felt that the most successful purchases were the ones that could be used multiple times and integrated into curricular and extra-curricular work. The five schools developed different purchasing strategies based on their strategic plans and the emphasis of the school. Two of the schools focused more on digital technologies and coding. The teachers initially would have liked more guidance on what to purchase, as they were new to delivering engineering, but over time grew in confidence and were able to expand their knowledge of what to order. Some teachers developed successful projects in school that were delivered year on year, such as the 'design and eco-city project' whereby each year group developed a different environmentally focused element that makes up a city (buildings, hospitals, transport, infrastructure etc.). Other teachers focused on purchasing technology that can support learning in class. The purchasing of the resources enabled three of the primary schools to develop bespoke STEM areas or classrooms that can support in-class and independent learning in the school (schools 1, 2 and 4)

The resources have also supported the running of STEM clubs in all primary schools. At the start of the project, only two of the schools ran science clubs and two schools ran kit car clubs. By year 5, all schools are running STEM or Engineering Clubs because of the WVEP funding and increased emphasis on the E in STEM in the schools.

The global pandemic affected the school's ability to run the STEM clubs and use the resources (especially during the years 2020 and 2021).

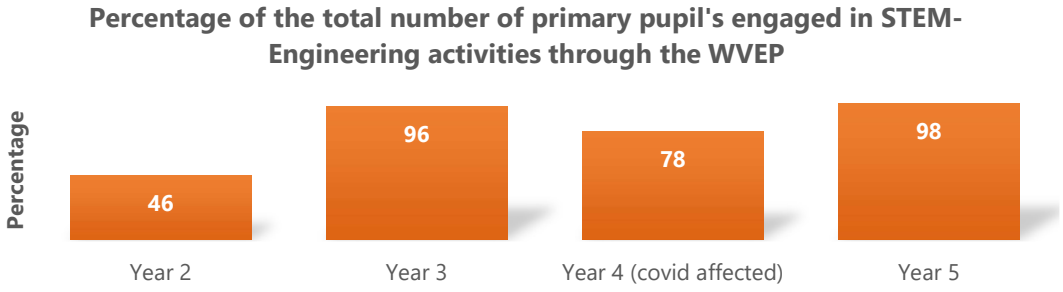
Pupils with their Green Powered Car

– designed and built by the year 6 with support from college students

The table below shows the increase in extra-curricular activity across the 5 primary schools,

School	Extracurricular clubs currently running at the start of the WVEP (baseline)	Extracurricular clubs currently running at the end of the WVEP (Year 5)
School 1	Kit Car Club	STEAM team and STEM after-school club
School 2	None	Digital leaders club and STEM clubs (Sept 2022)
School 3	Science Club & Kit car club	STEM Club
School 4	None	STEM club
School 5	Science Club	Future engineers and the young engineers' clubs & Coding Club

The primary schools evidenced increased levels of engagement throughout the WVEP project, by 2022, 98% of the primary school pupils in the five WVEP had engaged in engineering activities supported by the WVEP.

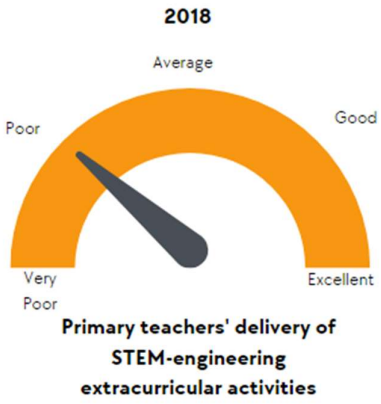


The WVEP primary school's coordinator teachers showed consistently increased ratings from the start of the project to the end of the project for:

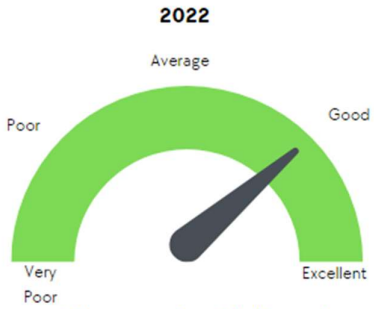
- the delivery of engineering extra-curricular activities,
- the number of STEM-Engineering resources available in school,
- Including more than 30 pupils in STEM-engineering activities

These are illustrated in the below charts,

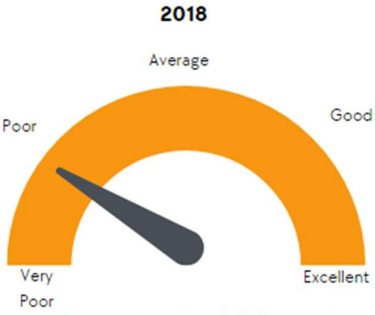
Primary Schools



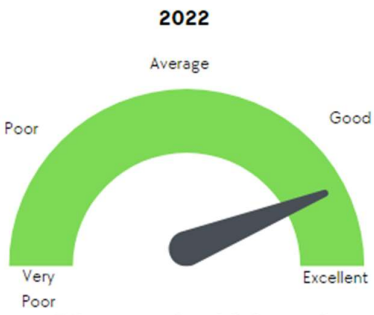
Primary teachers' delivery of STEM-engineering extracurricular activities



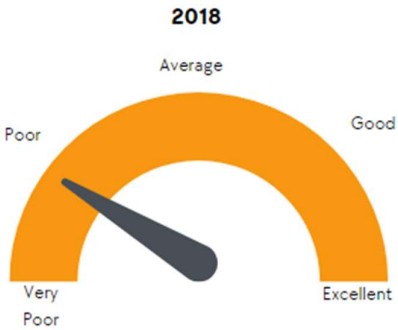
Primary teachers' delivery of STEM-engineering extracurricular activities



Primary teachers' delivery of STEM-engineering activities including 30+ pupils



Primary teachers' delivery of STEM-engineering activities including 30+ pupils



Primary school STEM-Engineering resources in school

Primary school STEM-Engineering resources in school

Secondary Schools

The secondary schools were able to access £3,250 per year to support STEM-Engineering enrichment resources, STEM club resources, Tomorrow's Engineers Week and British Science Week (the full list of resources is in Appendix B). Teachers felt that the funding was central to being able to enthuse the pupils and support STEM learning in the schools. The schools that retained the same coordinator teachers for the entirety of the project were able to develop purchasing strategies over the 5 years to best benefit the pupils' learning. Like the primary school teachers, the resources that were usable multiple times were felt to extend engineering opportunities across multiple groups of pupils. Teachers that focused on purchasing a bank of resources for one department (or room) were able to see the benefits more directly than those that chose to spread resources across the school for multiple projects.

The funding for resources allowed the teachers to focus on different aspects of engineering. Software, electrical and mechanical engineering was supported with the purchasing of LEGO Mindstorm, Drones, Dash Robots, Kitroniks, Graphics Pens and Coding kits. Bio-Engineering and Chemical Engineering with the purchasing of resources for bath bomb making project, molecular gastronomy project and Stop the Spread (global pandemic) project resources. Automotive and Eco Engineering was supported through the purchasing of Green Powered Kits Cars and Wind Turbine Kits and Civil engineering through LEGO and KNEX kits. One school purchased resources for a sound engineering project that could be run each year. Some schools purchased equipment central to supporting core traditional engineering skills, such as lathes, milling machines and laser cutters. These became core curricular components from year 7 onwards. ICT, coding, maths and design were supported through the purchasing of data loggers, CAD software, hardware and 3D printers. Over the 4 years, some of the larger resources have been used beyond the schools for transition projects and open days. One school (school H) has developed a lending scheme whereby feeder primary schools can borrow equipment (VR headsets have been especially popular). Some funding was used to support travel costs or a trip to engineering-related activities. All secondary schools received Smallpeice Trust engineering workshops annually (except during lockdown periods).

