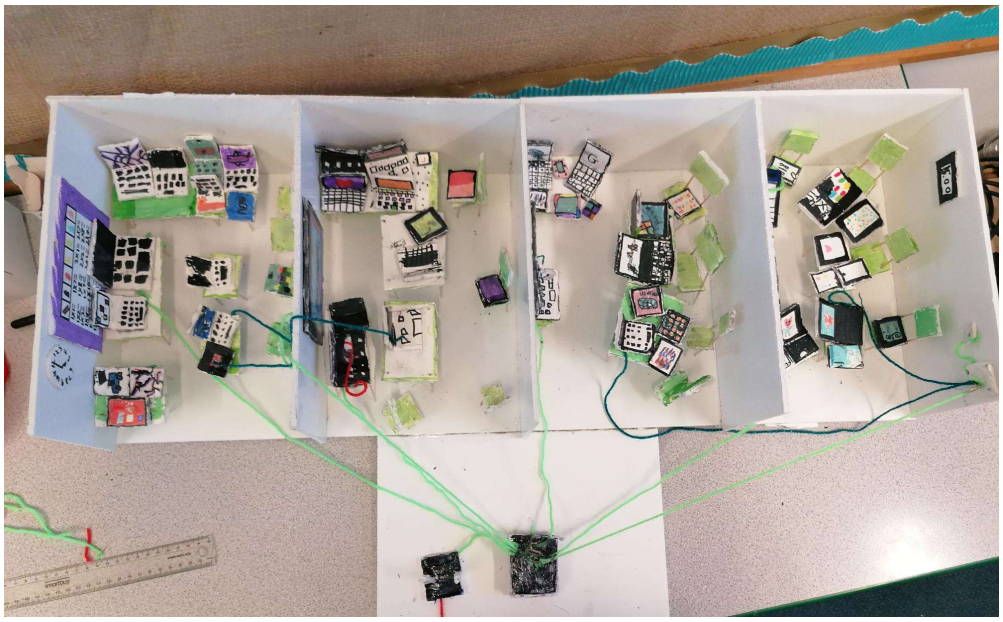
Welsh Valleys Engineering Project

Employer Engagement Strand

Evaluation Report



NDEC and Thales Network Challenge for the Employer Engagement Strand

Ariennir gan
Lywodraeth Cymru
Funded by
Welsh Government

July 2024

Report prepared by NC Simons

Contents

Zimmer Biomet biomedical engineering challenge for the Employer Engagement Strand

Introduction

The Welsh Valleys Engineering Project

The Welsh Valleys Engineering Project (WVEP), run by the Royal Academy of Engineering (RAEng) 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 successfully ran a 5-year project that delivered focused and targeted STEM (science, technology, engineering, and maths) resources, educational support, industry contact and career guidance to 5 primary schools, 8 secondary schools and 2 colleges located in Merthyr Tydfil and Blaenau Gwent, South Wales. The evaluation of this project showed improved understanding and aptitude for engineering by the pupils and increased confidence to deliver STEM-Engineering activities by the teachers among many other achievements[1] . Following this success, the Royal Academy of Engineering secured follow-up funding for three years from the Welsh Government's Tech Valleys Initiative for an extension to the WVEP, with a focus on the Employer Engagement Strand.

The Employer Engagement Strand

The WVEP Employer Engagement Strand launched in January 2021. This connects local, national, and global engineering industries to WVEP primary schools and secondary schools. The WVEP pairs teachers and industries to deliver co-produced, curriculum-embedded, careers-based engineering challenges in schools. The challenges can run for one day to up to eight weeks. The WVEP Employer Engagement Strand promotes industry-led, hands-on and experiential STEM-engineering learning opportunities. The challenges are designed to enrich cross-curricular learning, stimulate interest in STEM-Engineering and enthuse learners irrespective of gender or social status. Following the Tech Valleys funding, the WVEP expanded its reach to 43 primary schools, whilst still working with 8 secondary schools and two colleges located in Merthyr Tydfil and Blaenau Gwent, South Wales. All schools signed a memorandum of understanding to join the project.

[1] Evaluation report is available here: https://raeng.org.uk/media/1dddoym3/wvep-evaluation-report-2018-2022.pdf

Engineering in Wales and Curriculum for Wales

Progression in science, technology, engineering and maths (STEM) is vital in Wales for both long-term economic growth and creating a sustainable knowledge economy that will match others in Europe and beyond[i].

This project reflects the Welsh Government's strategic vision for STEM which highlights the importance of providing educational experiences that can widen young peoples' knowledge of STEM and STEM careers, whilst encouraging and facilitating their progression into those careers with a particular focus on gender imbalance.[ii] A significant skills gap has been identified within STEM industries that could negatively impact the UK's future productivity.[iii] The key to addressing this skills gap is widening participation from underrepresented groups, specifically girls, some minority ethnic groups and those from economically disadvantaged backgrounds[iv] [v]. Overall, UK figures show that 18% of the workforce is employed in engineering professions, with Wales figures at 17%. Further research has illustrated that in Wales only 12% of those working in engineering are female[vi].

Research undertaken in education has revealed complex factors that impact the decision-making of young people to pursue STEM engineering subjects. The opportunities given to an individual, their understanding of the options available, their capabilities, attainment and motivations are all said to impact on subject choice at school. Science Capital[vii], socio-economic background, gender and ethnicity have shown how external factors surrounding young people can also impact positively or negatively on subject choice. Additionally, teachers can also lack the expertise to successfully educate young people in the range of skills needed to support an engineering trajectory[viii]; this is especially acute in the primary school sector. Moreover, Engineering has also been found to be little understood by young people. Studies that investigate perceptions and understanding of engineering have found a widespread lack of awareness of engineering options with just under half of the young people surveyed unable to explain what engineering is[ix] or what it involves[x].

The new Curriculum for Wales (CfW)[xi] champions *experiences*, *knowledge* and *skills* that are needed for employment, lifelong learning and active citizenship. It supports the following four central purposes: ambitious capable learners, ready to learn throughout their lives; enterprising, creative contributors, ready to play a full part in life and work; ethical, informed citizens of Wales and the world and healthy, confident individuals, ready to lead fulfilling lives as valued members of society. Amongst other things, the CfW promotes collaboration and cross-disciplinary planning, learning and teaching, within and across subject areas.

The WVEP Employer Engagement Strand's aims are designed to tackle some of the issues highlighted in the research and to support CfW.

Aims of the Employer Engagement Strand

The aims of the Employer Engagement Strand are as follows,

Higher rates of attainment and uptake of STEM subjects at school*

Improved perception and understanding of engineering

Raised awareness of local engineering industries and pathways to engineering careers

Closer connections developed between schools and industry (in line with curriculum)

Increased confidence of teacher to apply engineering in the context of their own STEM lessons

* It was not possible to measure the attainment and uptake of STEM subjects for this evaluation[2]. Therefore, the focus shifted to assessing the pupils' perception of new knowledge and skills resulting from their involvement in the challenge(s). Pupil evaluation forms, observation of the challenges, verbal feedback, review of workbooks and teacher insight helped to evaluate this aim.

Concrete Canvas Challenge for the Employer Engagement Strand

[2] The reasons for not assessing attainment are, 1) the secondary school delivery varied from one-off industry-led day challenges to longer-term teacher-led challenges or site visits. 2) Secondary schools were harder to keep engaged through each term – so delivery was less than expected. 3) The variables in assessing attainment would be too great to attribute to the WVEP project alone.

HOW THE EMPLOYER ENGAGEMENT STRAND CHALLENGES WORK

1

WVEP COORDINATOR SETS UP A PARTNERSHIP WITH INDUSTRIES

The WVEP coordinator explains the project's aims, the schools involved, and the requirements of being involved in the project.

2

WVEP COORDINATOR FACILITATES THE FIRST MEETING WITH THE SCHOOL AND INDUSTRY AND SUPPORTS THE DEVELOPMENT AND DELIVERY.

Lead primary schools coordinate delivery across their cluster schools

3

INDUSTRY AND COORDINATOR TEACHERS CO-PRODUCE AN ENGINEERING CHALLENGE.

Challenges are developed online across one term. Challenges are designed to run between 1 day to 8 weeks.

4

THE TEACHER WORKS WITH INDUSTRY TO DEVELOP A WORK PACKAGE THAT CAN BE USED BY OTHER SCHOOLS IN THE WVEP.

5

DELIVERY

Schools run the challenge with pupils. The industry introduces the challenge in the first session in-person or online. Cluster primary schools facilitate delivery to all primary schools in their cluster.

6

THE PUPILS WORK ON CHALLENGE

with support from teacher(s) and Panasonic Trust Future Engineers (PTFEAs from college)

7

THE INDUSTRY ATTENDS THE FINAL SESSION AT THE SCHOOL OR THE INDUSTRY'S PLACE OF WORK.

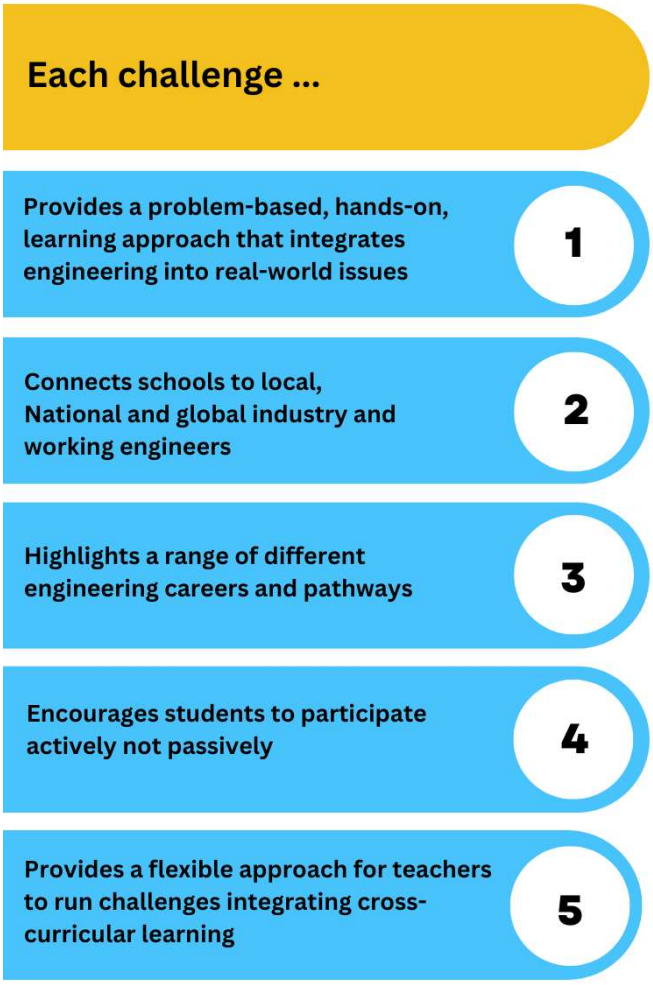
The pupils present the results of their challenge

8

THE CHALLENGE IS ROTATED TO OTHER SCHOOLS IN THE WVEP PROJECT (BACK TO 5).

Once all schools have undertaken the challenge, or when new industries engage, the process starts again from 2

In line with Curriculum for Wales, twenty challenges were developed and delivered between January 2021 and July 2024[3]. To accommodate the increase in primary school engagement following the Tech Valleys funding, 5 new Primary school challenges were developed in Spring 2023. Where possible, challenges were supported by college students who had been awarded Panasonic Trust Future Engineer Awards (PTFEAs) to support their studies at Coleg Gwent and Merthyr College. A summary of each challenge is available in Appendix A.



The primary schools and special schools that signed the MoU were each assigned a lead Primary school whose responsibility was to coordinate the delivery of the challenges across their cluster. The project had eight lead primary schools.