One teacher commented,

> ***"The resources have been a great asset for the school and have given the kids the opportunity to use equipment and experience new things and new ways of learning. The resources purchased have been used across the school and we have been able to use some of the equipment daily to support the curriculum as well as running one-off projects across the school that build enthusiasm. The VR headsets have been particularly well used. This year we have purchased a 3D state-of-the-art printer. We have planned a whole scheme of work around this tying in design and CAD training, problem-solving and building with the technology department."*** (Teacher, School C)

And another,

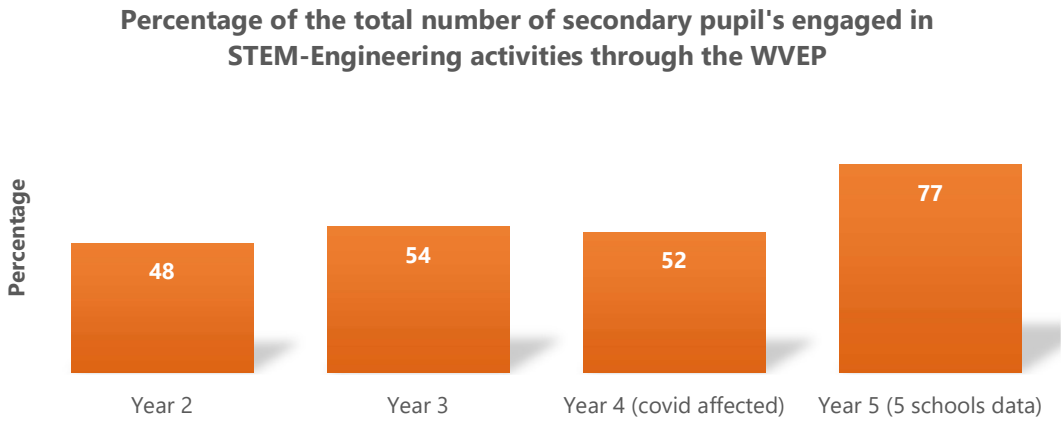
> ***"The resources have been phenomenal! The new resources are 3D printers and that has been attracting all the year 7 students into the engineering department rooms – they all want to have a go! So, we are going to build on that and hopefully attract them to take engineering. We are doing a 3D printing unit within the curriculum now. None of the resources that we have would have been possible without the funding from the WVEP"*** (Teacher, School E)

In year 1 of the project, all the secondary schools ran science, STEM or Formula One in Schools extracurricular clubs. By year 5, all participating WVEP secondary schools were running extracurricular STEM Clubs or Engineering clubs to support and enthuse STEM-focused students, many of these were better equipped and more popular with a more diverse range of students than previously. The STEM clubs for the participating schools are shown in the table below.

School	Extracurricular clubs currently running at the start of the WVEP (baseline)	Extracurricular clubs currently running at the end of the WVEP (Year 5)
School A	Science Club*	STEM Club – Raeng kits
School B	F1 (Formula 1 Club)	STEM club
School C	Science Club and F1 Club	STEM Club, Science Club, STEM Ambassadors & F1 Club
School D	None	Withdrew year 4
School E	STEM & Science Club and F1 Club	Future Engineers Lunchtime Club, Science & IT club, F1 Club
School F	STEM & Engineering Clubs*	STEM & Engineering Clubs (30+)
School G	Science Club & F1 Club	STEM Club (incl. solar club), Eco Club (using engineering to work with Morgan Sindel)
School H	F1 Club	STEM Lunchtime Club, IT & Radio Club (in development), F1 Club

*Run when staff are available to support only

The secondary schools evidenced steady and increased engagement of pupils across all year groups as the project progressed (there was only a slight dip during the covid year). By 2022, 77% of the pupils in five of the secondary schools had engaged in one or more STEM-engineering activities as part of the WVEP (this figure is drawn from 5 schools that supplied data, true figures in year 5 may fluctuate when all data is collected but is estimated to be over 65%). Three secondary schools engaged between 94%-100% of the pupils in one or more engineering activities in year 5.

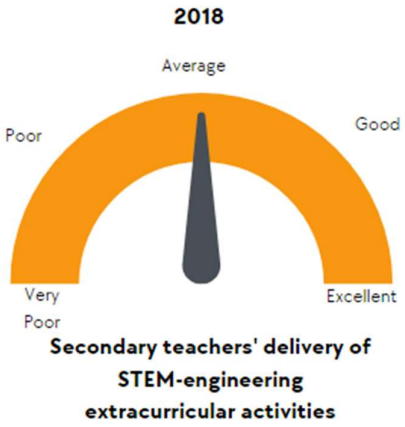


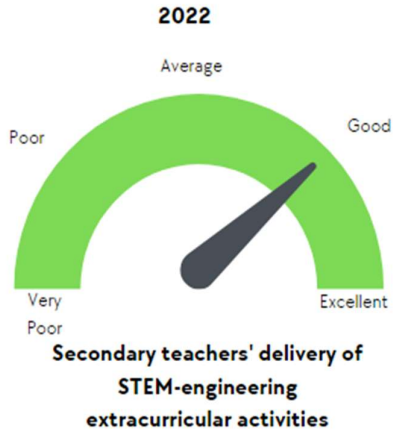
The teachers would have appreciated more sharing opportunities to find out what other schools had purchased and how they had used the resources in different projects, this would have helped guide purchasing especially in the early years of the project. Some purchases had been made that were not fit for purpose for working in larger groups or were defective (school F had purchased hovercraft kits that were not easily usable by the pupils) others had purchased significant resources that needed additional funding for training, software or supporting materials that had to be found within the school budget (i.e., 3D printers, VR headsets). The timing of the funding for the resources purchased to be available for key diary dates (such as Tomorrow's Engineers Week and British Science Week) was also an issue for many of the schools, who would have liked funding released the term before so that purchased could be made for the new term.

The increase in the number of resources and their use in school can be evidenced by comparing the teachers' pre- (taken in 2018) and post-survey results (2022) as shown below,

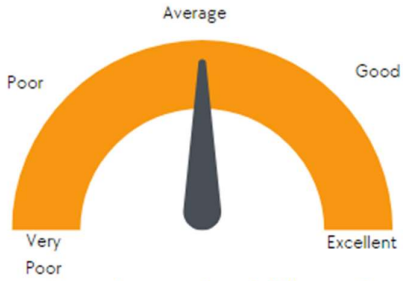
Secondary Schools

The results of the secondary teacher pre- and post- survey show increased ratings on indicators (using the average)





2018

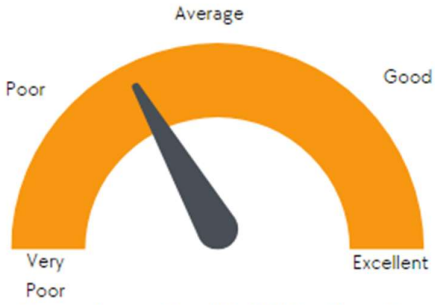


Secondary teachers' delivery of STEM-engineering activities including 30+ pupils

2022

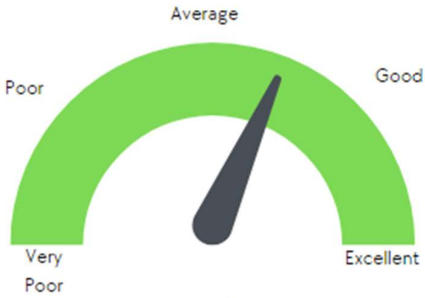
Secondary teachers' delivery of STEM-engineering activities including 30+ pupils

2018



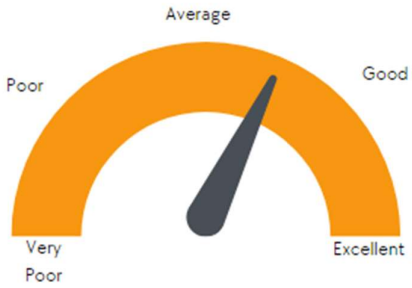
Secondary school STEM-Engineering resources in school

2022



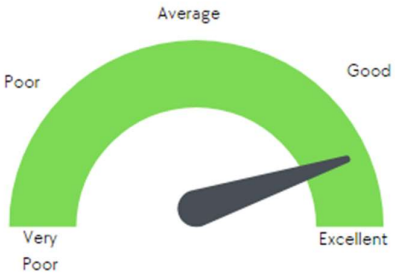
Secondary school STEM-Engineering resources in school

2018



Secondary school embedding STEM-Engineering activities into the curriculum

2022



Secondary school embedding STEM-Engineering activities into the curriculum

Pupils using STEM club resources

Developing long-standing school networks and local industry collaboration that coordinates and delivers engineering-enriched STEM

Through the WVEP project's Employer Engagement Strand, the primary and secondary schools were introduced to STEM industries located within a 30-mile radius of the project area able to enable them to develop and grow connections with local, national, and global engineering companies. Each WVEP school was partnered with a STEM company to together over one term design and develop an engineering challenge that could be delivered to the partner school. In this way, the engineering challenges that were developed reflected the needs of the pupils and linked with the curriculum, in particular the new guidance on careers and work-related experiences. This model is central to the new Welsh Curriculum that posits close alignment with 'real' situations and that can be taught across the subjects in themed projects.