[3] In addition to the challenges offered to secondary schools Future Valley's Construction offered site visits. A half-day site visit was offered to schools as an alternative to running a challenge where the scheduled challenge was unavailable (e.g. where the business was unable to staff the challenge) This if school with a continuation of an engineering activity.

Key Outputs

The key outputs for the WVEP from November 2021 – July 2024 are as follows:

Industry Engagement

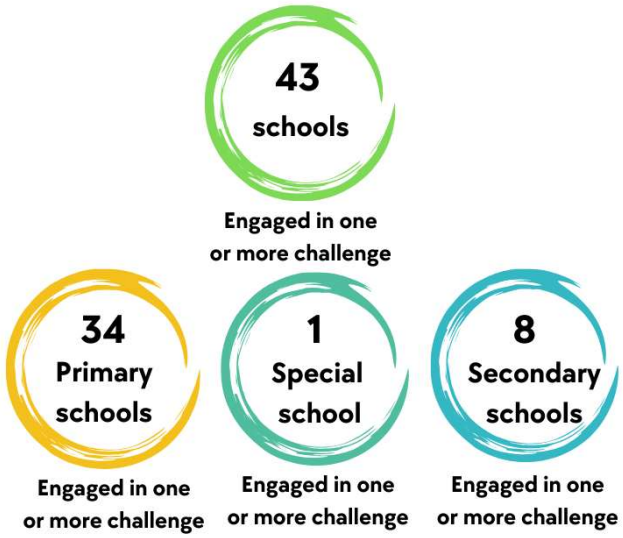
The WVEP engaged fifteen Industries during the project. The industries co-developed twenty challenges with teachers during the development phase of the project.

The industries that delivered challenges were: Panasonic, Vishay Intertechnology, Concrete Canvas, General Dynamics (global aerospace and defence), Continental Teves, Safran Seats (seating solutions for airlines), National Digital Exploitation Centre (NDEC) with Thales (aerospace, defence, digital identity, security and transport), Zimmer Biomet (biomedical engineering), TATA Steel, JC Moulding (injection moulding), ORE Catapult (off shore wind turbine solutions), Morgan Sindall (civil engineering and construction), Lightsource BP (renewable solutions & solar farms), Wild Connect (sound engineering and conservation). In addition, the Panasonic Trust Future Engineer Higher Education Awardees ran several rocket workshops. Sometimes the industries were unable to run a challenge due to staffing issues, and one industry (formerly Nexperia) was unable to continue to work with the project for a few terms due to a government investigation. In these cases, the WVEP coordinator asked existing industry partners if they would be able to provide schools with a site visit during the term that the school was unable to take part in a challenge. The businesses that offered site visits were Future Valleys Construction, Concrete Canvas, and Safran Seats. In this way, schools could continue to provide engineering experiences for their pupils.

Lightsource BP Eco Village Challenge and Zimmer Biomet Challenge for the Employer Engagement Strand

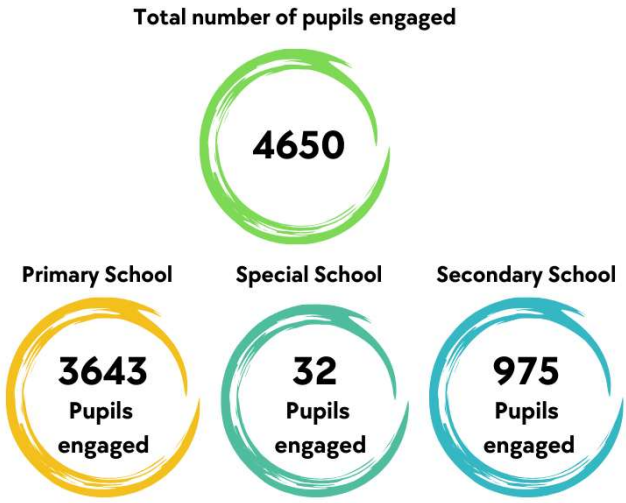
School Engagement

51 schools signed the MoU to take part in the WVEP Employer Engagement Strand. 43 schools engaged in one or more of the challenges (84%). 34 primary schools, 1 special school and 8 secondary schools engaged in one or more challenges.



Number of Pupils Engaged

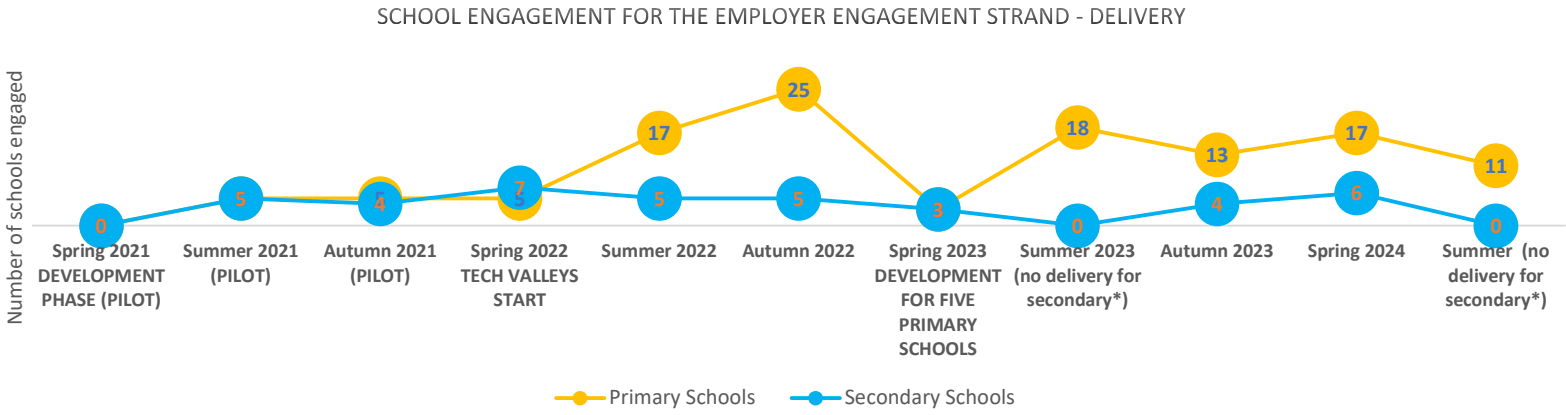
The WVEP Employer Engagement Strand engaged 4650 pupils from Spring 2022 – Summer 2024[4].

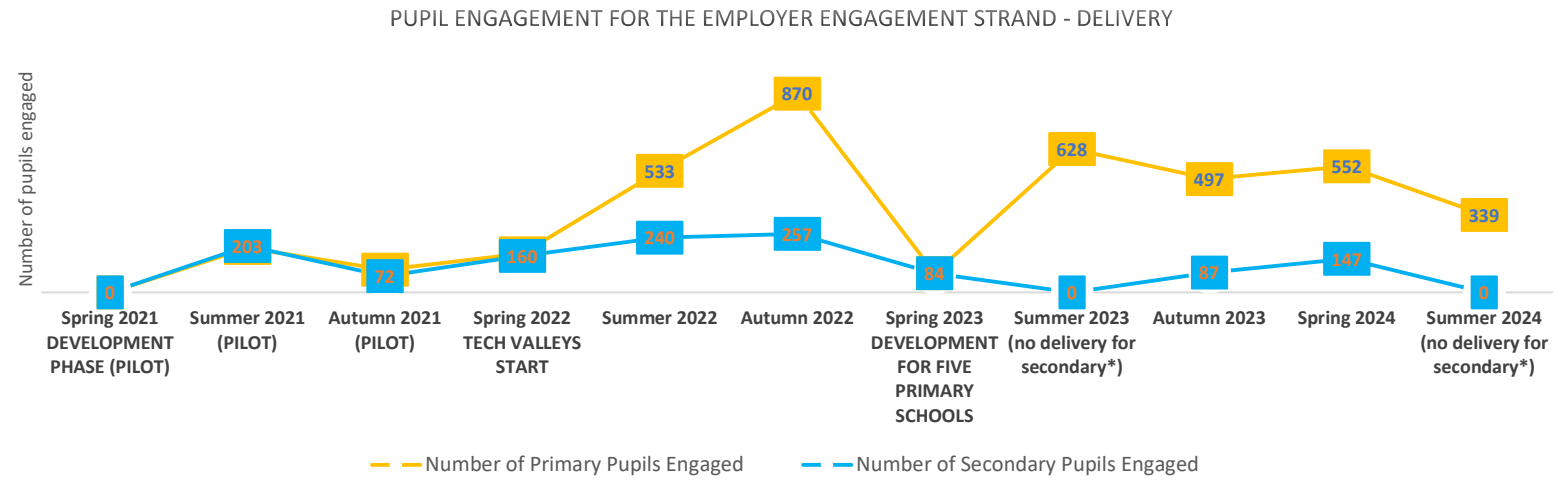


The below charts show a breakdown of the number of schools and pupils engaged per term.[5]

[4] The WVEP ran a pilot of the Employer Engagement Strand for two terms before Spring 2022 that engaged 295 primary and 275 secondary school pupils (total 570). In total, since inception the Employer Engagement Strand has provided 3970 primary school pupil engagements and 1250 secondary school pupil engagements – a total of 5220 engagements. The evaluation of the pilot in available in separate report.

[5] Note: Each school year has three terms.





*Secondary schools opted not to run in this term due to the exam period.

Training and Networking

The Royal Academy of Engineering offered eight on-line engineering CPD sessions using specially designed teaching resources to all primary and secondary schools in the WVEP. From November 2021 to July 2024, 43 primary and secondary schools were represented at the training sessions. Overall, there were 120 attendances. Appendix B provides a breakdown of the RAEng training.

The industries involved in developing and running an Employer Engagement Strand challenge were invited to a networking event at the Redhouse in Merthyr Tydfil in June 2023. Five engineers attended from five industries.

Additionally, The Royal Academy of Engineering offered STEM Ambassador Induction training in presenting STEM in schools to the participating industry teams. Three industry members from three industries were able to take part.

Development

The Royal Academy of Engineering has developed high-quality teacher resources for ten of the challenges (five primary and five secondary challenges). These have been designed so that teachers can complete the challenges independently or in combination with an industry. The WVEP produced videos to go alongside the interactive resources, these highlight different engineering careers in each of the ten industries.

The work packs will be made available, in English and Welsh, via the Welsh Government's intranet for teachers, Hwb, and on the RAEng website., from September 2024

An example of one of the RAEng's interactive resources

Celebration

Three celebration events were held between November 2021 and July 2024. Each celebration event was attended by over 100 school pupils, teachers, college lecturers and industry representatives. Each event was an opportunity for the schools to showcase the challenges they had undertaken with partner businesses.