In its first year, the Employer Engagement Strand developed and delivered,

- **5 secondary school Engineering Challenges that were co-designed by the WVEP coordinator teachers and industry (Thales/NDEC, Zimmer Biomet, Tata Steel and Nexperia)**
- **20 Primary Engineering Challenges were delivered across the five primary schools. one-off sessions to eight-week projects**
- **8 secondary school Engineering Challenges that were co-designed by the WVEP coordinator teachers and industry (Panasonic, Nexperia, Safran Seats, Continental Teves, Concrete Canvas and General Dynamics)**
- **21 Secondary Engineering Challenges were delivered across all eight secondary schools – the Challenges ranged from one-off sessions to eight-week projects.**

The Engineering Challenges included Civil Engineering, Software & Computer Engineering, Biomedical Engineering, Industrial Engineering, Aeronautical Engineering, Automotive Engineering, and Electrical and Mechanical Engineering. The Employer Engagement Strand Engaged,

Primary Schools

The teachers reported that working with the industries to develop the challenge gave them the confidence and ownership over the challenge to lead in the dissemination of the Engineering challenges across their school cluster group. The coordinator's primary teachers reported working with the WVEP partner engineering companies that they had been introduced to through the Employer Engagement Strand on spin-off projects or visits. Or they had built confidence through being part of the project to approach engineering companies that work locally to engage with pupils at the school (these industries have been approached to design Challenges for the Employer Engagement Strand). The close working with WVEP industry partners provided a greater sense of confidence and the networks to establish longer-term links that are sustainable and meaningful.

Although many of the schools had had contact with industries and hosted STEM ambassadors before in school, much of this contact was in the form of a one-off session rather than a longer engagement and, crucially, the content had not been developed in partnership with teachers and in-line with pupil need. One teacher commented,

> ***"The Employer Engagement Strand has responded directly to something we wanted more of in the school – connection to industry and 'real' working people to show the children a range of different options that are open to them and broaden their horizons to jobs other than the ones that are more visible in their day-to-day lives"*** (teacher, school 2)

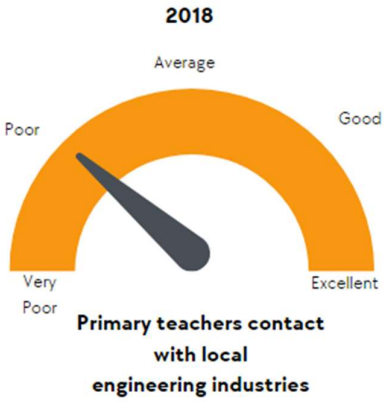
And another,

> ***"The impact of the Employer Engagement Strand has been incredible. It has been particularly monumental because it connects the pupils to people from real life who are coming into our schools to share their knowledge"*** (teacher, school 5)

The longer engagement has also enabled the teachers to develop strong relationships with some of the industries that have led to further projects, trips, or experiences. The coordinator

from school 1 was invited to speak in front of the First Minister for Wales about his work with NDEC. NDEC has supported their project 'around the world in 80 days' by digitally connecting the pupils to engineers across the globe and school 4's project around creating an App for the school.

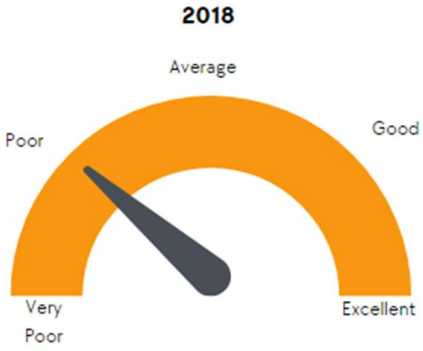
The primary school teachers rated their contact with industry at the start of the project and at the end of the project, increased ratings are seen across four of the five schools,



The networking between schools was felt to have been strengthened by the WVEP project but sharing practice and extending the networks to fully extend to secondary and college levels was still thought to need further development. The baseline interviews showed that previously the primary schools had varying degrees of contact and collaboration between the schools but little to none that focused specifically on engineering. The main contact that the primary schools had was during transition time with the feeder secondary schools or for the moderation of schemes of work and workbooks. The teachers felt that WVEP had started to establish connections between the primary schools through the Employer Engagement Strand and that the face-to-face coordinator meetings were a good starting point to develop stronger links and share practice with the colleges and secondary schools. However, it was felt that the outbreak of COVID and the moving of the meetings online had hampered these connections somewhat. The teachers said that the sharing of practice with primary schools had increased through the project, but that it had not significantly improved with the secondary schools although the networking opportunities had significantly improved.

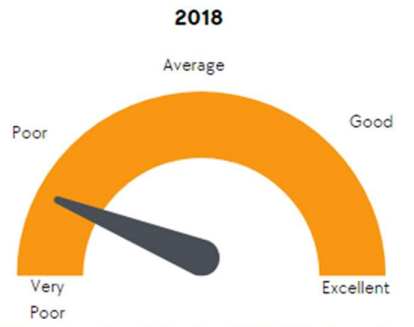
The charts below illustrate this,

Primary Schools

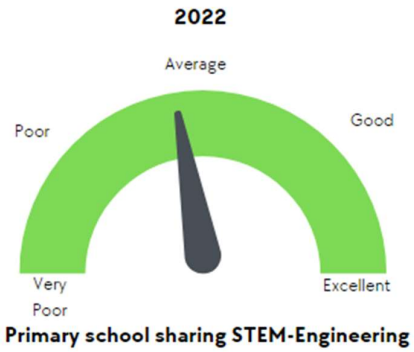


Primary school STEM-Engineering practice between primary schools

Primary school STEM-Engineering practice between primary schools



Primary school sharing STEM-Engineering practice between secondary schools

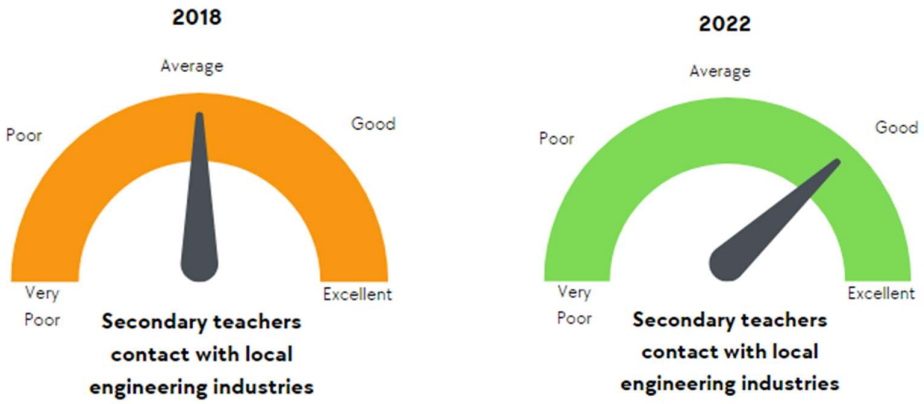


Primary school sharing STEM-Engineering practice between secondary schools

Primary school children embracing engineering activities

Secondary Schools

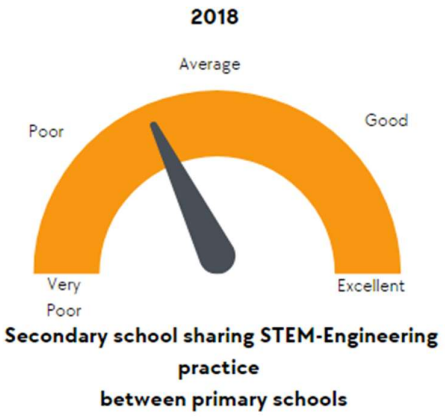
The secondary school teachers valued connecting to industry to promote and embed engineering into the schools. The Challenges were developed collaboratively with the teachers and industry to ensure a good fit between curricular expectation, enjoyment, and connection with real industry work. The teachers were confident that the Challenges they co-developed were interesting and able to cover a broad range of practical and academic skills and highlighted the different pathways into Engineering. Through the WVEP, the relationship between some of the schools and the industries have developed into extension projects or trips (school H, school B and school F). The teacher pre- and post- survey evidenced that rating for school connection with industry had gone from average (in 2018) to 'good' in 2022 as illustrated below,

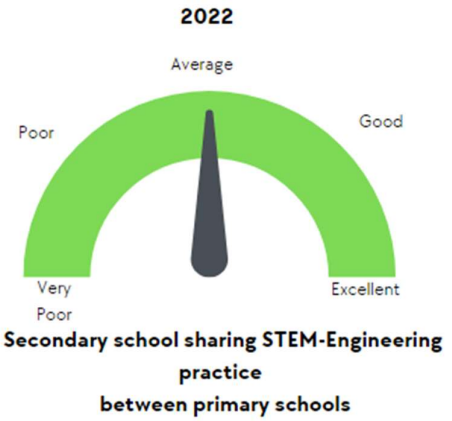


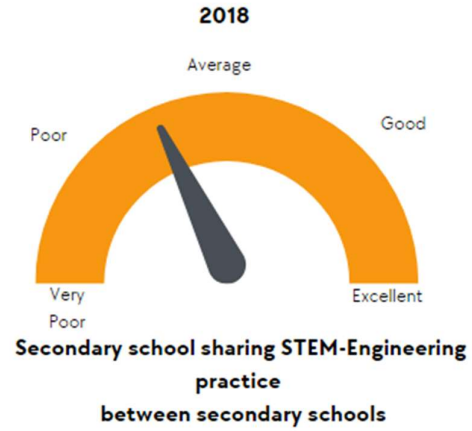
Although the challenges largely worked in the schools in which they were developed, once the challenges were run in other schools, there were some issues; all secondary school teachers felt that further planning, development, and adaptations were needed for the Employer Engagement Strand to be manageable and fully impactful in the schools. Lessons learnt and ideas to restructure were presented by some of the teachers and are presented in the recommendations section of this report (below). The teachers felt that the pupils responded positively to the Challenges and were enthused by working with 'real' Industries[6].

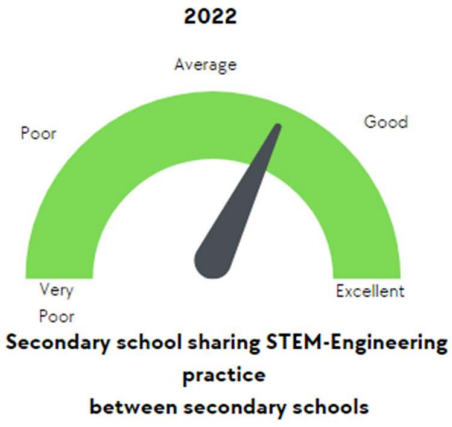
The secondary school teachers felt that pre-Covid there was a much stronger drive to network and share practice between schools and the colleges. Some of the new coordinator teachers who joined during lockdown had not had the opportunity to meet in person with the other coordinators and this had hampered the progress of developing shared practice. However, there was evidence of teachers supporting each other and exchanging information and advice around the Employer Engagement Strand specifically. One teacher helped install 3D printers for another school. The results from the secondary school teachers' pre- and post-surveys show overall increases from 2018-2022 (using average scores),

[6] A separate Employer Engagement Strand Report will document teacher and pupils feedback









Pupils showcasing the 3D printers

The following case studies from five participating schools further illustrate the impact of the WVEP,

Case Study – School 2

The WVEP project has helped us to make massive strides in raising the profile of engineering in our school. We have run STEM clubs using the resources that we purchased, and this has seen an increase in the number of girls joining the groups. The resources have enabled the children to experience hands-on learning that we would not have been able to have done before. The connection with local Industry through the Employer Engagement Strand has helped raised the profile of engineering even more! We have purchased resources that will benefit the children in terms of STEM projects and engineering for years to come. Our 3D printers, the tools and the Green Goblin, The LEGO kits, and the Drones – and this is all going to be important for us in keeping the legacy of the WVEP ongoing.

The impact has been really high – when we talk to the children about engineering, they know that it is not just fixing cars – they are more aware of the other types of engineers, like chemical engineers or software engineers and not only that, but that can now link these things to different companies who are doing these things locally. This is so important as they are more aware of the opportunities available both locally and elsewhere. Teacher confidence has grown as I now have two or three teachers who are taking on the industry projects in the school so that it is not just focused on me as the coordinator. They are more confident in delivering engineering projects and STEM, there has been a shift from talking just about science to talking about the other elements of STEM. Our resources in the school before were old and antiquated. The WVEP has gone a long way to changing that – now in the school we have 3D printers, codable drones, codable LEGO, VR headsets and Stix machines and loads of tools that we can use each year. We did a lovely project with the Green Goblin Car kit where we linked it to sport and formula one racing, aerodynamics and then linking that to the aircraft industry – so we did a design element to that and also the mechanical engineering side. The RAEng boxes have helped to reinforce this learning too. We also looked at chemical engineering, through an external coming in. We have been able to equip a whole free-choice STEM learning zone that will be used by pupils and parents into the future.

The project has helped to build our relationship with local companies. We have done two digital engineering projects and now we are working with TATA to look at materials, engineering, and the environment. So, this experience has shown the children so many of the different engineering pathways that they wouldn't have had access to before this project. The Employer Engagement Strand has responded directly to something we wanted more of in the school – connection to industry and 'real' working people to show the children a range of different options that are open to them and broaden their horizons to jobs other than the ones that are more visible in their day-to-day lives. It is vitally important that this is coordinated so that those links are made for us and then the school can draw upon them because we don't have the time to make those links in our current roles.

If I didn't have this project in our school, it would be something that I would be envious of. It is a great project. We have been very lucky to be involved in this project and it would be fantastic if every school could be involved in it -and if that happened, I think the impact would be huge. We are now putting forward a curriculum where our students benefit from engineering activities and know that there is a career path to engineering.

Case Study – School 1

"I think that the Welsh Valleys Engineering Project (with the Employer Engagement Strand) is one of the best things that I have seen done in the school. It is the consistency, even during the COVID years, through the provision of resources, the training and support from the Royal Academy of Engineers and the connection with the industries that have made the difference. It has allowed me, as STEM lead, to develop and embed science and engineering through KS2. A lot of the engineering ideas that we have used in school we have learnt through the contact with the industries. We have now incorporated this into the Digital Learning Framework and IT based-learning, I also do an assembly every Monday that focuses on E-safety and this area is really important to us as a school. The project is also developing our contact with other primary schools as we are a lead network school for the Employer Engagement Strand.

The confidence of the teachers to talk and teach about different types of engineering activities has also grown. The online Hwb has allowed us to create a playlist for STEM-Engineering resources that the teachers can draw from. This helps to develop the staff's skills to deliver STEM-engineering.

The relationship we have developed through the working with NDEC has been amazing for us and they are now supporting other projects in the school. The connection with Nexperia and TATA steel has really extended the children's understanding of engineering and helped to develop their thinking, planning and projection skills across different year groups. The children created their own project books which meant that they had ownership over the project and were able to explain the work they had done. We linked each project with the current topic and with what the children were interested in. The current project with Zimmer Biomet Biomedical Engineering links with our circus theme where an acrobat has lost a leg and a replacement needs to be designed!

Because of the consistency of the WVEP project, we have been able to build the school's resources over the years and we have developed a STEM/STEAM room for hands-on investigation. We have been able to use this room for other external projects, for example with Cardiff University. We also use this room for the STEAM team and STEM after-school club. Our club has 50/50 boys and girls. We have also used the resources to engage the parents for our 'come and do' STEM sessions. The focus on engineering was reinforced throughout the school this year when our AoLE governor came in for a whole engineering day. Pupils were challenged to build bridges, and, in the afternoon, they took part in a formula one challenge (supported by the EESW). The resources we have been able to purchase over the years have been useful not only in helping us to develop the STEM room, but also to enable staff to develop new ideas and projects and be able to run with the ideas using the resources now available.

The project has been a massive success for our school and the resources have enabled us to put engineering at the forefront of STEM in our school

Case study – school 4

I think that the WVEP has definitely raised the profile of engineering in the school, I think before it was an abstract concept for most of the pupils but meeting real people from local industry and taking part in some of the projects that we have been able to run in the school due to the resources we have purchased has highlighted the varied roles of engineering. We have also been able to link the work we are doing with the WVEP with other opportunities that the school has had too like the software and coding app-building project we did. This has culminated in a real app that is tangible for the pupils.

We have totally embraced engineering in the school now – we even have a new classroom being built where we are going to house a STEM room. Because of the resources that we purchased through the WVEP we have managed to get enough equipment together to support this new learning zone for the children. This will support STEM learning during class time and allow the children independent learning time too. The next step is to get the parents involved and let them know what is going on in the school.

We didn't have many resources to support STEM learning and specifically IT before this project. The resources we purchased through the project have been fantastic and we have integrated them into teaching the curriculum. We focused mainly on coding. We have planned our purchases throughout the school, focusing on coding and developing more complex resources as you go up the years, from the code bugs for the early years to the Speros for the years 3 and 4 and now the codable drones and 3D printer for the upper years, this year we are focusing on the youngest children and have purchased the Osmo kits to support that. Once we have those up and running, we will be able to support coding all the way up the school. The children have really enjoyed using these resources. The confidence of the teachers to use these resources has also grown and I have run workshops to share my knowledge so that more teachers can use and access these resources. The new curriculum will embrace the use of technology even more and we feel that we are ready for that.