Key Findings

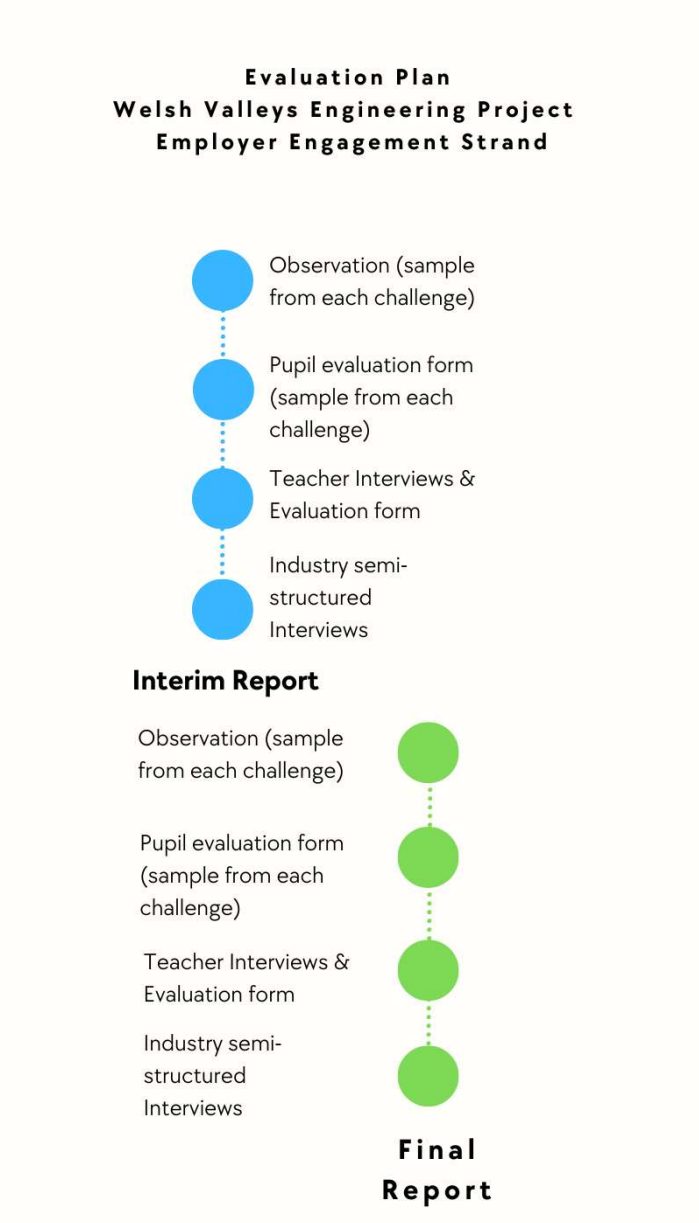
Key Strengths	Key improvements
All industries felt that being part of the WVEP was a fundamental part of the success of their engagement with schools. The industries were satisfied with their involvement and the direction of the WVEP project to date. The teachers felt that the challenges provided a vital contribution to connecting the pupils to real-life engineering opportunities. Teachers developed and co-produced projects with industry to develop flexible cross-curricular challenges in line with Curriculum for Wales. New learning resources for 10 of the challenges (5 primary/5 secondary) were welcomed by teachers. Industry partners and presence in school were felt to add additional motivation to engage and produce high-quality work. Pupils gained new skills and knowledge. Pupils gained a broader understanding of the broad range of engineering careers.	Industries requested better lines of communication with the schools. Industries would benefit from more structured communication information that was aligned with WVEP objectives. Primary schools were more successful in integrating challenges than secondary schools who adapted some to be industry-led drop-down days rather than integrated projects. The success of the challenge relies on skills and time available for the teachers – therefore additional training for teachers would maximise the impact. The cluster school engagement was lower than expected. The mechanism for engaging these schools should be reviewed to boost primary school engagement. Some challenges need reviewing to ensure that they maximise impact and that they are suitable for a wide age range (from year 1 upwards).

Overall, the primary school pupils rated the Engineering challenges 4.4 out of 5 stars,

Overall, the secondary school pupils rated the Engineering challenges 4 out of 5 stars,

Evaluating the Impact

The below evaluation plan was followed to evaluate the outputs and impacts of the WVEP Employer Engagement Strand,



Method & Sample Group

The following evaluation methods were used to evaluate progress to date,

Method	Primary Schools	Secondary Schools	Primary and Secondary total over two years
Post-participation evaluation forms (short form versions for under 7s or low-ability pupils)	**529** (upper primary long form = 301 and lower primary short form = 228)	**224** pupil feedback forms	**753** pupil feedback forms
Observation	**10** Challenges	**6** Challenges	**16** Challenges
Teacher semi-structured interview	**13** (Year 1 = 7 Year 2 = 6)	**6** (Year 1 = 5 Year 2 = 1)	**19** interviews
Teacher Feedback forms	**22**	**16**	**38**

Industry Interviews
21 twenty-minute industry interviews were undertaken (Year 1 = 9 Year 2 = 12)

A post-challenge evaluation method was selected to evaluate the Employer Engagement Strand. A representation of the challenges and a sample of pupils from each cluster-lead school (explained above) were sought to provide a sound sample group for the pupil evaluation[6].

Appendix C presents the evaluation questions asked of teachers and industry coordinators.

Individual evaluation reports were provided to each Industry halfway through the project to help guide them to improve and refine their challenges, and any teacher feedback received was passed on to the industries by the WVEP coordinator.

Limitations

There were several limitations to the evaluation,

1) A pre- and post-method was not selected for the Employer Engagement Strand because this method had already been undertaken for the first 5-years of the WVEP when fewer

[6] 753 responses from 4650 engaged provides a sound basis for analysis – Margin of Error = 3.20% and Confidence Level = 95%.

schools participated in a broader project[7]. Because of their participation in the WVEP since 2018, it was felt that the pupils from these schools had already had sufficient exposure to engineering. The unpredictability of which of the cluster primary schools would engage enough to be able to start to evidence change meant that baselines were not considered to be practicable from these schools.

2) A decision was made to focus on the lead-schools for the pupils' evaluation but to send online teacher feedback forms to all teachers who delivered the challenge. This limited the evaluation to post-challenge evaluation, rather than a comparison from pre- to post-challenge.

3) Teacher workloads resulted in a lack of engagement from secondary schools in the evaluation (interview) but many were able to complete the online evaluation instead.

Rocket Workshop run by PTFEA higher Education awardees

[7] The resulting report can be found on the WVEP website.

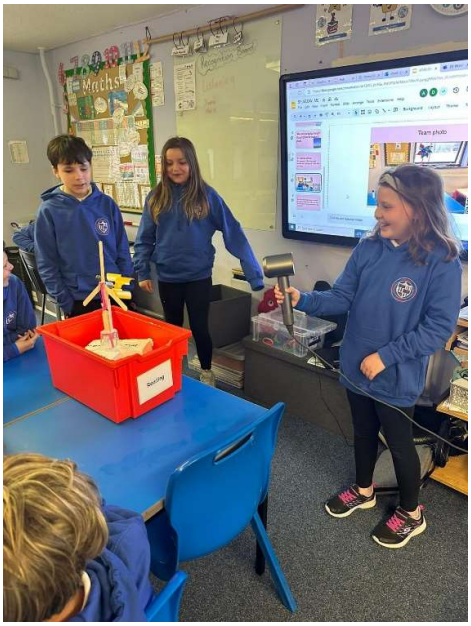
Results

Addressing misconceptions and misunderstandings of engineering and creating challenges to help students understand the range of engineering opportunities via hands-on experiential learning was a central aim of the WVEP. Previous evaluations and consultation with primary and secondary school pupils and teachers from the WVEP schools had revealed that many students have the assumption that engineering is connected to fixing cars or other equipment, building houses or trades careers (electrician, builder, carpenter) or that it involves large (often dirty) projects. The prior evaluation also established that the range, breadth and scope of engineering pathways were sporadically covered in secondary schools and rarely presented in primary schools. Any previous Industry connections, before the establishment of the WVEP, had mainly been through site visits or presentations by STEM-Engineering professionals in the school.

The evaluation of the Employer Engagement Strand shows that the project was able to address many of these issues and provide new ways for teachers to integrate engineering and work with local, national and international industries to deliver engineering challenges in their schools.

The results from the primary and secondary school pupil evaluation show high levels of enjoyment. Knowledge and skills acquisition also rated highly, especially in primary challenges which were usually undertaken across a larger time scale than the secondary school challenges. The primary school children found the challenges more inspiring than the secondary school pupils, however, conversely the secondary school pupils were more likely to think about an engineering career.

The infographic below shows these results.



ORE Catapult Floating Wind Turbine Challenge

PRIMARY ENGINEERING CHALLENGES

The following questions were answered by all 529 pupils sampled (Years 1-6)

ENJOYABLE!
88% AGREED OR STRONGLY AGREED THE CHALLENGES WERE ENJOYABLE

88%

81%

NEW SKILLS!
81% AGREED OR STRONGLY AGREED THEY HAD LEARNT NEW SKILLS AS A RESULT OF THE CHALLENGES

NEW KNOWLEDGE!
78% AGREED OR STRONGLY AGREED THEY HAD LEARNT NEW KNOWLEDGE AFTER TAKING PART IN THE CHALLENGES

78%

66%

INSPIRING!
66% AGREED OR STRONGLY AGREED THE CHALLENGES WERE INSPIRING AND MADE THEM WANT TO DO MORE

The following questions were answered by 301 pupils sampled (Years 5-6 only)

66%

MORE INFORMED!
66% AGREED OR STRONGLY AGREED THEY NOW KNOW MORE ABOUT DIFFERENT TYPES OF ENGINEERING

REAL-WORLD APPLICATION
64% AGREED THE CHALLENGES HELPED THEM LINK ENGINEERING TO REAL-WORLD PROBLEMS

64%

51%

CHANGED PERCEPTIONS!
51% AGREED THE CHALLENGES CHANGED THEIR PERCEPTION OF ENGINEERING (38% NOT SURE, 12% NO CHANGE)

SECONDARY ENGINEERING CHALLENGES

The following questions were answered by a sample of 224 secondary school pupils

ENJOYABLE!
81% AGREED OR STRONGLY AGREED THE CHALLENGES WERE ENJOYABLE

81%

64%

NEW SKILLS!
64% AGREED OR STRONGLY AGREED THEY HAD LEARNT NEW SKILLS AS A RESULT OF THE CHALLENGES

NEW KNOWLEDGE!
63% AGREED OR STRONGLY AGREED THEY HAD LEARNT NEW KNOWLEDGE AFTER TAKING PART IN THE CHALLENGES

63%

48%

INSPIRING!
48% AGREED OR STRONGLY AGREED THE CHALLENGES WERE INSPIRING AND MADE THEM WANT TO DO MORE

64%

MORE INFORMED!
64% AGREED OR STRONGLY AGREED THEY NOW KNOW MORE ABOUT DIFFERENT TYPES OF ENGINEERING

REAL-WORLD APPLICATION
65% AGREED THE CHALLENGES HELPED THEM LINK ENGINEERING TO REAL-WORLD PROBLEMS

65%

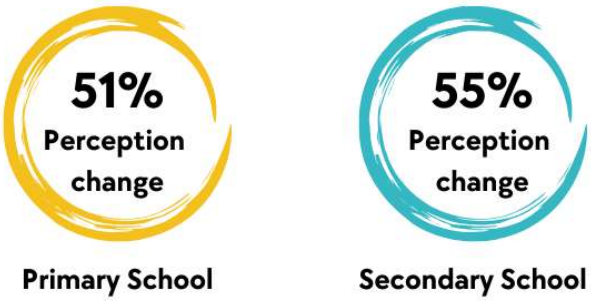
55%

CHANGED PERCEPTIONS!
55% AGREED THE CHALLENGES CHANGED THEIR PERCEPTION OF ENGINEERING (28% NOT SURE, 17% NO CHANGE)

1. Improved Perception and Understanding of Engineering

Challenging pupils' assumptions about engineering

Fifty-one per cent of primary school pupils and fifty-five per cent of secondary school pupils felt that the challenges had helped to change their perception of engineering.



The respondents were asked to provide more detail on how their perceptions had been changed, what they had thought previously and what they thought now. 45% of primary school pupils and 46% of secondary school pupils provided valid extended answers to illustrate how the challenges had changed perceptions. The responses that were not valid or did not provide examples of perception change were excluded. Many of the respondents who did not have their assumptions changed demonstrated that they already had a good understanding of engineering.

For the pupils, whose perception changed, the following five themes emerged that explored this change.

The pupils were more informed about what engineering involves and the variety of engineering pathways and careers following. A selection of comments to illustrate this is provided below,

> *"I thought that engineering didn't involve maths and science and now I know that it does!"* (Year 5 pupil, JC Moulding Challenge)

"It has changed the way I completely think about technology and engineering and how many different career paths to choose" (Pupil, Concrete Canvas challenge)

Following the challenges, many of the students felt that engineering was more fun and interesting than they had previously thought. This is illustrated by the following comments,

"I thought that engineering might be boring, but this project was way more fun than any project that we have ever done!" (Year 6 pupil, ORE Catapult Challenge)

"I thought engineering was boring until I did the workshop now, I think it's really fun" (pupil, General Dynamics challenge)

Some of the students felt that their perception of the soft skills that engineering required had been changed by taking part in the challenges. They found that engineering involves resilience, teamwork and problem-solving – and that engineering can be harder and more complicated than they had thought.