The projects that we are running in school with the industries has broadened our children's awareness of the different types of careers out there. Whereas we normally hear that they want to be a teacher, doctor, or fireman they are now saying that they want to work in app or games design. Industry coming in from outside of the school has really helped raise our pupils' aspirations. The connections we have made through the Employer Engagement Strand have been brilliant and really exciting for the pupils. Now we are the lead for our cluster the communication with other schools has grown and I have had input from the other WVEP schools who have already undertaken projects, that hasn't happened before.

The WVEP has made STEM-Engineering a priority in the school, and the resources we now have in school would not have been possible without input from the project. It has enabled us to focus on engineering and we are keen to enhance this in the future.

School B

"Having the employers involved has definitely helped to raise the profile of engineering and given us lots of ideas about how to involve the school more with what is happening locally. That has been a big jump for the school and helped us to make links that we can extend beyond the reach of the project. Due to the work with the WVEP I have been appointed STEM coordinator with alleviated time and that role didn't exist before in the school – so that has progressed us further so that we can do more STEM-engineering engagement in the school to enthuse the pupils

The way that I have approached the WVEP project is that it is something that needs to have a legacy and that it is not just a one-off thing so this means that we can continue to build engineering projects into the curriculum. The resources and the industry projects that we have been able to run in school have supported this journey. We have been able to spread the resources across the school in the IT department, the Design and Technology Department and here in the science department.

The resources have helped to broaden the pupils' horizons and provided us with construction, IT and coding equipment that is used in the school regularly. The first few years we also supported some trips that took the pupils out of school and inspired them. This year we have focused on building up our LEGO kits for the STEM club and curricular work. We were really lacking science kits in school, so we can use these again and again across the year groups. The raspberry Pi's and graphics kits are used in IT. Our year 7 class are looking at robotics in space and we are using the LEGO Mindstorms kits in our new space scheme of learning. None of these would have been purchased without the WVEP. The students all love the engineering activities that we are doing and they highlight to the student that engineering is an option. We have so many engineering companies in the local area that they could potentially work for, this project is helping to support them early and get them enthused

We don't currently offer an engineering option in the school, but the WVEP has helped us to raise the profile and demand for engineering in the school has gone up, so we are now exploring how we could integrate Engineering BTEC or GCSE in the future at the school. The WVEP has really helped us to embed engineering across the whole school we now celebrate Tomorrow's Engineers Week' and have enhanced what we do for British Science Week. The WVEP funding enabled up to purchase resources that can get every class involved. Last year we did a hydroponic plant growing project and then a design project using playing cards. They were really simple ideas, but the pupils were totally engaged and talking about it for ages afterwards. The head teacher was delighted that everyone was getting involved in the same project and he wants more of that in the future and has developed the STEM coordinator role for this. Our STEM club is really popular due to the range of resources we can now offer

Panasonic Future Engineers Awards (PTFEA) scheme provides an added incentive for our students to go on and study engineering or STEM subjects at college.

We would like to establish a working partnership beyond the WVEP with the schools and colleges that would be a really good legacy for the project. We could continue to share knowledge and ideas across the two counties.

School H

The project has gone from strength to strength, I would say that raising the profile of engineering has been well achieved really because when we started five years ago there was very little opportunity for people regards to engineering. So, exposure to it through the funding and the innovative resources being available and through the business partnerships and Smallpeice trust has been transformative. COVID obviously affected it in the middle, but we've got back to it now.

I think the project has helped raise the profile of engineering for the pupils and the teachers because lots of the teachers have now been involved in delivering the project through the Employer Engagement Strand. Many of the Employer Engagement Strand activities were delivered across the departments. The Panasonic Weather Stations project involved the maths, ICT and Design and Technology Departments and that is the model for the new Welsh Curriculum going forwards. I have enjoyed the business partnerships; I think they added an extra element which wasn't there when we have initially started the project. It's been very enriching for the pupils to be involved with the businesses as well.

The project has also strengthened the links with the local college and that relationship has benefited everyone. The PTFEA awards have really helped this our year 11 pupils who are going on to college to focus their ideas down and really consider engineering as an option. I know that some of the PTFEAs from our school who were awarded in year one and two of the project have gone onto university to study engineering now. it has been a real incentive for some of our students to get involved in engineering. We have also had some of the current PTFEAs coming into school to support the Employer Engagement Strand and this has been critical in inspiring the students using people that they can relate to. Number of year 11 students applying for the PTFEA has been increasing each year.

Having industry involved has also helped to highlight apprenticeship routes into engineering we have also notice that lower down the school the project has really helped to challenge the perceptions that engineering is about engines and cars. The resources have also helped to challenge this idea. The Lego is being used all the time one of the teachers runs a Lego club and it is part of a national competition, so they get broken down and reused every year. the VR headsets are currently in one of our feeder primary schools and they're being used we lend them out for a term at a time for transition projects, but they have also been used in the science department too. The welders are being used in the DT department and the KNEX kits are on their second or third time round now our six-foot Ferris wheel is something we use again and again in the stem club and for display. The drones are now part of the IT scheme of work for year 8 and year 9 and the 3D printers are utilised daily in the DT department.

The WVEP has really embedded engineering across our whole school.

Colleges

The WVEP worked with the two colleges throughout the five-year project. The model of the WVEP was to strengthen the links between primary schools, secondary schools, and colleges to encourage a natural progression of students into Engineering-related higher-level qualifications to college level.

The two participating colleges provide the destination point for further education (post-16) for all the participating secondary schools in the WVEP. The colleges run a suite of engineering opportunities as well as the traditional STEM A-level route into engineering. Both colleges are well resourced in core engineering workshop equipment, but at baseline, lack portable engineering activities that could be used on open days and transition days to engage and enthuse students. College 1 had not successfully engaged in transition projects at baseline and was keen to establish these links with their feeder secondary schools. College 2 had been more successful in engaging secondary schools but had had more limited contact with primary schools. College coordinator 2 felt that engaging and embedding engineering at primary level was essential to not only build the foundations of understanding but to build trust in the college with children and parents early on.

The colleges were successful in supporting the Panasonic Trust Future Engineers Awards throughout the project, with 82 bursary grants being awarded from 2018-2021 (48 by college 2 and 34 by college 1)[7]. 30% of the awards were granted to female pupils (the national figure for women engineers in the UK is currently 11%). The PTFEA evaluation evidenced the following,

The WVEP project helped both colleges to network more effectively with their feeder primary and secondary schools, especially during the first years of the project, before the pandemic. This connection was valued by both the colleges and the primary teachers. The primary and secondary teachers felt that this connection was crucial to providing a clear link for the pupils to engineering qualifications. Additionally, having access to the PTFEA students to support the Employer Engagement Scheme provided relatable role models. College 2 was able to establish clear pathways for PTFEA students to engage with the delivery of the Employer Engagement Scheme in primary and secondary schools, with around half of the PTFEA students engaging in one or more activities in year 5. College 1 was less able to develop this pathway due to workload, timetabling and transport issues for the students.

Both colleges are in the process of expanding their engineering facilities with independent state-of-the-art buildings focusing on engineering in development to house future

[7] 20 bursaries are available in 2022, 14 have been award to date (11 by college 2 and 3 by college 1)

engineering and eco-engineering facilities. College 1 has been awarded £8.5m to develop an Advanced Engineering Facility called the Hive (Estates Developments - Coleg Gwent) and College 2 is pursuing funding for a state-of-the-art facility that focuses on renewables and environmentally focused engineering.

College 2 had seen an upsurge in students studying engineering and engineering-related subjects and now offers more courses connected to engineering. (Appendix D shows 5-year uptake data for college 2, college 1 did not supply their data). The college coordinator felt that the WVEP had played a crucial role in increasing this interest which in turn enables the college to evidence the need for further funding for development and the ability to run more engineering-focused courses in years 1 and 2. College 1 had a decline in students signing up for direct engineering BTECs in year 5 following COVID, although had not seen this decline in the other years. The reasons are unclear for this change in 2022, but there has been a national trend in students selecting more traditional A-Level routes following COVID. College 1 also was unable to connect to feeder schools to promote engineering early enough in the year (although they had run a successful open day later in the year). In all previous years, an increased number of engineering students in college 1 had been evidenced, as illustrated by this quote from 2021,

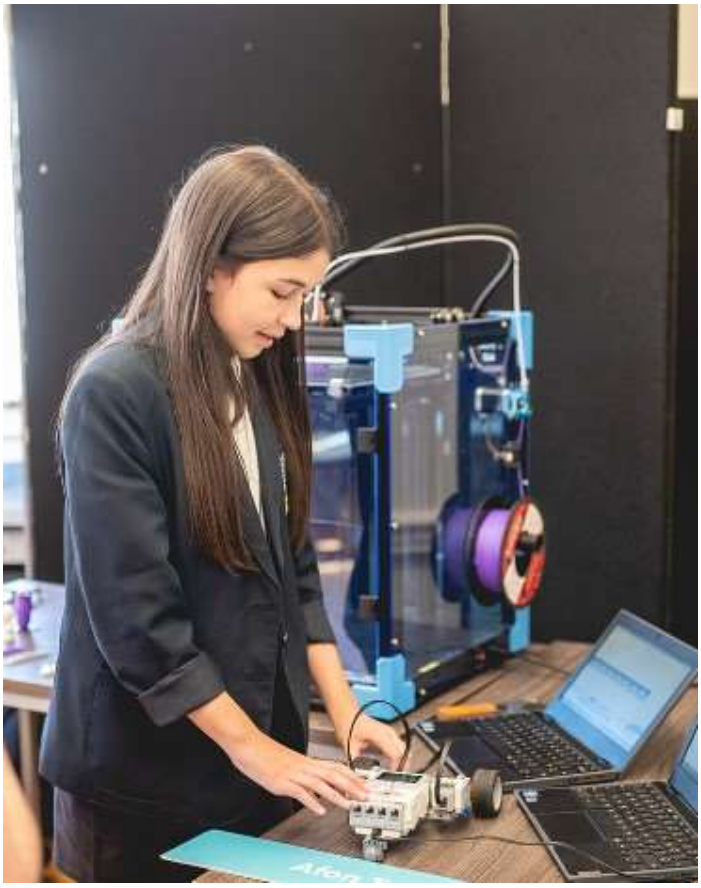
> *"The project has increased motivation for all students involved in all phases of education. The PTFEA finance has assisted students to achieve potential that would not have been previously possible. Most of the learners say they owe their success this year to the funding. The funding has also been a good advertisement to year 11s showing the value placed on studying an engineering pathway. The grant funding has had a direct impact on interest and uptake in STEM, particularly engineering. From the new projects to the potential of being awarded a PTFEA grant, there has been a surge in our numbers coming from feeder schools and transferring from other subject areas. We have also seen an increase of roughly 70 applications for the next academic year with an increase in female representation from 10% to 15%. No other department has shown this growth. We attribute this growth mostly to WVEP-related activities and projects"* (WVEP Coordinator, College 1, Year 4 of WVEP)

Both colleges felt that the resources that had been purchased from the WVEP funding enabled them to ring-fence and direct resources specifically for transition projects, open-days and engineering projects that could be undertaken in college and then showcased across the feeder schools adding value for both current and future students.

> *"The WVEP has provided us with a brilliant vehicle to advertise the college and its engineering opportunities to primary and secondary schools and has helped to network students with industries. These networks are now starting to develop into tangible opportunities for our students in terms of internships, trips, and placements. We saw an upsurge in students wanting to take engineering and this has helped in the plans to develop a new advanced manufacturing and engineering*

facility that will focus on renewable and environmentally focused engineering (hydro electrics, hybrid vehicles and solar) – the WVEP has played a massive role in this by helping to promote engineering and get students hooked in and enrol on engineering courses. When the college first opened in 2015, we had two engineering courses, we now have three first-year courses and four second-year courses in engineering alone (the extended diploma, diploma and A Level route for second years and first years we have an enhanced route, the award and the certificate.). We are now looking at introducing A-level product design and construction with archaeology. So, with the help and support of the WVEP, our engineering possibilities are growing year on year" (WVEP coordinator, College 2, Year 5 of WVEP)

The WVEP Coordinators in both colleges offered recommendations and ideas for future projects which are presented below.



Demonstration of coding and design skills

Improvements & Key Learning

Key learnings from the project were principally connected to logistics and workload following on from the launch of the Employer Engagement Strand in 2021, this was more pertinent in the secondary school than the primary schools which were more able to incorporate challenges into the curriculum with relative ease.

The workload was exacerbated by Covid, which had already increased the teachers' workloads. The secondary teachers could see the benefit of working more closely with industry to deliver cross-curricular projects that are in line with the new Welsh Curriculum, however, all secondary teachers felt that the timeframe of an 8-week delivery was not achievable and, in some cases, prevented teachers from teaching key curricular content.

Although the teachers were able to adapt the project to suit their schools, the expectation of a longer project was felt, and initial clarity and guidance were required to ensure that teachers were confident and able to adapt the challenges to suit their schools. Adaptation took time and presented teachers with additional work. Differences in staffing, equipment, and timetabling in each school, meant that although the projects had been developed with one school, transference to another school was not always straightforward. A lack of lesson plans for each challenge session resulted in additional preparation.

Nearly all the teachers felt that a one-day challenge (or a maximum of 3 days) was preferable and more achievable in school at present. Development of longer projects, that fit with the Welsh Curriculum objectives, could develop once initial relationships with industries are established. The organisation of the Employer Engagement Strand was more manageable for the teachers who had been allocated time to manage this project. Many of the teachers shortened their projects to one or two-day drop-down days with industry rather than the proposed 8-week project. One teacher commented that she would have liked more representation from female engineers in the industries that were part of the Challenges. The importance of working to engage under-represented groups in engineering is central to the project. The WVEP Project Coordinator highlighted to STEM industry partners and other stakeholders the need to work with these groups and the encouragement of female students to apply for the PTFEA, with 30% of the awards being given to future female engineers.

The resources purchased were well received overall, but teachers would have liked more structured guidance and advice early in the project to help formulate ideas that work well in school (this could be in the form of websites, videos, a reference library, or reports from similar projects). Some of the purchased resources required an extra input of money from the schools for software, hardware or training, and this was an unexpected cost that the schools had to cover.

The PTFEA was felt to be a successful scheme. However, the teachers would have welcomed an information pack and more support from the colleges at an earlier date to fully integrate and establish the scheme with the pupils before they made their final decision on post-16 education.

Conclusions

The WVEP has been successful in promoting engineering in all participating schools and connecting schools meaningfully and sustainably to engineering industries. The year 6 and year 8 pupils have evidenced significant increases in both their understanding of engineering but also in their aptitude to pursue engineering careers as a direct result of the integration of engineering activities into the schools. Participating primary schools had been able to focus resources on developing designated STEM-engineering hubs in school and three of the secondary schools have trailed a BTEC Engineering qualification for the first time (for at least one of the years of the project).

The project has been particularly effective across the primary schools, not only in improving the knowledge and understanding of the pupils from the Foundation Phase up to year 6 but also in upskilling the teachers and improving their confidence and motivation to deliver engineering activities. This has been evidenced by the universal uptake of the teachers to deliver Employer Engagement Strand activities and also by the independent actions of many of the teachers to extend activities with the WVEP partner industries. The teachers were also enthused and upskilled by the process of co-producing, designing and delivering Engineering Challenges with industry in school. The project has seen significant progress where schools purchased long-term engineering resources that could be used year-on-year or where the resources spear-headed the formation of new STEM classrooms or learning zones in school. The coordinator teachers have all encouraged engineering to be delivered across the school in all years, including in Foundation Phase. 96% of the pupils had experienced one or more engineering activities in the last year of the project.

Progress at secondary school level was evidenced by the pupils showing more awareness and aptitude for engineering and also increases in student exposure to engineering in year 8. There were significant increases in the pupil's exposure to teacher-led engineering activities. These increases evidence a school-wide promotion of engineering, with approximately 70% of the pupil body undertaking one or more engineering activities by year 5 of the project. Covid significantly affected the teacher's delivery of practical engineering activities, especially during the lockdowns, and also slightly impacted the flow of information between schools in years 4 and 5 of the project. However, all schools shared information and offered support to the other schools to support the Employer Engagement Strand.

The PTFEA scheme, which supports pupils who are pursuing engineering-related subjects at college level, was successful in awarding 82 bursary grants over the life of the project (2018-2021). This scheme was found to be a good incentive and a good way to highlight engineering opportunities to the year 11 pupils and boost opportunities and confidence. 30% of the awards went to female students. The existence of the scheme meant that conversations about the range of engineering opportunities available had helped the pupils to recognise their options early on. The scheme worked differently in the two participating colleges, with college 2 being able to facilitate PTFEA students to support the Employer Engagement Scheme in primary and secondary schools as engineering ambassadors. College 1 was unable to establish this in year 4 and 5 but were able to encourage PTFEA students

(before Covid) to act as engineering ambassadors at open days, career days and transition projects.