"I didn't know much about engineering but now I know that it involves working together as a team – and engineering is harder than I thought" (Year 3 pupil, TATA Steel challenge)

"I think that engineering is more than just coming up with things it takes a lot of thinking and knowledge behind it" (Year 8 pupil, Safran Seats challenge)

"I now know that engineering isn't just building and fixing stuff. It's hard work and dedication – along with using innovation to solve problems" (Year 8 pupil, Concrete Canvas Challenge)

Some of the students found that the challenges changed the direction of their career choice or found it to be inspiring. The two comments below show this,

> *"I wanted to be an engineer before, but now I have done the tough books project, I would like to do it more"* (Year 8 pupil, Panasonic Toughbooks challenge).
>
> *"I found out that engineering is much more important than I thought it was and so much more necessary than I thought"* (Year 9 pupil, Panasonic Weather Station challenge)

A few primary students commented that they learnt that engineers can be women and not just men. this is illustrated by the following comments,

> *"I thought that engineering was mainly for boys. Now I think that girls can do what boys can do!"* (Year 6 pupil, ORE Catapult challenge)
>
> *"Engineering is for everyone – not just boys"* (Year 6 pupil, ORE Catapult challenge)

It is important to note that some pupils who took part in the challenges were less clear or were unable to write about their perceptions of engineering. Continual reinforcement is needed by teachers to ensure that the pupils retain this knowledge going forward.

2. Knowledge and Skills Increases

The observations of the challenges together with the open-ended responses in the evaluation forms provided by the sample of pupils illustrate that the challenges helped the children understand crucial world issues such as climate change and sustainability, renewable energy, cyber engineering and security, how engineering can help the human body, biodiversity, coding and more.

Eighty-one per cent of the primary school children and sixty-four per cent of the secondary school children felt that they had learnt new skills as a result of taking part in one or more challenges. The new skills included: using new software (i.e. Keynote, CAD, sound equipment, coding software, OnShape, 3D printing); developing making skills (using tools, using a variety of materials, testing, construction, and sewing) and inventing and designing skills. Moreover, the challenges were instrumental in reinforcing soft skills such as teamwork, critical thinking skills, application to the real world and presentation skills.

Primary School

Secondary School

Seventy-eight per cent of the primary school pupils and 63% of the secondary school pupils sampled felt that they had acquired new knowledge from taking part in one of the challenges.

Primary School

Secondary School

The pupils explained what they had learnt during the challenge via open-ended comments. A thematic analysis of the comments showed that all the primary pupils and 65% of the secondary pupils were able to provide valid answers to illustrate some learning[8]. The responses were coded into the following themes to show the type of learning,

Many pupils were able to demonstrate that they had learnt new information or skills that were linked to the specific challenge that they were set[9]. A selection of the comments to illustrate this are presented below,

> *"I learnt about different joints, making joints and the differences in materials - hard, waterproof, bendy, soft*" (Year 3 pupil, Zimmer Biomet Challenge)
>
> *"I learnt that the sun hits the solar panel, and the solar panel stores the energy. I learnt that solar is environmentally friendly"* (Year 4 pupil, Lightsource BP Challenge).
>
> *"I learnt how to design in 3D using OnShape. I learnt about the different opportunities within engineering"* (Year 8 pupil, Panasonic Toughbooks challenge).
>
> *"The challenge helped me to learn about databases and how to analyse data"* (Year 9 pupil, Panasonic Weather Stations challenge)
>
> *"We learnt how to design and manufacture a product from start to end"* (Year 8 pupil, Safran Seats challenge)

The pupils were also able to show how taking part in the challenges had provided them with new knowledge about careers in engineering and about local engineering industries and

[8] Assessment of learning has not been undertaken for this evaluation, instead the evaluation assesses the pupils' perception of their own learnings.
[9] Teachers were able to confirm the skills and knowledge that had not previously be covered at school.

what they do. They also demonstrated an ability to link engineering to real-world issues. A selection of comments to illustrate this theme are below,

> *"I learned that nature and engineering can be linked"* (Year 5 pupil, Wild Connect Challenge)
>
> *"That engineering is not only making things but also contributing to science, marine biology and rocket ships and buildings, in a way engineering is everything"* (Year 6 pupil, Morgan Sindel challenge)
>
> *"I learnt about the type of fabric/material concrete canvas uses and how it is a revolution to modern society (in my opinion)"* (Year 8 pupil, Concrete Canvas Challenge)
>
> *"I learned how civil engineering shapes and moulds local Eco structures and helps maintain biodiversity"* (Year 11 pupil, Future Valleys Trip)

Many of the comments related to learning to work effectively in teams and learning to critically evaluate or problem-solve. The selection of comments below shows this,

> *"I liked how we had to work in teams and solve clues together. I think that it improved my idea of working with others (as a team). We learnt about coding, how to solve clues, how to work in a team"* (Year 5 pupil, NDEC Challenge 1)
>
> *"I like the problem solving and the teamwork needed for the work. I also learnt that not everything works the first time"* (Year 6 pupil, ORE Catapult challenge)
>
> *"Teamwork is important, and you need to communicate with each other instead of going on your own"* (Year 8 pupil, Concrete Canvas challenge)
>
> *"I learnt how to problem solve and work under pressure"* (Year 8 pupil, Safran Seats challenge)

Some pupils suggested that they had learnt that they enjoyed the challenge or/and they had an aptitude for it. This is shown in a selection of the comments below,

> *"I really liked building the turbine. I learnt how to build a wind turbine that actually works"* (Year 5 pupil, ORE Catapult Challenge)

> *"I loved being able to have an idea and stick to it like being able to design my turbine then have fun building it. I learnt that I can work in a good team even if I don't know the people very well"* (Year 6 pupil, ORE Catapult)

> *"I thought there was just one type of engineering. Now I know there are lots of types and engineering is great! It is so fun experiencing engineering"* (Year 6 pupil, Morgan Sindall Challenge)

> *"I enjoyed the challenge and learning about engineering, and it was fun"* (Year 8 pupil, Panasonic Weather Station challenge)

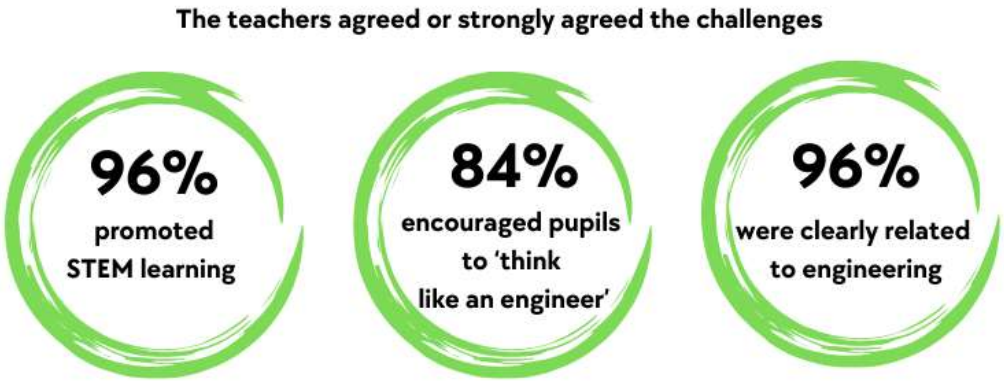
A few pupils learnt about the importance of resilience in engineering activities (testing, retesting and trying again) as shown in the comments below,

> *"We learn that it takes quite a lot of steps to get the internet to the device from the modem to the switch or for wireless internet to get the internet to our devices"* (Year 5 pupil, NDEC Challenge 3)

> *"Our team learnt that you have to design things and plan them before you make them"* (Year 6 pupil, ORE Catapult challenge)

> *"I learnt that you have got to design and draw and discuss BEFORE you start to build"* (Year 8 pupil, Safran Seats challenge)

The teacher evaluation (feedback forms *n*=36) and interviews found the following,



The primary and secondary school teachers expanded on this at interview and reported that the challenges had increased skills and knowledge in the following ways,

Engagement

Teachers and industry reported high levels of pupil engagement for most of the challenges. The teachers valued the opportunity to promote engineering pathways and careers (both locally and more widely) that are traditional and non-traditional, extending the knowledge of engineering careers. This was especially valued for the non-traditional engineering pathways like biomedical engineering and software and cyber security engineering. Teachers reported that having a challenge set by the industry further enthused and motivated the pupils to engage. The challenges were also reported to appeal to pupils who thrive in a hands-on learning context.

> *"The children were all fully engaged in the task, and all collaborated with the challenge. I was really impressed with how they all trialled their designs and models and then how they adapted their designs so that they were able to float. I was pleased with the perseverance that they all showed and their willingness to try new things. It was an enjoyable experience and it linked well to real-life experience and the engineering of wind turbines. The learning experience had a purpose, which helped drive and promote learning. It has helped the pupils fully engage with the four core purposes and helped them understand the importance of learning and given them an insight of different careers they could engage with in the future"* (Coordinator teacher, Deighton Primary school, ORE Catapult Challenge)

"This challenge was highly enjoyable, highly engaging and had great links to engineering. The company ran the event really well and was super supportive and willing to come in an engage with the pupils. The students that took part in the challenge increased their engagement for science and certainly gave an increased awareness of engineering" (Coordinator teacher, Abertillery Learning Community, Concrete Canvas Challenge)

Challenges highlight STEM learning and build confidence

The challenges were seen as a good way to impart the core engineering skills to pupils – testing, problem-solving, re-testing, trailing and designing - in a fun and engaging way from year 1 up to year 10. These skills were said to be cross-applicable to other STEM and non-STEM subjects. The hands-on, creative and real-world elements of the challenges were seen to build confidence in the student's abilities and appeal to a wider range of pupils.

"Pupils absolutely loved setting the scene with the story of the Lorax. They enjoyed becoming eco-warriors, learning all about sustainability and how it was their responsibility to care for the earth by recycling and saving energy. Pupils enthusiastically enjoyed the hands-on building and designing of the villages. This encouraged teamwork, problem-solving skills and perseverance as well as learning how circuits work - developing knowledge of how batteries / solar panels, bulbs and switches work. The challenge fulfilled our four curricular purposes - ethical, creative, healthy and ambitious learners" (Coordinator teacher, Light Source BP Challenge)

"The pupils had insight into a real-world engineering challenge and were able to experience a range of STEM-based skills to complete the task. As a school, we will continue to incorporate the challenge into our teaching. Pupils had a greater understanding of Engineering and Computer Science - many realising that it was rewarding, and that it would need effort if taken as an option subject" (Coordinator teacher Tredegar High School, General Dynamics Challenge)

Challenges teach core skills

The teachers were confident that the challenges integrated opportunities to teach STEM skills and knowledge – using new IT programmes/software, building and design, testing materials, statistics, analysis, forces and more. The challenges promote teamwork, problem-solving, resilience, presentation skills and confidence building.

"Pupils have learnt about pitch and identifying different sounds from a recording by looking at the sound waves. The pupil's knowledge and my

own have progressed through extensive research on local birds. We have looked at their habit, migration, behaviour and life cycles. We have also looked at different shaped beaks and how the shape allows birds to have a specific diet. We focused on the recording and used the apps to identify sounds and look at different pitches. The pupils had an authentic learning experience in looking at the design and development of the audio recorders named Biophones. It linked to the design and technology aspect of the curriculum for Wales in designing and building a bird house." (Cluster lead, Coed Y Garn Primary, Wild Connect Challenge)

"The learners really enjoyed the challenge. We are planning to run a second day of this in the near future because of the enjoyment and interest. Learners were able to adapt and change their designs to make improvements. They used trial and error a lot and were able to use investigative and problem-solving skills to resolve issues with their designs. They were able to display strong teamwork skills also" (Coordinator teacher, Abertillery Learning Community, Safran Seats Challenge).