The PTFEA evaluation showed the bursary had improved confidence, broadened their understanding of engineering opportunities, provided structure to act as engineering ambassadors and provided financial support for their studies (including for books, technology, equipment, transport, and savings for university).

In college 2 there has been a consistent increase in applications to engineering and engineering-related subjects at college level, this increase was not as evident in college 1.

The Royal Academy of Engineering has been successful in securing follow-on funding through the Tech Valleys Project (Welsh Government) to extend the WVEP, with a focus on the Employer Engagement Strand to all 54 primary schools in both counties. This will extend the project to all primary schools, all special schools and the pupils' referral units in Merthyr Tydfil and Blaenau Gwent and continue delivery in all secondary schools.

Recommendations

Resources & Project Delivery

1) Primary and secondary school teachers need to be given more advice and guidance (including successful engineering projects run in other RAEng areas) to help guide them in purchases early on in the project. Video resources of projects would be additionally valued.
2) Teachers would benefit from help and advice from Engineering experts (especially at college level and the RAEng) to strategically plan the purchasing of engineering resources that are sustainable and can be used over several years. This maximises benefit. Specific advice for engineering in Foundation Phase would also be valued.
3) Money for resources needs to be released earlier so that the resources arrive in time for key events like British Science Week and Tomorrow's Engineers Week. A year's advance would be useful for schools to be able to fully plan and deliver proposed projects in time.
4) Some purchases required additional funding that had to be found in school budgets to enable them to run. Clearer guidance or a directory of resources would help teachers fully understand the total costs
5) Consider developing branded resources to support the project – these could be distributed to industry and schools (posters, stickers, badges, postcards etc.) and a starter pack for teachers.

Networks and Staff

1) Training in the different aspects and opportunities of engineering needs to be addressed at the start of the project in each participating primary school to ensure all the teachers can talk and deliver engineering activities with confidence (inset day training)
2) Secondary schools need to allocate time for the coordinator teacher to deliver the project fully so that schools don't drop out due to workloads (drop out breaks the chain between feeder primary schools and colleges) – SMT needs to be involved.
3) The college coordinator also needs admin support allocated to ensure maximum impact for the project
4) Develop stronger links between primary and secondary schools (and both colleges) to share practice and deliver collaborative projects

Employer Engagement Strand

1) Lesson plans need to be provided for each session so that any teacher can follow and deliver the longer projects (for primary and secondary schools) – the scheme of work provided was a helpful guide only.
2) Secondary school teachers need time allocated to deliver and coordinate the Employer Engagement Strand
3) In Secondary schools, the Employer Engagement Strand Challenges need to be one session or a maximum of three sessions initially (with one drop-down day being preferable by most of the teachers)
4) Summer term delivery needs to be at the very beginning of the term away from exam time.
5) Employers could benefit from being offered additional training and development opportunities to ensure their workshops are pitched and delivered to the highest levels.
6) Clear instructions and a longer run-in for projects that involve hi-tech equipment that might need additional support outside of the school are needed.
7) Ensure that the industries can commit to the projects proposed longer-term and that if they cannot, then schools are made aware and can adapt earlier on – last-minute changes are difficult.
8) A website that lists further information on the industries and challenges (including extension activities and which departments each challenge would suit best would be useful)

PTFEA

1) Implemented and advertised by the colleges much earlier in the year to ensure that pupils are aware of engineering opportunities (existing PTFEAs to support this to help promotion)
2) Clarity is needed for new coordinator teachers on their role in promoting the PTFEA in school – assemblies, connection with colleges, promotion in class
3) A work pack is needed to ensure PTFEA information is available to all teachers (including posters and promotional materials and letters to parents)
4) Allocated time for PTFEA administration and delivery is needed in *both* colleges when students are supporting the Employer Engagement Strand
5) A short training session (or presentation event) is needed for the PTFEAs to connect with the industries and fully understand the challenges and their role in delivering these challenges. This will strengthen the links between students and industries and build confidence. It will also enable more effective use of the PTFEA students.
6) A structure needs to be developed for the PTFEAs in schools, suggestion is
    a. Introduction to the WVEP project and what their role is
    b. Presentation by the industry to showcase their Challenge to the students so that they can be prepared to support this in schools and ask questions and be primed on what to talk to the pupils about for each company.
    c. Timetabling or signing up of PTFEA to do an engineering ambassadorial role (i.e. supporting industry challenges or giving an assembly, supporting open-day, starting a social media account)

Appendix A – Project Years

September 2017 - July 2018 – Year 1 (Schools sign up & Organisation and project launch)

March 2018– Project Launch

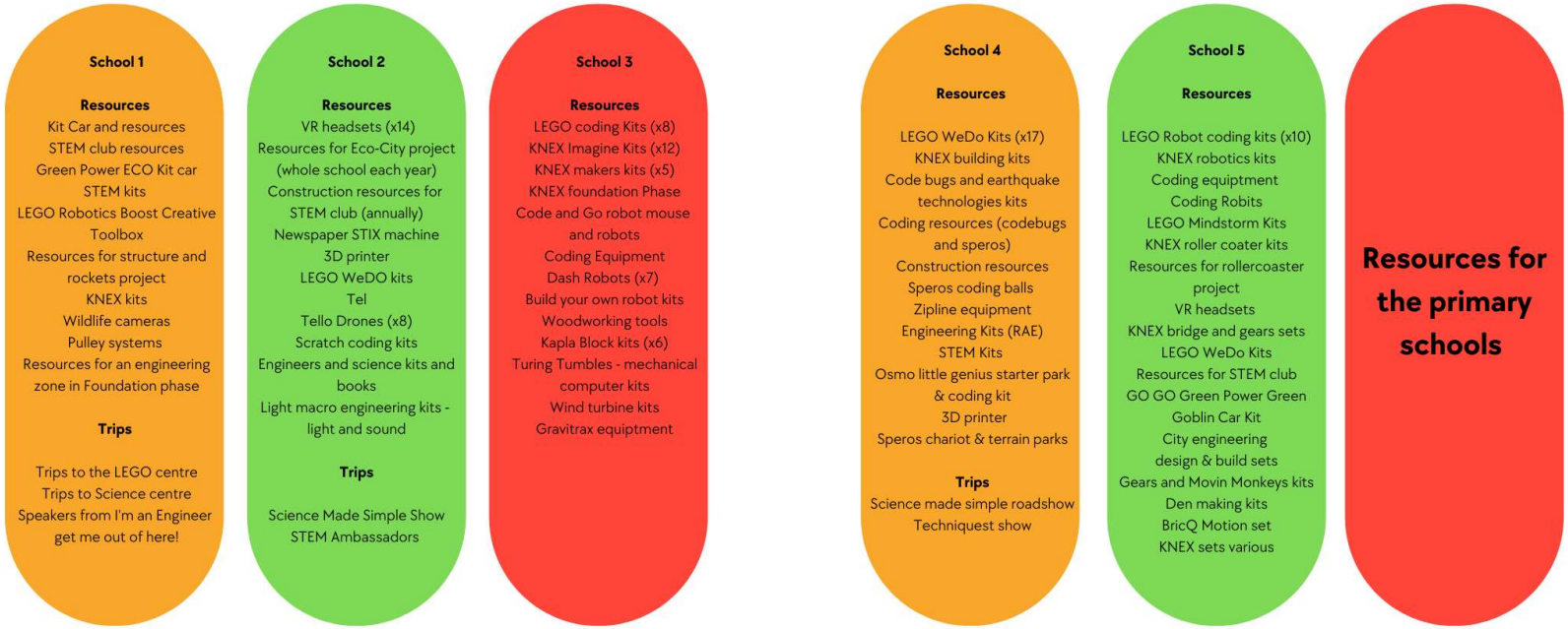
September 2018 – July 2019 – Year 2 (year 1 of delivery)

September 2019 – July 2020 – Year 3 (year 2 of delivery)