Although the students gained new skills and knowledge, it is important to note that evidence to connect this with attainment and uptake of STEM subjects in the participating schools has not been assessed in this evaluation. A more systematic approach that works with a specific group of students would be needed to fully understand the longer-term impact of this project.

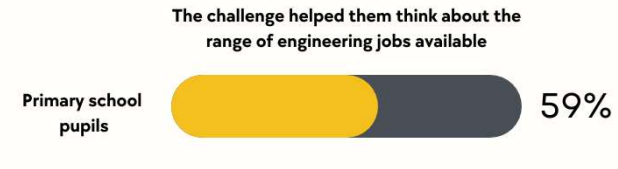
General Dynamics challenge

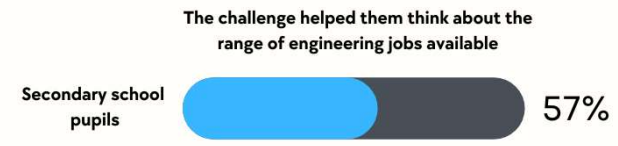
3. Raised awareness of local engineering industries and pathways to engineering careers

The evaluation of the WVEP from 2019-2021 established that primary school teachers had limited knowledge of local engineering industries and the secondary schools had sporadic contact with industry. Before the WVEP, none of the schools had a systematic approach to highlight the range and breadth of STEM-engineering opportunities locally, nationally or globally. The WVEP Employer Engagement Strand linked schools to industries to build relationships and increase the range of engineering careers that schools were exposed to.

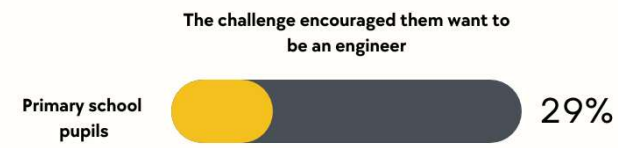
Awareness of pathways to engineering careers

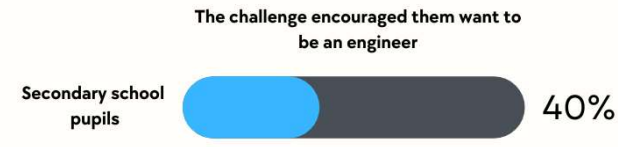
Fifty-nine per cent of the primary school and 57% of the secondary school student sample group agreed that the challenge helped them to think about the range of engineering jobs available to them,



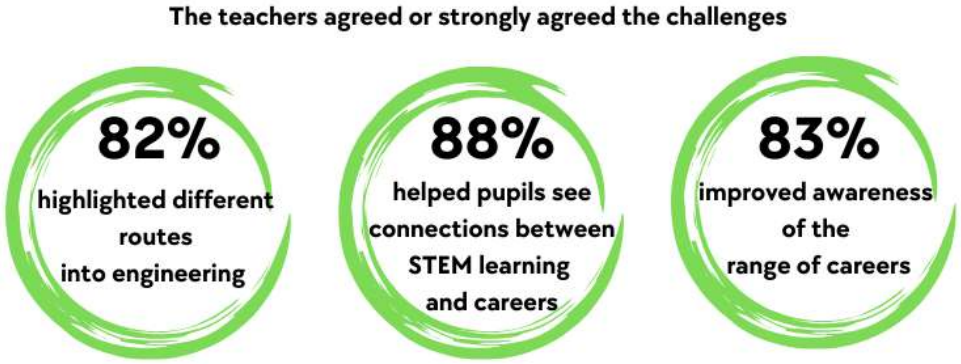


Twenty-nine per cent of the primary school pupils felt that they would like to become engineers after taking part in one or more challenges. Forty per cent of the secondary school pupils felt that they would like to become engineers (some of these already were thinking of this career path, others were influenced by the challenges).





The teacher evaluation forms (*n*=36) agreed that the challenges were well connected to engineering pathways and careers.



The interview evaluation of the teachers confirmed that the challenges were able to,

Highlight local opportunities that are often not visible at school

The teachers felt that providing the pupils with real-world access to a range of engineering opportunities was essential in broadening the children's minds about what is available and what is possible in engineering. This is exemplified by the following quotes,

> *"Before this project, we had very few contacts and therefore this project has really expanded the understanding of the children about industries in their area and where they might be able to work in the future"* (Coordinator teacher, Willowtown Primary).

> *"The WVEP Employer Engagement Strand has raised the profile of engineering and allowed our pupils to get experience of a broad range of different careers and different elements of engineering. They now understand that you could be a sound engineer, software or hardware engineer, construction, bio-medical or a chemical engineer – they now know that an engineer is not just a mechanic! But additionally, it is the skills that are built from the engineering challenges that are passed on. From designing a product to construction building, problem-solving and coding. The children are also aware now that women can be engineers too"* (Coordinator Teacher, St Illtyds School)

Provided more insights for teachers

The teachers reported that the delivery of the WVEP project and the closer connections with industries had improved their knowledge and understanding of engineering and the multitude of career opportunities available through engineering.

> *"The WVEP has worked well to link us to companies that we have not heard of before. It has raised our confidence in the school to approach other companies to work with us too. We now know that we can work in this way and that the children really enjoy it"* (Coordinator teacher, Blessed Carlo Acutis Primary School)

Importance of engagement from primary school

The teachers agreed that early exposure to engineering was key to embedding it within the schools and increasing the awareness and understanding of engineering for pupils and teachers alike. This is demonstrated by the following comment,

> *"It is very important to introduce engineering concepts and pathways at primary school. This is when they are little sponges, this is where you plant the seeds that will grow later. If you expose them at a young age, when they are teenagers, they will be able to draw from their early childhood experiences and feel more confident and engaged – as it is not all new to them. It might inspire them in the future to pursue an engineering or STEM career"* (Coordinator teacher, Willowtown Primary).

> *"The WVEP has really established us as a school that does engineering – we had a parent comment to us that they sent their child to our school because of all the engineering that we do. It has been a privilege to be part of the WVEP – our school has enjoyed it"* (coordinator teacher, Blessed Carlo Acutis Primary School)

Although the WVEP Employer Engagement Strand was able to highlight local industries and pathways to engineering, the evaluation found that for the primary challenges some of the pupils configured their understanding of engineering around the type of industry that they were currently working with. There is a danger that pupils will interpret engineering as the 'topic' that they covered in the challenge without a wider understanding of engineering in other areas.

In both primary and secondary schools, the challenges were usually undertaken by one class at a time, therefore different cohorts of pupils experienced different engineering challenges, potentially resulting in a narrower understanding of the range of engineering opportunities available. Many of the primary cluster schools were not able to run a challenge each term and this limits the pupils' access to different engineering opportunities in those schools.

4. Closer connections developed between schools and industry in line with the Curriculum for Wales

The WVEP Employer Engagement Strand helped to connect schools and industry. The co-design of the challenges with teachers and industry was seen as a core strength of the WVEP, allowing the teachers to work with industry. This was mutually beneficial to schools and industry as the teacher provided the curricular and cross-curricular elements and the industry partners connected this to real-world STEM engineering issues. The involvement of the industry in presenting the challenge at the first session and attending the final session to hear directly from the pupils about how they had addressed the challenge was a motivation for the pupils and staff alike. Having industry involvement motivated the pupils to complete the challenge and gave staff opportunities to deliver the curriculum differently.

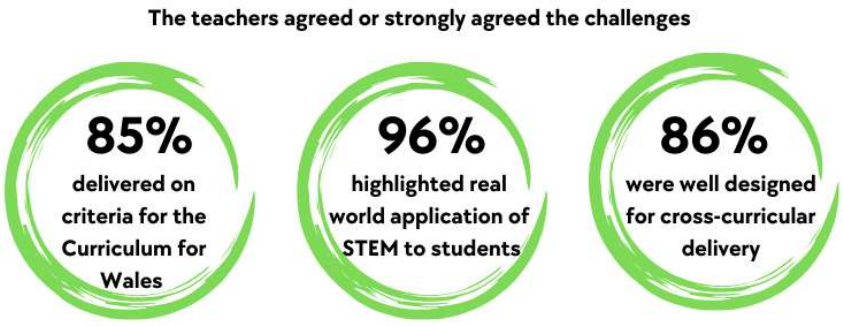
> *"It is massive for our school to get outside industries involved in the pupils' learning process. The new curriculum for Wales is geared towards getting experts in. Our school curriculum has now been designed so that each term we present our final outcome to a critical audience that isn't a teacher or parent – the reason being that children raise their game when external people who are experts come into the school to look at their work. They really respond to that" (Coordinator Teacher, Twynyrodyn Primary School)*

> *"A key part of the new curriculum and our curriculum is experiential learning which was a huge part of this challenge. It also made students really think about how they could solve a problem and connect different parts of the STEM curriculum. Overall, a very well-made challenge that was fun and engaging*" (Coordinator Teacher, Abertillery Learning Community, Continental Teves Challenge).

Some of the teachers reported that they had made strong connections with the industries that they had worked with. This has led to increased confidence to work with them again even, in some cases, outside of the WVEP. However, the teachers felt that the WVEP coordinator was best placed to broker new connections with industries, as this was beyond their knowledge and would be hampered by lack of time.

Delivers for the new curriculum for Wales

The teacher responses from the evaluation forms were confident that the challenges were well matched to Curriculum for Wales.



The teachers felt that many of the challenges fitted with their curricular aims for 'purpose-based learning' and 'areas for learning and experience'. The challenges were thought to be dynamic and enabled teachers to develop methods and draw in the curriculum to support learning. This extends the learning beyond what is traditionally thought of as Engineering or STEM subjects (including geography, media, drama, art, health and wellbeing, morality and ethics and music). The design of the challenges means that the teachers can pick and choose elements that will work in their schools.

> **"***Schools are looking for a project that links all parts of the curriculum together and they are looking to make links with real-world industries. It helps children to understand that the skills taught in school can be applied to engineering careers and other careers too. The NDEC Network design challenge for example used a real process that they use for designing in the real world for the children's project. Our children got to experience that"* (Coordinator Teacher, St Illtyds Primary School).

> *"Everybody enjoyed the challenges. They fitted in really well with the new Welsh curriculum. In the past, when we have had projects, we have done them as an add-on – which increases the teacher's and children's workload. We decided to make these challenges the centre of learning for the half term. I based all of the areas of learning around the Zimmer Biomet Challenge. I brought in health and well-being, PE lessons focusing on joints, I brought in celebrating differences, parts of the body and the use of different materials for science. The other teachers also did the same and planned their challenges within the curriculum – rather than an add-on" (*Coordinator Teacher, Ystruth Primary School)

"The key strengths of the WVEP project for our school are the engineering concepts taught through the various Employer Engagement Scheme challenges. That was learning for the children which would not have taken place without this project. I don't think any of us would have planned the projects in the way that the WVEP Employer Engagement Strand has done. It helped to put us ahead of the new curriculum for Wales" (Coordinator teacher, Willowtown Primary School)

The primary and secondary teachers valued the opportunity to integrate challenges into the curriculum but also highlighted the time, effort and level of coordination needed to achieve this. Some of the secondary schools chose to run the challenges as one-off industry led challenges that required less planning and time commitment from the teachers. The teachers felt that more run-in time for each challenge where the planning takes place the term before would be beneficial to maximise each challenge. It was also noted the challenges were not as successful when they did not complement the topic or subject currently being covered in school.

Future Valleys Construction Trip

5. Increased confidence of teacher to apply engineering in the context of their own STEM lessons

The teachers were confident that the challenges could be used independently and many teachers themselves learnt new skills by delivering the challenge – these skills can be used independently of the project in the future. However, many of the teachers felt that they required more support and information to run challenges successfully and to their full capacity.

The interviews with the teachers elucidate these responses,

Teacher progression and development

Many of the teachers felt that the challenges had developed the teacher's knowledge and ability to deliver STEM engineering at the school (particularly in primary school). As shown by the below comments,

> *"The idea of the challenges and of working with industry is really good – it puts a different spin on it. I have done STEM projects in the past myself, and they have not been quite as involved as the WVEP challenges. But now I have done this one, I can see the value of bringing in the science, technology, maths and other areas of the curriculum into one challenge – so I will do that again.* (Coordinator teacher, Ystruth Primary School)

> *"Teachers are definitely more confident because of the design of the WVEP Employer Engagement Strand means that the teachers are leading the project – so they build that confidence through the contact with the industry, interweaving curricular content and using the resources"* (Coordinator teacher, Blessed Carlo Acutis Primary School)

Further support and training are needed in order to maximise teacher confidence in delivering the challenges and increase its potential to link to the curriculum for Wales. The new RAEng resources will provide some of this support when launched.

Benefit to Industry

The evaluation also established that involvement in the WVEP Employer Engagement Strand also had positive impacts on the industries involved. These were as follows,

Personal & Team Satisfaction and staff buy-in. Several of the industries suggested that they had personally gained from 'doing something worthwhile' and 'giving back'. This has led, in some instances, to further interest from other staff members to get involved and a strong sense of team satisfaction. As illustrated below,

> *"It is part of our company ethos to give back to society and to bring people along – it could be a way that people get engaged in what we do at a young age and then they want to work for us in future years. We have enjoyed this project and have enjoyed working with the schools. We hope that this will continue*" (Industry Coordinator, Panasonic Weather Stations Challenge)
>
> *"I get joy from watching the children be excited about a project in engineering! I was that kid once – I enjoyed taking things apart to see how they worked and putting them back together again. So I guess this project has helped me do that for others. We hope that this project will help to guide them into engineering in the future!"* (Industry coordinator, Safran Seats)

Developed communication and creative skills: Several Industries reported that working with the schools and designing a challenge has been good for professional development.

> *"We have changed and developed the challenge over time. We grab them first now and let them see more, and we talk less – and get straight into making sounds. This grabs them straight away and they understand the challenge more"* (Industry coordinator, Wild Connect)
>
> *"I've adapted the presentation each time and I have learnt an awful lot. I get prompts from the children about what works and what doesn't. I've adapted the presentation to get the right balance between talking and hands-on tasks"* (Industry coordinator, Zimmer Biomet).

Provides opportunities to promote apprenticeships and careers in their company: all industries suggested that delivering to schools provided a great vehicle to inspire the next

generation of engineers and to promote their industry (including other non-engineering roles within that). This may help to plug the skills gap in engineering in the long term. Additionally, it was suggested that the project provides access to talented and interested local young people. By connecting on a personal level with students, Industries can enthuse and advise talented or interested pupils on engineering pathways and ensure that they know about career opportunities locally.

> *"The WVEP creates a brilliant pathway into engineering – from primary school upwards, giving students experience and enthusiasm for engineering and access to industries. It also encourages them to apply for a PTFE award and then potentially for those students or others to come full circle to work for one of the industries. We hope that this project continues!"* (Industry coordinator, General Dynamics)

> *"It is really important for Industry to work with schools, and it helps pupils to understand types of careers and what they involve – then they can assess whether that might be something that they are interested in. it helps link the pupils to real-life companies so that they can aspire to work for them – it also helps them to understand the relevant pathways to get there. In the end, these kids are the future generation of employees"* (Industry coordinator, Zimmer Biomet).

Fits with Corporate Strategy: Industries reported that the WVEP challenges fit with their corporate responsibility and help with their contribution to society. Some industries also felt that, when effectively advertised, the challenges are great publicity for the industry.

Reconnects staff with core hands-on engineering – The industries reported that delivering to schools has reconnected staff to core-engineering principles – this is important for staff that normally work on projects or work in an office each day.

The reach and type of delivery of the industries have expanded – All the industries reported that their engagement with schools has increased due to their involvement in the WVEP. Engaging with the primary sector was new to all industries and was seen as a welcome addition. Industries also noted the novel approach of the WVEP Employer Engagement Strand encouraged them to engage more fully with schools, teachers and pupils on a real-life project rather than by a static presentation.

> *"The WVEP is so important to us – as we didn't have this type of educational outreach before. We need support from the WVEP – this helps bring us the schools and connects us to the other companies. Without the WVEP we wouldn't be doing outreach in this way"* (Industry coordinator, Safran Seats)

> *"We absolutely needed the WVEP – it completely expedited the process of engaging primary schools for us – now our focus is mainly on Primary Schools. I am not exaggerating when I say that the WVEP has entirely shaped and*

influenced how NDEC runs its education projects now. The longer-term sustained engagements with primary schools have transformed how we can connect with pupils. We welcome any opportunity to work with the WVEP" (Industry Coordinator & Engagement Officer, NDEC)

The evaluation shows that a closer connection between the schools and industry has brought mutual benefit. The WVEP model has provided a sound framework for working with industry in the future.

Vishay Intertechnology challenge (primary)

Vishay Intertechnology challenge (secondary)

6. The impact of the Welsh Valleys Engineering Project

The industries and teachers reported that working with the WVEP created the following opportunities,

- **Connections:** The WVEP established connections with industries, schools and teachers which means the development and delivery can happen straight away.

- **Administration**: Teachers and industry felt that the administration and organisation of key meetings between industries and schools was a vital strength of the WVEP

- **Deadlines and guidance:** The industries felt that the WVEP provided a good format that gives a stepped approach that makes engagement logistically easier for Industries. Ongoing guidance provided by the WVEP coordinator was also appreciated.

- **Meaningful engagement and relationships**: The WVEP were praised for developing a structure that enabled industries and schools to develop longer-term more meaningful projects with schools (rather than one-off engagements)

- **Flexible approach**: The WVEP structure was felt to provide a flexible approach for industry and schools. This enabled them to decide what works best for them, their pupils, the curriculum and the timescales in each school.

- **Communication** between Industries and schools was managed effectively when required.

- **Momentum**: It was felt that the WVEP coordinator was key to maintaining delivery and keeping up momentum for the project over the years

Appendix D presents a selection of quotes from the interviewed industries, exemplified by the following comment,

> *"We couldn't do this without the WVEP – they are absolutely essential! It would be hard for us to find the connection with the school, then find the right teachers within that school, and then coordinate a meeting with us to discuss or develop the challenge – it just wouldn't be possible without the WVEP coordinating that. The WVEP make a persuasive case for us all to get involved in this project – the coordinator has the drive and passion to get all of us onboard with this project"* (CEO, Concrete Canvas)

Areas for Improvement

There were several suggestions and areas for improvement for the WVEP and for the Engineering challenges going forward, these are presented below,

Development Phase

1. **Engagement levels**: On occasion, there was a disparity in the levels of engagement of the industries during the development phase - some of the industries designed most of the challenges with some input from the teachers, others co-designed challenges, and some industries gave little support and development to their challenges. This led to different workloads for the teachers and in the school-led projects, with some teachers feeling unable to support in areas of learning in which they were inexperienced (e.g. Engineering/CAD). Challenges may need to be adapted to suit new curricular requirements as time goes on.

Delivery Phase – The challenges

1. **Time constraints:** Some secondary schools reported that busy terms or scheduling issues meant that they were not able to complete the longer challenges; sometimes these were carried over to the next term, but on occasion, this was not possible (schools gave multiple reasons for this including, illness, assessments, Estyn inspection, missed communications, timing, the workload of teachers, coordinator changes or Christmas etc.). Throughout the project, many of the challenges for secondary schools were adapted to accommodate the school restrictions or the WVEP offered alternative opportunities (such as a visit to an industry) to encourage continuous engagement. The time investment for the teacher to plan and run a multi-week challenge was also highlighted by the secondary school teachers. **Planning Challenges as early as possible:** The timing of the introduction to the challenge (at the beginning of the delivery term) was seen as a barrier for some of the secondary school teachers to fully integrate and plan the challenge to its maximum capacity. The teachers suggested that sharing the challenges the term before delivery was key to the successful incorporation of the challenges in school integrating curriculum and cross-curricular learning. It was also noted that some of the challenges needed teacher training time built in so that the teachers could acquire new skills (e.g., the challenges that required self-led use of software) – a longer lead time would accommodate this.
2. **Pre-planning and Communication** between the WVEP, the industries and the schools could be improved to ensure that the teachers understand the challenge and what is expected of them (most of the challenges are teacher-, not industry-led). The coordinating teachers in each cluster primary school received information about the challenge that they could run that term from the lead primary school for that cluster. Sometimes the cluster primary schools did not understand the structure of the challenges or what was expected of them, so a different model, where the cluster primary schools are as informed as the lead primary school would be helpful. Industries need to ensure that they communicate effectively with teachers about resources and space needed to complete their challenges and clear communication is needed between industry and the teacher who is delivering the challenge so that

expectations are clear. Teachers need to ensure they are clear about the age-group that has been selected for the challenge and adapt the tasks and the presentation to suit the selected age-group's knowledge base and ability. The teachers felt that the most successful presentations were concise and clear, highlighted the industry and the task and provided hands-on tasks or resources to look at throughout the presentation. Both primary and secondary schools felt that the challenges would work best if connected to the class's current topic or learning.

3. **Support to deliver across the curriculum:** Although the challenges have been designed to work across the curriculum, as the project continued, the secondary schools chose not to run them in this way (due to restrictions such as timetables, core curriculum teaching, multiple teachers etc.) If this is a longer-term strategy of the WVEP, more time is needed for teachers to plan cross-curricular delivery. As mentioned earlier, introducing a challenge to secondary schools the term before they are due to run the challenge would provide additional time for the schools to incorporate the challenge into the curriculum in a cross curricular way. Many of the primary school teachers are now integrating the challenges into the curriculum making the challenge the centre of learning. The WVEP needs to harness the expertise of these teachers to help and encourage other teachers to do the same. Inexperienced teachers would particularly benefit from this.
4. **Industry constraints**: The industries worked very hard to support the delivery of the challenges in the WVEP schools. However, it was reported that, on occasion, opportunities were missed due to industry members or staff being off-work, missing or slow in their responses to emails, and because staff had changed job roles. This can create knock-on repercussions with the schools due to timetabling and fitting a long challenge into the term structure.
5. **Draw out the different types of Engineering and include practical tasks:** The connection between the challenge and the various types of engineering was felt to need more promotion (and explanation) on some of the challenges so that the pupils understood the range and type of engineering that their challenge is focused on – this was especially relevant at primary level. Teachers appreciated the challenges that focused on design and making prototypes but felt that the pupils would respond more favourably to real engineering tasks like welding, construction and other practical tasks to embed authentic learning.
6. **PTFEA (Panasonic Trust Future Engineer Awardees[10])**: The teachers valued any support provided by the PTFEA college students from Merthyr College and Coleg Gwent. However, whilst there has been engagement between Merthyr College PTFEAs and their schools, this has not yet been established effectively by Coleg Gwent meaning that additional support was not available in the schools located in Blaenau Gwent.

[10] PTFEAs are students who have been recognised for their aptitude for Engineering and awarded £1000 per year for their two years of college. This bursary is funded by The Panasonic Trust.

Primary School Clusters

1. **Parity:** It was noted by some teachers that the Cluster schools might not get the same experience and connection with industry as the lead schools as they were not involved in the development phase.
2. **Lack of consistent engagement:** Although 35 primary schools engaged in the project, many of the cluster schools only engaged in one or two of the challenges which lessens the potential impact of the project for those schools.
3. **Meetings:** teachers suggested that as the cluster schools did not attend the WVEP meetings, they might feel less invested in the project. The industries thought that it might be useful to include the cluster teacher who would be leading the challenge in the initial meeting with the industry.