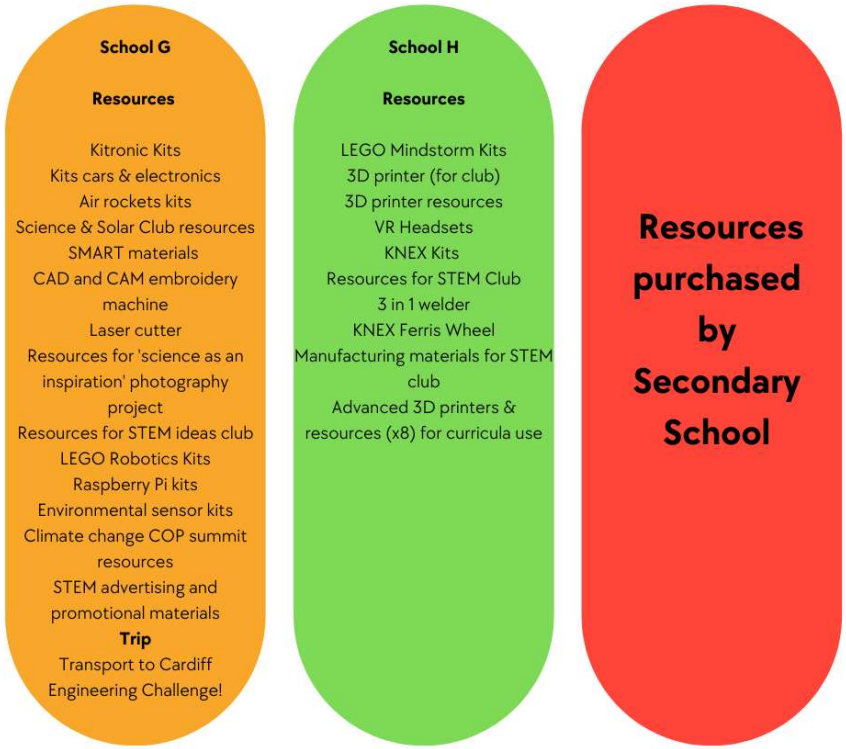
September 2020 – July 2021 – Year 4 (year 3 of delivery)

September 2021 – July 2022 – Year 5 (year 4 of delivery)

Appendix B – Resources Primary Schools



Appendix B – Resources Secondary Schools


School G
Resources
Kitronic Kits
Kits cars & electronics
Air rockets kits
Science & Solar Club resources
SMART materials
CAD and CAM embroidery machine
Laser cutter
Resources for 'science as an inspiration' photography project
Resources for STEM ideas club
LEGO Robotics Kits
Raspberry Pi kits
Environmental sensor kits
Climate change COP summit resources
STEM advertising and promotional materials
Trip
Transport to Cardiff Engineering Challenge!
School H
Resources
LEGO Mindstorm Kits
3D printer (for club)
3D printer resources
VR Headsets
KNEX Kits
Resources for STEM Club
3 in 1 welder
KNEX Ferris Wheel
Manufacturing materials for STEM club
Advanced 3D printers & resources (x8) for curricula use
Resources purchased by Secondary School

Appendix C: Secondary School Data

	UPTAKE							ATTAINMENT										
School E	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**Average 2016-2021**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**Average 2016-2021 (where applicable)**	**Inc uptake in 2021 from the previous year?**	**Inc uptake in 2021 compared to 6-year average**	**Inc Attainment in 2021 from the previous year**	**Continued increased attainment from 2019-2021**
Applied science	104	58	71	63	62	85	74	98.1	96.5	29.8	39.7	46.7	49.4	60.0	Yes	Yes	Yes	Yes
Double award science	63	57	58	60	58	32	55	95.2	57.3	68.9	85	91.3	100	83.0	No	No	Yes	Yes
BTEC Engineering	26	25	34	29	30	33	30	100	68	100	79.3	83.3	87.9	86.4	Yes	Yes	Yes	Yes
ICT		28	24	27	24	48	30		96.4	62.5	85.2	100	83.3	85.5	Yes	Yes	No	No
Maths								56	42.6	50.4	44.7	56.7	57.6	51.3	All	x	Yes	Yes

	UPTAKE							ATTAINMENT										
School H	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**Average 2016-2021**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**Average 2016-2021 (where applicable)**	**Inc uptake in 2021?**	**Inc uptake in 2021 compared to 6-year average**	**Inc Attainment in 2021**	**Continued increased attainment from 2019-2021**
Applied science	93	13	64	61	63	80	62	92	71	31	80	77	83	72.3	Yes	Yes	Yes	No
Double award science	5	74	30	26	31	33	33	75	60	86	100	100	100	86.8	Yes	Same	Yes	Same (100%)

D & T	5	14	31	11	6	17	14	38	20	79	42	73	100	**58.7**	Yes	Yes	Yes	Yes
ICT	57	61	69	62	64	12	54	30	65	77	88	92	88	**73.3**	No	No	Yes	No
Graphics					10	11	11					0	60		Yes	Same	One year only	One year only
Computer science					15	19	17					0	93		Yes	Yes	One year only	One year only
BH Maths								49	52	62	69	81	83	**66.0**	All	x	Yes	Yes

	UPTAKE							**ATTAINMENT**										
School B	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**Average 2016-2021**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**Average 2016-2021 (where applicable)**	**Inc uptake in 2021?**	**Inc uptake in 2021 compared to 6-year average**	**Inc Attainment in 2021 against a 6-year**	**Continued increased attainment from 2019-2021**
Applied science				74	62	41	59				5.2	19.3	7.3	**10.6**	No	No	No	No
Double award science	14	65			65	49	48	57.1	58.5			56.9	65.3	**61.1**	No	No	Yes	Yes
Triple Science: Chemistry			61	50	22	31	41		67.2	37.7	46	77.2	96.7	**65.0**	Yes	No	Yes	Yes
Triple Science: Physics			79	18	20	31	37		30.4	30.4	83.3	95	90.3	**65.9**	Yes	No	Yes	Yes
Triple Science: Biology			93	50	22	31	49		33.3	33.3	46	90.9	100	**60.7**	Yes	No	Yes	Yes
Design Technology (or DT / Technology)	6		11	14	0	0	10	50		45.5				**47.8**	x	x	x	x
Product design	15	26	16	18	17	22	19	29.6	30.8	25	38.9	58.8	72.7	**42.6**	Yes	No	Yes	Yes

Construction GCSE or BTEC Level 1				20	31	26	26				63.2	80.7	30.7	**58.2**	No	Same	No	No
ICT	33	59	27	56	25	20	37	78.8	67.8	70.3	75	90.5	97.3	**80.0**	No	No	Yes	Yes
Maths								25.7	55.2	31.9	37.6	50	48	**41.4**	All	x	Yes	No

	UPTAKE							**ATTAINMENT**										
School G	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**		**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**Average 2016-2021 (where applicable)**	**Inc uptake in 2021?**	**Inc uptake in 2021 compared to 6-year average**	**Inc Attainment in 2021**	**Continued increased attainment from 2019-2021**
Applied science								50	100	98		100	100	**89.6**	No data provided		Yes	Yes
Double award science								92.8	27.9	34.8	42.4	49	63.5	**51.7**	No data provided		Yes	Yes
Triple Science: Chemistry								84.2	93.3	75	100	89.5	39.6	**80.3**	No data provided		No	No
Triple Science: Physics								38.9	80	71.4	85.7	94.4	94.7	**77.5**	No data provided		Yes	Yes
Triple Science: Biology								84.2	86.7	53.6	92.9	46.7	53.1	**69.5**	No data provided		No	No
BTEC Engineering													26.7	**26.7**	No data provided		One year only	One year only

ICT								66.7	37.5	9.5	25.9	78.6	50	**44.7**	No data provided		Yes	No
Design Technology (or DT / Technology)								25	65.4	68.8				**53.1**	No data provided		x	x
Product design											60	64.1	72.4	**65.5**	No data provided		Yes	Yes
BSC EDCL Digital literacy qualification												100	17.5	**58.8**	No data provided		No	No
Maths								58.8	44.2	52.6	35.4	45.8	52.5	**48.2**	No data provided		Yes	Yes

Appendix D – College data

Data from College 2

Engineering only

Academic year	Funded Learners	Completion Rate(%)	Attainment Rate(%)	Success Rate(%)
17/18	110	95.5	90.9	85.4
18/19	111	94.6	91.8	85.7
19/20	108	97.2	93.9	91.1
20/21	110	93.6	85.3	79.8
21/22	136	93.4	pending	pending

Engineering and Science & Maths dept

Academic year	Funded Learners	Completion Rate(%)	Attainment Rate(%)	Success Rate(%)
17/18	170	95.9	85.2	81.0
18/19	301	89.7	86.0	76.5
19/20	304	93.7	96.4	90.2
20/21	278	92.4	93.4	86.3
21/22	282	81.9	0.0	0.0