The WVEP

The industries suggested a few areas of improvement for the WVEP which are as follows:

1. **Publicity and advertising** – The industries requested better cross-publicity through school social media channels and other avenues - this would help with publicity and buy-in both internally and externally.
2. **Information packs** – Some industries requested more information on the schools that they are engaging. This should include parking instructions, and teachers' contacts (including personal mobile if possible). Also, a brief description of the school, its curriculum and its ethos and values.

Conclusions

Between November 2021 – and July 2024, The WVEP Employer Engagement Strand delivered challenges to 43 primary, special and secondary schools connecting 4650 pupils with local, national and global engineering industries. Pupil evaluation demonstrates positive attitudes and shifts in pupil perception of, and aptitude for, engineering careers and pathways. New knowledge and skills were introduced to the pupils through the challenges, many of which offered new and unique opportunities to both teachers and pupils alike. There was clear evidence to show that the challenges can raise teacher and pupil awareness of local opportunities in STEM-Engineering which has been further reinforced by the industries that offer field trip opportunities as part of the challenge.

The WVEP has been able to establish and deepen the relationship between industries and schools – especially between those who worked together during the development phase. This was strengthened at key events (i.e., the Celebration event in July) and could be further reinforced at other meetings where industries and schools can network. The WVEP provided a reciprocal opportunity where both schools and industries benefitted from engagement.

The delivery of the WVEP Employer Engagement Strand to the schools has built the confidence of the teachers to communicate with the industries and establish new links to engineering companies. It also enabled schools and industry to co-produce the challenges. Moreover, it has enabled teachers (especially those in the primary sector) to build their knowledge around engineering and it has strengthened their ability to deliver STEM-Engineering to the whole class. Many of the teachers were able to teach across the curriculum throughout a term. The flexibility of the challenges was seen as a strength by many of the teachers.

The teachers valued the idea of the bilingual resource packs (in production) that would reduce their workload and help them to deliver the challenge and would open the challenges up to more schools in Wales.

Several areas were identified that could improve the challenges that were mainly around the pre-planning stage and communications so that teachers could more effectively plan the engagements and lessons – this was particularly relevant to the secondary schools where teachers needed to plan across timetables. The challenges could be improved by a further re-development phase that pairs up teachers and industry to adjust the challenges for different age-groups and abilities. The timing of the introduction of the challenges to the schools could benefit from being brought forward for the primary schools and as much time as possible given to secondary schools (even up to one or two terms ahead of delivery). The engagement with the cluster and secondary schools needs further review to ensure that all schools benefit from the project.

The WVEP has developed a scheme that links industries with schools to deliver co-designed engineering challenges that encompass problem-based experiential learning for the pupils. The WVEP fulfils the requirements of the new Curriculum for Wales (CfW) and provides teachers with the agency to run the challenges in a way that best suits their pupils to create engineers of the future.

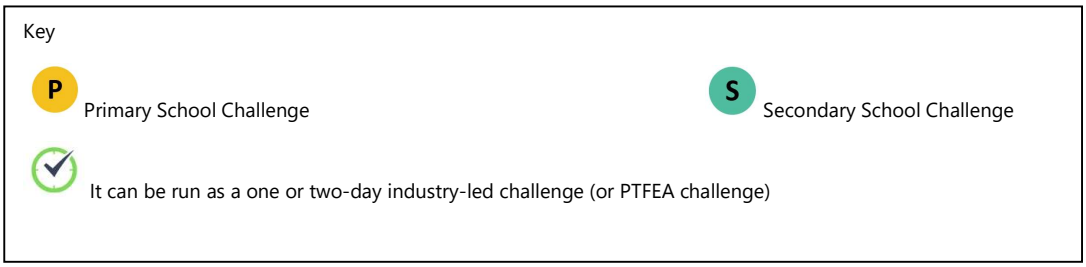
Recommendations

1. **Recruiting Industries**: more industries are needed to provide experiences for a larger number of primary schools if engagement increases.
2. **Development phase:** For a new challenge the industries and schools should develop an introduction pack that sets out the challenge and what is required from each party using a standardised proforma. This could also establish preferred communication methods, timescales, and expectations. The introduction pack will set out each challenge step-by-step, links to the curriculum and help to prepare and guide teachers who take on the challenge after development. This will also aid the RAEng in converting the proforma into a resource pack.
3. **Closer Tie-in with WVEP**: The WVEP could produce an interactive PowerPoint slide to show at the beginning of each challenge that highlights the WVEP and the type of engineering that the current challenge is focusing on. This could be shared with all industries. This ties in the challenges more with the WVEP name and promotes the WVEP as well as highlighting the engineering area(s) for the pupils.
4. **A re-development or review phase** is needed help industries to pitch correctly for all age groups. Pairing industries up with Key Stage 1 teachers would be particularly useful to help industries and teachers successfully adjust tasks and presentations to suit the youngest age-group of children. A review of the secondary school challenges to deliver more effectively to the year 7 and year 8 pupils would also be fruitful. The aim of this would be to perfect and successfully pitch each challenge, not necessarily to change them.
5. **Training**: The most experienced teachers' expertise and/or advice could be harnessed for training sessions for new teachers and cluster schools running the challenges. This could reduce workload and help guide inexperienced teachers.
6. **Clusters primary schools:** The cluster approach should be reviewed looking specifically at snagging and assumption-mapping. Additionally, the number of schools each industry can engage in one term needs to be established and cross-referenced with the total number of schools. This could clarify whether fewer schools or more industry partners are needed. The monitoring data collected throughout the project should be used to establish cluster schools that engaged 3+ times – on this basis, these clusters could become lead schools for one or two other schools thus alleviating pressure on the original lead cluster coordinators. Some primary schools the project is working with are now part of a 3-16 super-school and would need a bespoke approach to ensure participation in the future.

Appendix A

The Challenges

A summary of each challenge is provided below,



S Panasonic Toughbooks Challenge – Design a 3D phone holder

Designing & Programming for the future! Students design, test and create a mobile phone holder using online CAD software. Students are challenged to think about usability, practicality, durability and the overall look of the holder. Designs are sent to the team at Panasonic for review. The challenge culminates in a trip to the Panasonic manufacturing plant and the team reveals the winning 3D-printed designs.

S Vishay Intertechnology – Escape Room

Vishay Intertechnology bring the Escape Room format to the classroom with this engineering challenge! Four groups are tasked to come up with a problem that needs to be solved by engineering. The groups work together to solve the clues to release the class from the escape room.

S Concrete Canvas – Bridge Construction

Students are introduced to the wonderful world of concrete! Students explore how innovative engineering has helped create pop-up shelters for humanitarian aid before getting hands-on themselves exploring tensile strength through a bridge-building team challenge using Concrete Canvas. Which team will build the strongest bridge?

S General Dynamics – Build and Code

How do you create an autonomous system that can deliver supplies to soldiers in a warzone? Tank manufacturers General Dynamics lead student teams in this challenge to design and build a small vehicle. Students are taught coding to manoeuvre it across a classroom-sized

maze to get it to its target destination! But which team will successfully carry out the challenge?

S Panasonic – Weather Station

How do we design for an ever-changing world? Panasonic lead this challenge to find out! Students build and programme a compact and portable weather station. They monitor and record temperature, pressure and humidity then analyse the results for patterns, using physics, maths and geography to explain what they found.

S Continental Teves – Think like an engineer

International tyre and car part manufacturers Continental Teves challenge the students to Think Like an Engineer. Students are tasked to design and build a transport system that can move 10 marbles from one place to another using their creative, digital, numeracy and problem-solving skills to do so. Will they succeed?

P S Safran Seats – Extreme egg-drop

Engineering for safety! Students explore aerodynamics through a unique egg drop challenge. Safran Seats, engineers of high-end aircraft interiors, set several physics and maths challenges that help the students to find the perfect design to protect their egg. But which one will survive the drop?

P S Vishay Intertechnology – Precision Engineering

How do you precision engineer the micro? Students take part in tasks demonstrating precision testing and retesting that Vishay manufacturers specialise in. Student teams are challenged to design a box that can be made on a production line to exacting standards. Boxes are filled and donated to local charities.

P S PTFEAHE – Rocket Workshop

Led by Panasonic Trust Future Engineer Awardees (Higher Education Award) this workshop explores the wonderful world of rockets!

P The National Digital Exploitation Centre (NDEC) & Thales – The Internet of Things

What is the Internet of Things? NDEC take pupils on a journey through cyber security and online safety. The pupils research and design new items for the Internet of Things taking into consideration the practical, ethical and security implications of their designs. Pupils showcase their designs to NDEC/Thales. Who will come up with the most useful and well-thought-out design?

P The National Digital Exploitation Centre (NDEC) & Thales – Car theft Challenge!

Ever wondered how cyber engineering can help solve crimes? NDEC lead this multi-stage project to solve the mystery of the stolen car. This immersive experience encourages pupils to use cyber skills to solve the crime, culminating in a real court case! But who will end up in jail?

P The National Digital Exploitation Centre (NDEC) & Thales – Cyber Networks

Cyber networks exist in every school, business and industry. NDEC challenge the pupils to explore their school cyber network and examine its use, security and pinch-points to see where the network could be improved. Students explore the school to create a living-map of the school network and complete cyber challenges along the way!

P Zimmer Biomet – Engineering for health

Engineering to help others! Pupils explore how engineering can help the human body. Biomedical engineer Zimmer Biomet challenges pupils to design a bendable knee for Barbie. Pupils explore how joints work, test a range of metals for use in the human body and design and make a prosthetic limb. Pupils explore the potential of the bionic human!

P TATA Steel – Engineering and the Environment

Ethical Engineering! TATA Steel explores big industry engineering and its environmental responsibility. TATA challenges pupils to work in teams to find thrown-away goods to create a 3D model. The challenge culminates in a presentation to TATA where pupils get to try on protective clothing and present their models.

P JC Moulding – Prototype Manufacturing

Engineering the small and useful! JC Moulding introduced this challenge to create a useful holder that can be manufactured and promoted. The pupils get experience in testing materials,

measuring, designing, teamwork, presenting and marketing. Pupils present their designs, and the best prototypes are taken to be manufactured by JC Moulding!

P Morgan Sindall – Net Zero Schools

Ever wondered how carbon-efficient your school is? Morgan Sindall will help you to audit your school's energy use. Pupils will explore ways to improve their school's environmental impact and be encouraged to take action to achieve results closer to net zero now and in the future!

P ORE Catapult – Off-shore wind turbine

Can you help design the best-floating wind turbine to help the UK mission to become less dependent on fossil fuels? ORE Catapult challenges students to design, test, redesign and prototype a floating wind turbine that could be used out at sea. Students work in teams and consider the weight, height, materials used, design and durability of their designs. ORE Catapult judges the competition and questions the students on their presentations.

P Lightsource BP – Eco-Villages

How can we live more sustainably? Lightsource BP challenges students to learn more about solar farms and other sustainable methods to create a perfect eco-village for the future! Students work in teams to research sustainable ways to live and then create a model eco-village using re-cycled materials. The students are encouraged to think of multiple ways to utilise sustainable methods in their model villages. Lightsource BP judges the eco-villages and presentations; whose is the most well thought out?

P Wild Connect – Wild about Sound

How do you use technology to get closer to nature? Wild Connect bring an introduction to sound engineering by challenging the students to set up 'sound-traps' in the playgrounds to record bird songs and other sounds. The students then identify the bird song and create a presentation on which sounds were identified. This challenge combines technology and nature creating opportunities for exploring birdlife, art, maths, technology and more!

S  Future Valleys Engineering – Road and Bridge Building – site visit

Ever wanted to experience a real-life multi-million-pound construction project? Future Valleys Construction leads a half-day on-site session that helps students understand the engineering

that underpins a large civil engineering project. The students will be shown a presentation illustrating the issues that are present when expanding an existing A-road including constructing new bridges, roundabouts, moving houses and trees and key services. The students then get to see large-scale machinery and cutting-edge techniques being used in this project.

Appendix B

A summary of the RAEng CPD training

Date	Name of RAEng. CPD	Number attended
Autumn 2021	Future of Flight	30
Summer 2022	Sustainable Futures	16
Autumn 2022	Water	23
Spring 2023	Water Digital Resource	14
Summer 2023	Technocamps/SPL (primary only)	8
Winter 2023	Engineering materials for a greener planet	16
Spring 2024	Entertainment	7
Summer 2024	PSTT (primary only)	6
Total		**120**

Appendix C

Industry & Teacher Evaluation Questions

The key questions asked at the interview were as follows,

Strengths

Of their Industries Engineering challenge

Of the Welsh Valleys Engineering Project

Of their industry in being involved in delivering to schools

Improvements needed.

Of their Industries Engineering challenge

Of the Welsh Valleys Engineering Project

Schools and teachers

Opportunities and sustainability

What opportunities does the industry consider that have arisen from this project?

How sustainable is this project following the end of the funding period?

For Teachers: How far did the WVEP meet its main objectives (list)

Additional questions:

How did the development phase with the industry and schools impact the design and development of the challenge?

What are the strengths and weaknesses of delivering across the cluster schools?

Appendix D

Comments from Industries & Teachers

Panasonic Toughbook.

"This is not something that Panasonic could have done off our own backs, the WVEP (and Anita) has been instrumental in arranging and setting up the meetings. The WVEP has introduced us to the schools that we have worked with – without that contact, we would never have got this off the ground"

Concrete Canvas

"We couldn't do this without the WVEP – they are absolutely essential! It would be hard for us to find the connection with the school, then find the right teachers within that school, and then coordinate a meeting with us to discuss or develop the challenge – it just wouldn't be possible without the WVEP coordinating that. The WVEP make a persuasive case for us all to get involved in this project – Anita has the drive and passion to get all of us onboard with this project"

General Dynamics

"We have run projects with schools before and they are often one-off things and a bit piecemeal. The WVEP provides a good format and a stepped approach that makes it easier logistically. The WVEP coordinator does a really good job coordinating the project, it is hard to know what she could do better".

JC Moulding

"Anita has been instrumental in this project. We are so busy so having a coordinator who has the know-how and the connections and can get us all working together is a key strength of this project, we couldn't/wouldn't have done this without that coordination. She makes sure that we all know what is happening and what each side needs to achieve and arrange"

Safran Seats

"Without the links that the WVEP provide we would struggle to organise and manage that process. Anita does all of that for us and she sets up meetings and opportunities for us. We just wouldn't be able to do that. We can provide the engineers and the know-how, but the WVEP makes all the connections and does the organising for us"

Panasonic Weather Stations

"Being part of this project has enabled us to impact many schools rather than just one school, so it has been really useful to us"

Zimmer Biomet

"We need the WVEP to keep it all going term by term and keep us all engaged and delivering. The WVEP is vital in this process, and we couldn't do it without them. We could do one-off things, but not an ongoing project like this"

Tata Steel

" If I had done this myself, I would have had to knock on school doors to see if they were interested. I'm not sure that would have happened. So the admin and organisation are all taken care of with the WVEP and the central coordination, consistency and contacts – specifically the teachers – are all prepared and ready. That is what has got this off the ground"

NDEC

"We absolutely needed the WVEP – it completely expedited the process of engaging primary schools for us – we were initially targeting older students – so to have the structure and the aim to engage younger primary students has completed turned things on their head at NDEC and now our focus is mainly on Primary Schools. And the Cyber First team now handle secondary school. ***I am not exaggerating when I say that the WVEP has entirely shaped and influenced how NDEC runs its education projects now. The longer-term sustained engagements with schools. We welcome any opportunity to work with the WVEP"***

Contributor	***Comments in year 2***
Will Crawford. ***Concrete Canvas***	Anita supports the day-to-day we couldn't ask for more! She has been essential in driving the programmes through and it must be a challenge to convince companies to give their time freely and to engage with teachers to get them on board is not an easy task, as it's hard to engage teachers even on a Zoom call, and she does it brilliantly.
Thomas Phillips and Valerie Ng. ***Panasonic***	Anita arranges and organises the framework that the project is run in. She also helps to chase up the schools if they are not engaging. She also organises funding for the school. If we did this outside of the WVEP, we would only be able to go to one or two schools. The WVEP helps us to build up those relationships with other schools. Time is an issue – so the formal framework of the WVEP – and the mix of schools and industries – that really helps. It is a really positive thing, to have Anita there.
Chris Fall ***JC Moulding***	The challenge wouldn't work without the WVEP. Anita is brilliant and has been brilliant with communication and doing what she can with her scope to make it as easy as possible for both sides. It doesn't always work, but that is not her failing. We wouldn't have been able to connect with these schools without the WVEP – this aspect of what they do is crucial to delivering the project. We can't possibly know how to connect with the schools ourselves. A coordinator for the project at each school is essential.
William Todd, ***Wild Connect***	I think Anita is brilliant! has been trying really hard with the clusters – we are still not seeing much take up and that is a bit shocking as it is such a great opportunity for the schools.
Cathy Gregory	Anita has introduced us to the teachers each time and that was useful to have her there to introduce us and the concepts of the

Safran Seats (Secondary School)	challenge and initially to guide us through the project. Anita has been really helpful – I'm not sure what else she could do!
Tabitha Varlot ***Zimmer Biomet***	Anita connects us to schools and has helped connect us to other schools for Women in STEM. It is definitely useful to be linked to schools – that is hard for us to build those connections – so once the WVEP has made that contact for us we can work with those schools again.
Jonathan Jones ***General Dynamics***	Being part of the WVEP makes it easier for us. Anita also helps us to work with other schools that she knows – we ran a D-Day event recently, and Anita rallied the teachers around to attend. Anita is really good at her job. I understand now how hard this is as I could not get people engaged in our DDAY event! **No improvements needed**
Anish Pradhan ***Safran Seats*** *(Primary challenge)*	The WVEP is so important to us – as we didn't have this type of educational outreach before – Safran is a large multinational company, that has smaller operations across the globe. We need support from the WVEP – this helps bring us the schools and connects us to the other companies. Without the WVEP we wouldn't be doing outreach in this way.
Georgie Davies ***Morgan Sindall***	We do a lot of this anyway – but it always helps to have someone connecting with the schools and having those connections. Anita has done a great job at helping us connect with more schools in our target areas.
Dan Williams ***Light Source BP***	Anita's role is very important. We wouldn't be involved if it wasn't for Anita's efforts to keep us engaged and support us. There are no improvements that Anita could make. She is doing fantastic! And it is not just me that she holds to account – but the whole team as well. She has engaged with my team too and she has to liaise with us and the schools – and that is not an easy task to align all the diaries. Hats off to her – she absolutely nails it!
Nicola Wright **Ystruth School**	The idea of the Challenges and of working with industry is really good – it puts a different spin on it. I have done STEM projects in the past myself, and they have not been quite as involved as the WVEP challenges. But, now I have done this one, I can see the value of bringing in the science, technology, maths and other areas of the curriculum into one challenge – so I will do that again. It enthused the children more because they were working on something that the industry had set for them, not something that their class teacher simply wanted them to do – so that motivated them – especially because they knew the industry was coming back in to see what they had done.
Sam Olden	Anita is great! She is always on hand to chase people up and wrangle people together and she is consistent. She has her goals

Twynyrodyn Primary School	for the WVEP, but she understands sometimes the schools might have something else on (like Estyn inspections) – so she is flexible for us. She is realistic – she is a real person. But she does a lot of work behind the scenes – she makes a lot of connections and puts a lot of people together who wouldn't be able to make those connections themselves. Without Anita, I wouldn't be able to have worked with any of the companies that we have been paired with so far. It has been great to have Anita working on the project.
Latimer Rees-Williams ***St Illtyds Primary***	It is vital to have someone like Anita on board. This is key to the project. If it wasn't for Anita, the project would not be as successful as it has been. She has been the glue that has helped to motivate us and kept us all together. Having that organised voice in the background has been very helpful in keeping us all on track. She has worked tirelessly behind the scenes – she has done a fabulous job ensuring that the connections with the schools and industry have been successful. Moving forward, having that role is key to moving the project forward. It would be a massive shame if Anita left, as the schools won't have time, or teachers will change over and the project will peter out.
Sarah Thomas **BCACS Primary School**	The WVEP has really established us as a school that *does* engineering – we had a parent comment to us that they sent their child to our school because of all the *engineering* that we do. It has been a privilege to be part of the WVEP – our school has really really enjoyed it. To be honest, Anita is the centre of everything – she is the one that gets the businesses on board, she keeps us all together and she checks that everything is running smoothly and sends us all of the information. She is central – if she goes you'd need someone with the same drive and ambition – and someone who does not take no for an answer – to really keep this project on track.
Tom Buttress **Willowtown Primary School**	You need someone at the level of Anita to ensure that the project continues running and that it doesn't just fizzle out. Especially with cluster working, as that relies on somebody overseeing the whole cohort and ensuring that new teachers come on board if a teacher leaves. Without that, the project would fizzle out. You need a person driving it on a strategic level.

References

[i] NATIONAL ASSEMBLY FOR WALES, 2011. Science, Technology, Engineering and Maths (STEM) agenda. Enterprise and Learning Committee, Welsh Assembly. January 2011 (http://www.assembly.wales/NAfW%20Documents/stem_agenda_report-e.pdf%20-%2026012011/stem_agenda_report-e-English.pdf)

[ii] WELSH GOVERNMENT REPORT, 2016. Science, Technology, Engineering and Mathematics (STEM) in education and training: A delivery plan for Wales. Welsh Government Publication. (http://gov.wales/docs/dcells/publications/160311-stem-delivery-plan-en-v2.pdf)

[iii] DEPARTMENT OF BUSINESS, ENERGY AND INDUSTRIAL STRATEGY POLICY REPORT, 2017. Industrial Strategy: Building a Britain fit for the Future. 27 November 2017. Department of Business, Energy and Industrial Strategy. (https://www.gov.uk/government/topical-events/the-uks-industrial-strategy)

[iv] SOCIAL MOBILITY COMMISSION. STATE OF THE NATION 2016. : Social Mobility in Great Britain. November 2016. Social Mobility Commission. (https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/569410/Social_Mobility_Commission_2016_REPORT_WEB__1__.pdf)

[v] ASPIRES report, 2013. Young Peoples Career and Science Aspirations aged 11-14. Kings College London.

[vi] Council, MERCATOR Report for Engineering. 2020. *Mapping the UKs Engineering Workforce*. https://www.engc.org.uk/media/3466/mapping-the-uks-engineering-workforce.pdf.

[vii] Archer, Louise & Dawson, Emily & DeWitt, Jennifer & Seakins, Amy & Wong, Billy. (2015). 2015. *Science, Technology, Engineering and Maths (STEM) agenda*. Journal in Research in Science Teaching 52/7.

[viii] Engineering UK 2020 Educational pathways into engineering (2020) engineering-uk-report-2020.pdf (engineeringuk.com)

[ix] Civil Engineering Surveyor. 2020. *The State of Engineering Report: Educational Pathways to Engineering*. https://journals.cices.org/ces/ces-april-2023/features/the-state-of-engineering-report.

[x] Royal Academy of Engineering (2020) summary-of-research-into-public-perceptions-of-engineering.pdf (raeng.org.uk)

[xi] Developing a Curriculum for Wales (2023) Developing a vision for curriculum design - Hwb (gov.wales)